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

2015 ANNUAL REPORT
April 1, 2015 thru March 31, 2016

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2015 Executive Summary
by

Steve Williams

This report presents results for year twenty-five in the basin-wide Northern Pikeminnow Sport Reward Program designed 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 as much as 40%.

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 a 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 is responsible for coordination and administration of the program; PSMFC subcontracted various tasks and activities to ODFW and WDFW based on the expertise each brings to the tasks involved in implementing the program. Roles and responsibilities of each cooperator are 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 2015 by report are as follows:

Report A (WDFW)

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

1. The objectives of the 2015 NPSRF were to (1) implement a public fishery that rewards recreational anglers for harvesting northern pikeminnow ≥ 228 mm (9 inches) total length, (2) collect, compile, and report data on angler participation, catch and harvest of northern pikeminnow and other fish species, and success 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 other fish species caught.

2. A total of 200,213 northern pikeminnow ≥ 228 mm were harvested during the 2015 NPSRF season. Of these, 196 northern Pikeminnow had both an external ODFW spaghetti tag and internal PIT tags and 161 that were found with ODFW PIT tags but missing spaghetti tags. An additional 154 PIT tags were recovered from juvenile Salmonids ingested by northern Pikeminnow received during the 2015 NPSRF. A total of 3,210 different anglers spent 24,040 angler days participating in the fishery during the 2015 season.

Report B (PSMFC)

Northern Pikeminnow Sport-Reward Program Payments: *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.*

1. For 2015, the reward amount for the three standard payment tiers *increased* from $4, $5 and $8 per fish to $5, $6, and $8 per fish. In addition, the seasonal cumulative number of paid fish required for entering the second and third payment-tier levels was *lowered* from 100 & 400 fish (in 2014) to 25 & 200 fish (in 2015).

2. During 2015, 198,415 fish were paid at the standard tiered-reward of $5, $6 and $8 per fish. The season total reward paid for these fish (excluding coupon amounts and tag-loss bonus payments) was $1,466,079.

3. A total of 195 tagged fish (having an external spaghetti tag) were paid at $500 each. The season total paid for tag rewards was $97,500.

4. A total of 161 tag-loss fish (external spaghetti missing but still possessing a verifiable pit tag) were paid a *bonus* reward of $100. The season total paid for tag-loss *bonus* was $16,100

5. A total of 858 anglers attached a one-time *$10 bonus coupon* to their reward voucher before submission for payment. The season total paid for *$10 bonus coupons* was $8,580

6. The total value for all 198,610 northern pikeminnow submitted for payment in 2015 (including all coupons, tagged fish and tag-loss *bonus* payments) was $1,588,259.

7. A total of 1,043 separate successful anglers caught one or more fish and received payments during the season. A total of 3,210 separate anglers registered to fish, of which 45.2% returned vouchers for payment.

Report C (ODFW)

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

1. Primary objectives in 2015 were to: (1) quantify 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 Dalles and John Day 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. System-wide exploitation of northern pikeminnow greater than or equal to 250 mm fork length was 17.2% (95% confidence interval 12.3–22.1%).

2. Model-predicted reduction in predation for 2015 (based on exploitation during 2014) was estimated to be 29% of pre-program levels; harvest of northern pikeminnow during 2015 is predicted to result in a 32% reduction during the following year.

3. Biological evaluation of northern pikeminnow, smallmouth bass and walleye was conducted in The Dalles and John Day reservoirs (high water temperatures during summer months precluded sampling). Abundance index values for northern pikeminnow in the areas sampled ranged from 0.00 to 0.18, whereas estimates varied between 0.57 and 10.00 in 1990, the first year of biological evaluation. Calculation of consumption index values during 2015 for northern pikeminnow were constrained by sample size in most areas during the spring (i.e., $n \leq 5$). However, consumption in the tailrace area of The Dalles Reservoir (2.88)–the one reservoir section in which a consumption index value could be calculated–

exceeded all previous estimates in that area. Further, within a given area, time series of consumption index values from 1990 to 2015 varied considerably, displaying no obvious inter-annual trends. Like consumption index estimates, spring predation index values for northern pikeminnow were highly variable among years.

4. As characterized by index values, spring abundance of smallmouth bass during 2015 was greatest in the mid-reservoir area of John Day Reservoir (49.01). Abundance index estimates in The Dalles varied spatially, with the largest value occurring in the mid-reservoir section (13.68). In a given area, consumption index values for smallmouth bass in both The Dalles and John Day reservoirs generally remained comparable to previous years; with the exception of the John Day tailrace section, where the calculated value was an order of magnitude greater than any year since the inception of the program. Predation index values for smallmouth bass varied among areas sampled, with the largest value occurring in the mid-reservoir section of John Day Reservoir (5.95).

5. In 2015, walleye were encountered in all areas sampled. As for smallmouth bass, abundance index estimates generally were comparable to previous years and varied considerably among reservoir sections. Juvenile Pacific salmon were encountered frequently in gut content samples of walleye in The Dalles ($\hat{p}$ = 0.35) and John Day ($\hat{p}$ = 0.44) reservoirs. Similarly, considering only those samples in which fish material occurred, salmonids were encountered most frequently in both reservoirs ($\hat{p}_{The\ Dalles}$ = 0.67 and $\hat{p}_{John\ Day}$ = 0.70).

6. We evaluated 474 and 337 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 dams ($\hat{p}_{The\ Dalles}$ = 0.53 and $\hat{p}_{John\ Day}$=0.45). Of identifiable taxa encountered in diet samples, juvenile lamprey generally were consumed by the greatest number of northern pikeminnow ($\hat{p}$ = 0.04-0.60). During the month of August, American shad were found in a majority of samples analyzed ($\hat{p}$ = 0.77). Juvenile salmon or trout were encountered in the contents of northern pikeminnow digestive tracts during May through July, however typically in smaller proportions of samples than lamprey ($\hat{p}$ =0.01-0.35).

7. Highly variable index values for the predators considered in our study provide no obvious indication of an area-specific compensatory response to the targeted removal of northern pikeminnow. Yet, given the dynamic nature of these systems both biotic and abiotic, we encourage continued monitoring efforts to assess trends in predator populations throughout the Columbia and Snake rivers to help elucidate potential local and net (system-wide) effects.

Report D (WDFW)

Dam angling at The Dalles and John Day dams

1. The 23 week fishery took place at The Dalles and John Day dams from May 5th to October 11th, 2015.

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 2015 Dam Angling crew.

3. Harvests for the 23 week fishery totaled 7,693 northern pikeminnow at the two dams with 4,566 fish harvested at The Dalles dam and 3,127 fish at John Day dam. The total fishing time at the two dams was 2,247 hours for a combined overall average catch per angler hour of 3.42 fish. The catch at The Dalles dam was 3.65 fish per angler hour and at John Day dam, 3.14 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 308 mm and 340.03 mm at John Day dam.

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

2015 Annual Report

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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, 2015. The objectives of this project were to (1) implement a recreational fishery that rewards recreational anglers for harvesting northern pikeminnow ≥ 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 200,213 northern pikeminnow ≥ 228 mm fork length (FL) and 6,656 northern pikeminnow < 228 mm FL were harvested during the 2015 NPSRF season. There were a total of 3,210 different individual anglers who spent 24,040 angler days of effort participating in the NPSRF during the 2015 season. Catch per unit effort for combined returning and non-returning anglers was 8.33 fish/angler day. The Oregon Department of Fish and Wildlife (ODFW) estimated that the northern pikeminnow harvest activities from the 2015 NPSRF resulted in an overall exploitation rate of 17.2% (Barr et al. 2016).

Anglers submitted 196 northern pikeminnow with external ODFW spaghetti tags and all of these fish also had internal PIT tags. There were also 161 northern pikeminnow with ODFW PIT tags only, but missing spaghetti tags. An additional 154 PIT tags were recovered from juvenile salmonids ingested by northern pikeminnow received during the 2015 NPSRF.

Peamouth *Mylocheilus caurinus*, smallmouth bass *Micropterus dolomieue*, yellow perch *Perca flavescens*, 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 (Northwest Power Planning Council 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 (≥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 over 4.2 million reward sized northern pikeminnow and spent over 867,000 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. 1994, Friesen and Ward 1999).

In an effort to spur angler participation, the tiered angler reward system developed in 1995 (Hisata et al. 1996) which paid anglers higher rewards per fish based on achieving designated harvest levels was updated for the first time in NPSRF history for the 2015 season. Reward changes for the 2015 NPSRF include raising the reward for Tier 1 fish from $4 to $5 per fish. Lowering the threshold for Tier 2 rewards from 100 fish to 26 fish, and lowering the threshold for Tier 3 rewards from 400 fish to 201 fish. The new 2015 reward structure thus became $5 each for the first 25 eligible northern pikeminnow, $6 each for 26-200 fish, and $8 for each fish over 200. The 2015 NPSRF also continued to maintain the separate bonus reward for returning northern pikeminnow spaghetti and/or PIT 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 continue to monitor the potential effects of the NPSRF on other Columbia basin fishes.

The objectives of the 2015 NPSRF were to (1) implement a public fishery that rewards recreational anglers for harvesting northern pikeminnow ≥ 228 mm (9 inches) total length, (2) collect, compile, and report data on angler participation, catch and harvest of northern pikeminnow and other fish species, and success 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 fish species.

METHODS OF OPERATION

Fishery Operation

Boundaries and Season

The 2015 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 operating during a regular season extending from May 1 through September 30, 2015.

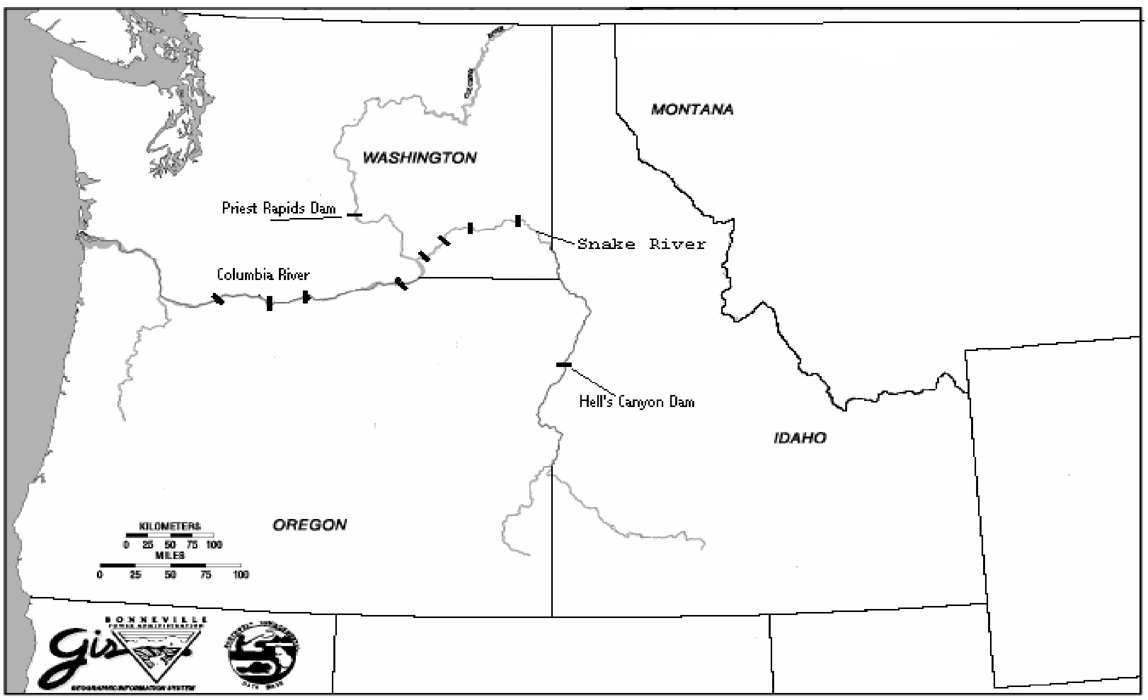


Figure 1. Northern Pikeminnow Sport-Reward Fishery Program Area

Registration Stations

Twenty 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 6.5 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-2:00 pm)
2. Willow Grove Boat Ramp (2:30-5:30 pm)
3. Rainier Marina (9:30am-1:00 pm)
4. Kalama Marina (1:30-5:30 pm)
5. Ridgefield (9:00 am- 12:00 pm)
6. M. James Gleason Boat Ramp (12 pm-5:30 pm)
7. Chinook Landing (9am-11:30am)
8. Washougal Boat Ramp (1 pm- 6 pm)
9. Beacon Rock (9:30am-12:30pm)
10. Cascade Locks Boat Ramp (1pm-5:30 pm)
11. Bingen Marina (9am-12:30pm)
12. The Dalles Boat Basin (9am-3pm)
13. Maryhill (3:30pm-5:30pm)
14. Giles French (1:30pm-5:30 pm)
15. Umatilla Marina (10:00 am-12 pm)
16. Columbia Point Park (2pm-6:30 pm)
17. Vernita Bridge (1:30 pm-5:30 pm)
18. Lyon's Ferry (10:30am-12:30pm)
19. Boyer Park (10:30 am-2 pm)
20. Greenbelt (3:30pm-6:30 pm)

Figure 2. 2015 Northern Pikeminnow Sport Reward Fishery Registration Stations

Reward System

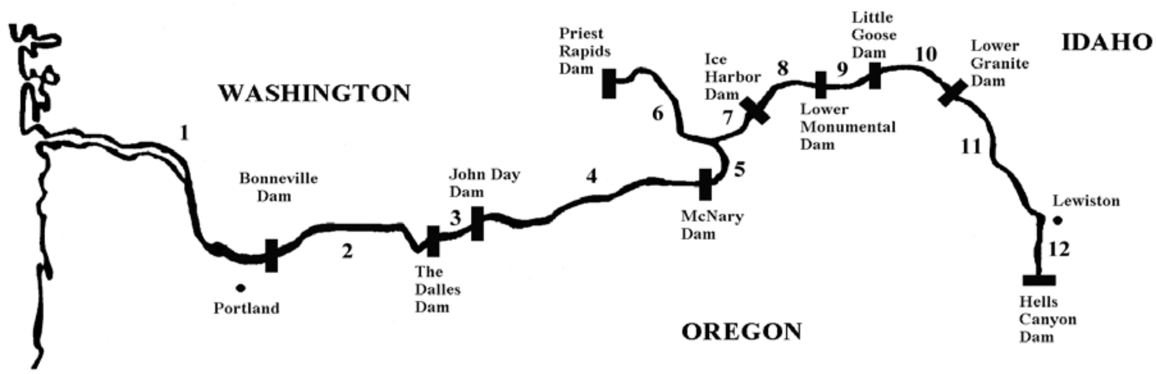
The 2015 NPSRF rewarded anglers for harvesting northern pikeminnow $\geq$ 228mm TL (9 inches) using an updated tiered reward system first implemented in 1995 (Hisata et al. 1996), which paid anglers a higher reward per fish once they had reached designated harvest levels over the course of the season. 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.

The following significant changes were made to the NPSRF's tiered reward system during the 2015 season. The 2015 NPSRF utilized a higher Tier 1 reward of $5 each, up from the $4 Tier 1 pay level used since 2004 (Hone et al. 2005). In addition, for the first time since 1995, tier levels were adjusted downward in hopes of increasing angler effort. Tier 1 was changed to pay anglers $5 each for their first 25 northern pikeminnow (rather than first 100). Tier 2 was changed to pay anglers $6 each for numbers 26-200, and Tier 3 paid anglers $8 each for all fish over 200.

Anglers continued to be paid $500 for each northern pikeminnow which retained a valid spaghetti tag used by ODFW for the biological evaluation of the NPMP. For the second season, 2015 NPSRF anglers continued to be paid $100 for each northern pikeminnow missing a spaghetti tag but still retaining the ODFW PIT tag.

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 2015 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, the number of reward size northern pikeminnow, and the number and species of any other fishes 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 collected again in 2015 per NPSRF protocol (Fox et al. 2000) 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 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 2015 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. 2001). 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 either Destron Fearing portable transceivers (model #FS2001F) or Biomark portable transceivers (model #HPR.PLUS.04V1) 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/or the PIT Tag Information System (PTAGIS) on a regular basis. Data from verified ODFW PIT tags was forwarded to PSMFC so that angler would be paid a $100 bonus reward.

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 2015 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 2015 NPSRF harvested a total of 200,213 reward size northern pikeminnow ($\geq$ 228 mm TL) over the course of a 23 week field season. Harvest was 36,155 fish higher than 2014 harvest (Dunlap et al. 2015), and higher than the mean 1991-2014 harvest of 173,317 fish (Figure 4). The 2015 NPSRF harvest equated to an exploitation rate of 17.2% (Barr, et al. 2016), which was near the upper end of the 10-20% exploitation goal of NPMP. In addition to harvesting 200,213 reward size northern pikeminnow, anglers participating in the 2015 NPSRF also harvested 6,656 northern pikeminnow < 228 mm TL.

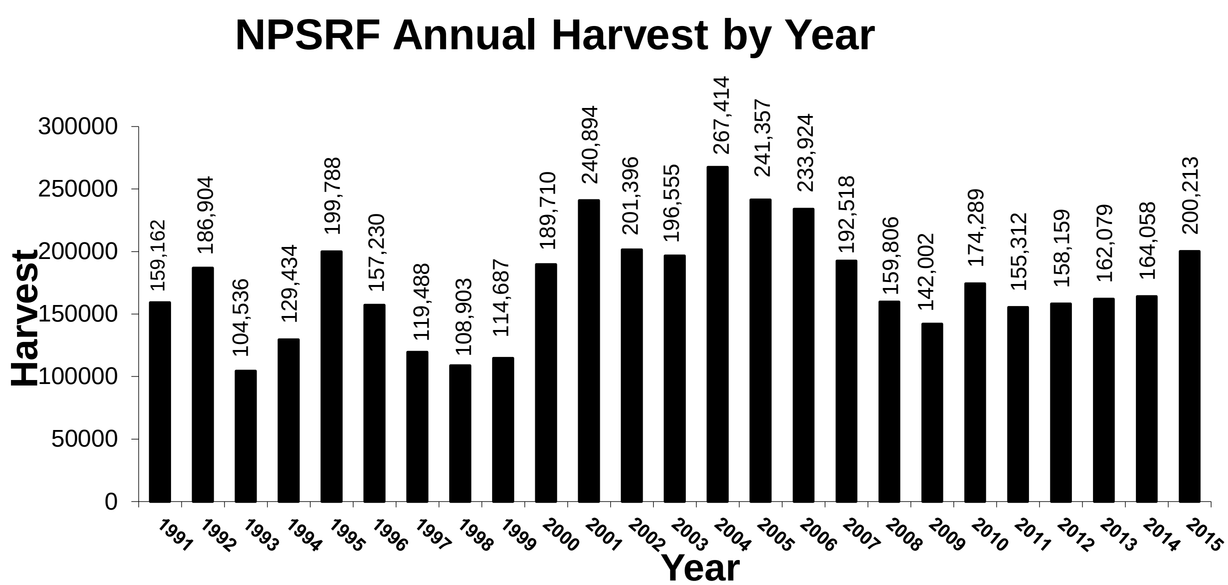


Figure 4. Annual Harvest Totals for the Northern Pikeminnow Sport Reward Fishery

Harvest by Week

Peak weekly harvest was 14,048 fish and occurred in week 22 (Figure 5), four weeks earlier than in 2014 (week 26), and also 28.8% higher than in 2014 (10,905). Weekly harvest in 2015 was above 2014 weekly harvest for all but 3 weeks (Figure 6), and mean weekly harvest was 22% higher in 2015 (8,705) than in 2014 (7,133). Low water conditions in effect during the 2015 NPSRF resulted in higher weekly harvest totals during weeks 18-25 and peak harvest occurred four weeks earlier (week 22) than the NPSRF's historical 1991-2014 peak in week 26 (Fox et al. 2000), but retained the familiar two peak pattern (Figure 7).

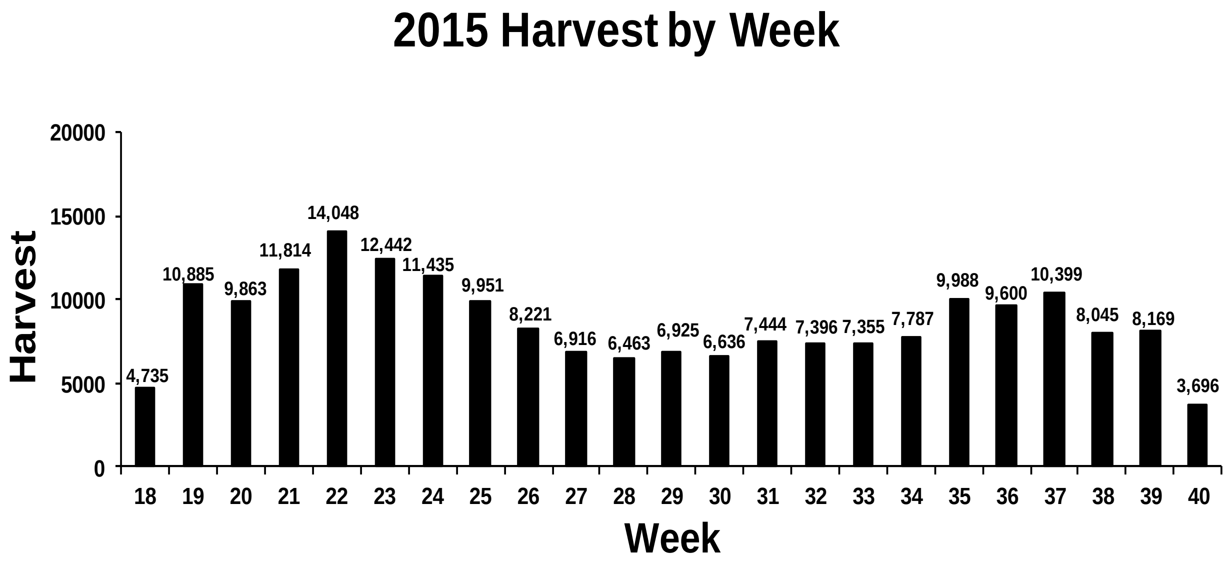


Figure 5. 2015 Weekly Northern Pikeminnow Sport-Reward Fishery Harvest.

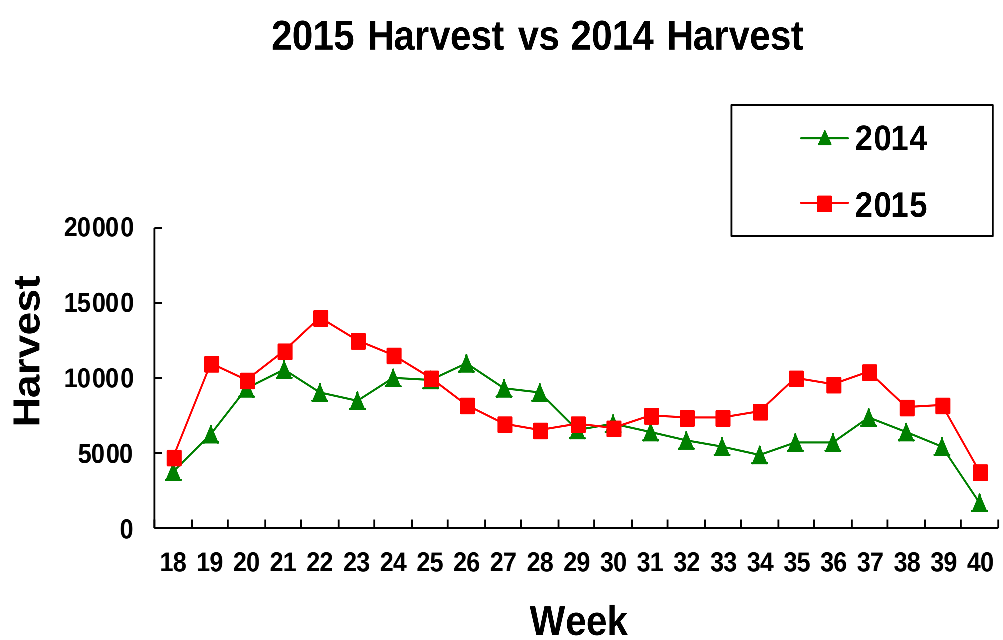


Figure 6. 2015 Weekly NPSRF Harvest vs. 2014 Weekly Harvest.

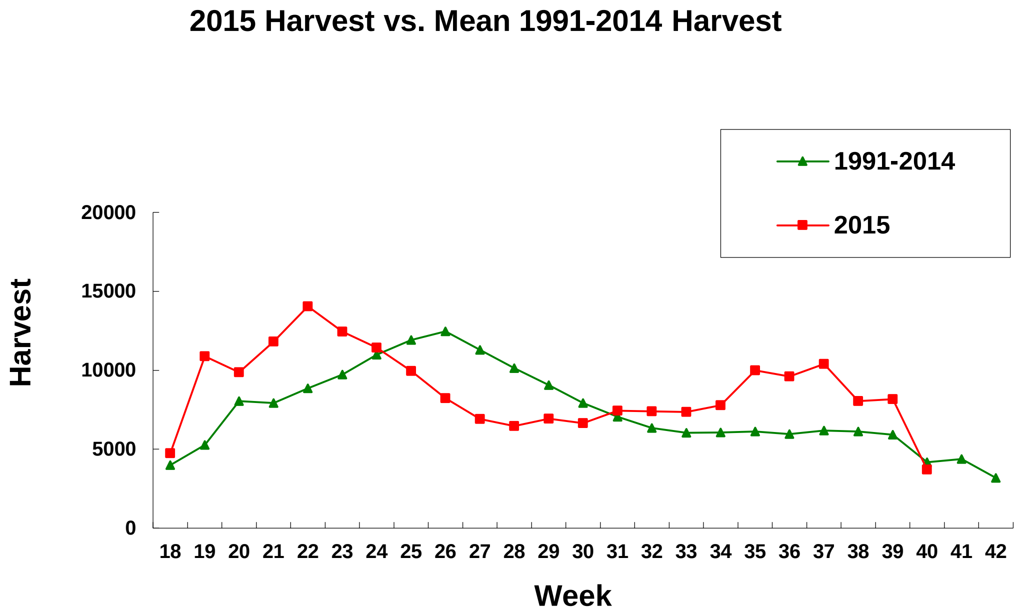


Figure 7. Comparison of 2015 NPSRF Weekly Harvest to 1991-2014 Mean Weekly Harvest.

Harvest by Fishing Location

The mean harvest by fishing location for the 2015 NPSRF was 16,684 northern pikeminnow and ranged from 76,233 reward size northern pikeminnow in fishing location 01 (Below Bonneville Dam) to only 4 northern pikeminnow 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 38% of total NPSRF harvest and has been the highest producing location for all but one season since the NPSRF began system wide implementation in 1991 (Hone et al. 2012). Fishing location 02 (Bonneville Reservoir) accounted for an additional 20% of the total 2015 NPSRF harvest.

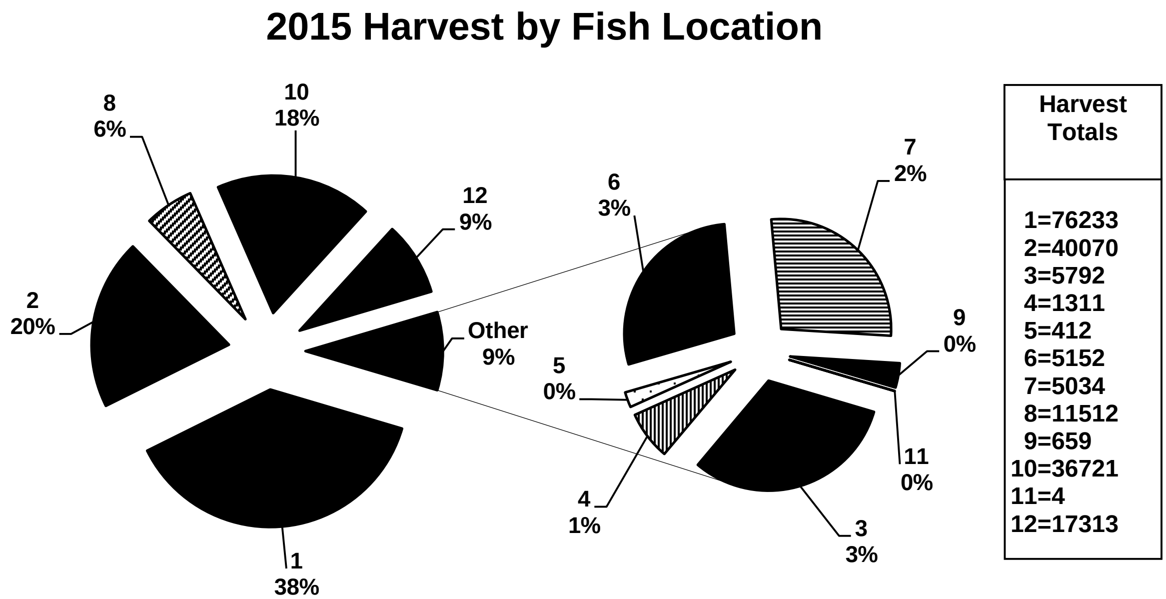


Figure 8. 2015 Northern Pikeminnow Sport-Reward Fishery Harvest by Fishing Location.*
*Fishing Location Codes for Columbia River; 1 = Below Bonneville Dam, 2 = Bonneville Reservoir, 3 = The Dalles Reservoir, 4 = John Day Reservoir, 5 = McNary Dam to the mouth of the Snake River, 6 = Mouth of the Snake 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 2015 was up from 2014 at 14 of the 20 registration stations. The Boyer Park registration station reclaimed the title of the NPSRF's top producing station for the first time since 2010 as anglers harvested 36,037 northern pikeminnow, equaling 18% of total 2015 NPSRF harvest (Figure 9). The Dalles registration station finished with the second highest total of 27,353 northern pikeminnow (13.7%) harvested in 2015. The average harvest per registration station was 10,011 reward size northern pikeminnow, up from 7,812 per station in 2014. The registration station with the smallest harvest was Maryhill where anglers harvested only 281 northern pikeminnow during the 2015 season. The Boyer Park registration station also showed the largest increase in harvest during the 2015 NPSRF with 12,738 more reward size northern pikeminnow turned in than in 2014 (Dunlap et al. 2015).

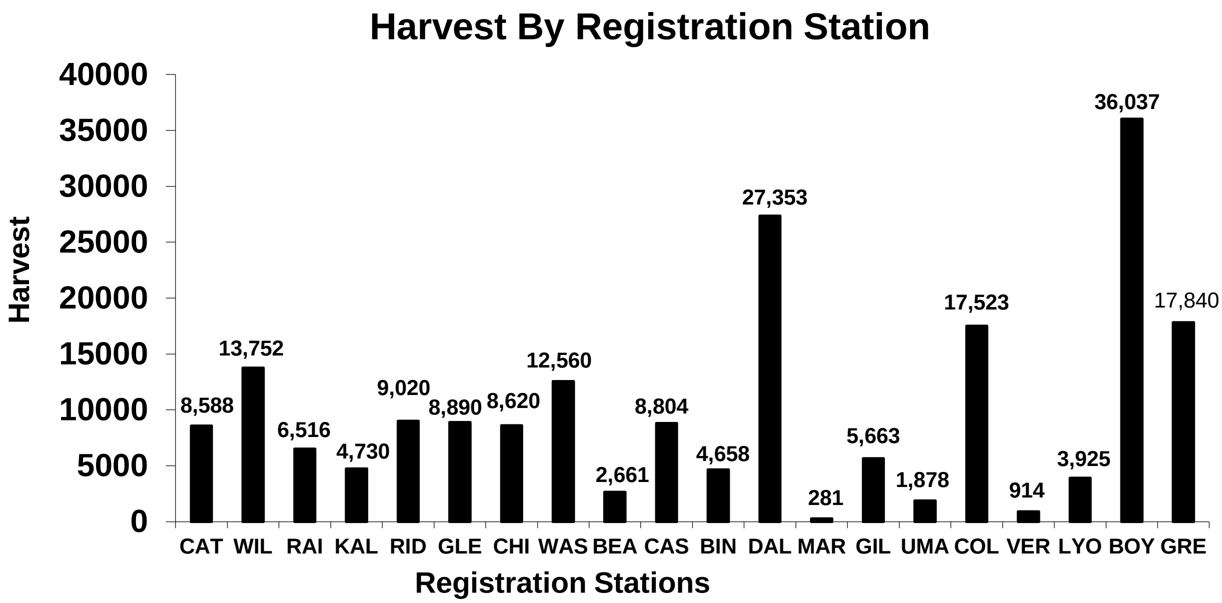


Figure 9. 2015 Northern Pikeminnow Sport-Reward Fishery Harvest by Registration Station. CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, POR-Portco, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL- The Dalles, MAR-Maryhill, GIL-Giles, 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 catching northern pikeminnow, returning anglers participating in the 2015 NPSRF also 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 2015.

Salmon

Species	Caught	Harvest	Harvest Percent
Steelhead Juvenile (Hatchery)	236	0	0%
Steelhead Juvenile (Wild)	94	0	0%
Chinook(Juvenile)	91	0	0%
Trout(Unknown)	52	5	9.62%
Steelhead Adult (Hatchery)	25	11	44%
Chinook (Adult)	24	12	50%
Cutthroat(Unknown)	21	1	4.76%
Chinook (Jack)	16	3	18.75%
Steelhead Adult (Wild)	9	0	0%
Coho(Adult)	1	0	0%
Coho(Juvenile)	1	0	0%

Anglers reported that all juvenile salmonids caught during the 2015 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 2015 NPSRF, but were only retained during legal salmonid fisheries. Past investigation has shown that instances where NPSRF anglers reported harvesting “trout” from the Snake River during a legal fishery were typically residualized hatchery steelhead smolts which are caught and kept by anglers and identified as “trout”. NPSRF protocol for anglers who report illegally harvesting salmonids during the exit interview (whether juvenile or adult salmonids), is for that information to be forwarded to the appropriate enforcement entity for action.

Other fish species incidentally caught by returning NPSRF anglers targeting northern pikeminnow were most often peamouth, smallmouth bass, yellow perch, sculpin, white sturgeon, channel catfish, and suckers (Table 2).

Table 2. Catch and Harvest of Non-Salmonids by Returning Anglers Targeting Northern Pikeminnow in 2015.

Non-Salmonid Species	Caught	Harvest	Harvest Percent
Northern Pikeminnow >228mm	200,217	200,213	99.99%
Northern Pikeminnow <228mm	57,493	6,656	11.58%
Peamouth	24,700	10,893	44.10%
Smallmouth Bass	18,965	1,441	7.60%
Yellow Perch	7,431	1,310	17.63%
Sculpin (unknown)	7,421	5,028	67.75%
White Sturgeon	2,721	1	.04%
Channel Catfish	2,508	390	15.55%
Sucker (unknown)	1,254	169	13.48%
Walleye	861	352	40.88%
Catfish (unknown)	401	62	15.46%
Bullhead (unknown)	381	85	22.31%
Starry Flounder	313	36	11.50%
Chiselmouth	291	32	11.0%
Bluegill	288	6	2.08%
Crappie (unknown)	249	38	15.26%
Carp	230	13	5.65%
American Shad	227	15	6.61%
Largemouth Bass	109	1	.92%
Pumpkinseed	68	3	4.41%
Whitefish	6	1	16.67%
Redside Shiner	5	0	0%
Sandroller	3	0	0%

Non-returning Anglers Catch and Harvest Estimates

As in past years, we conducted telephone interviews to randomly survey participants at each of the NPSRF's 20 stations in order to survey and record their catch and/or harvest of reward sized northern pikeminnow and other incidental species. In 2015, a total of 1,532 non-returning anglers (22.97% of all non-returning anglers) were called. 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 2015 NPSRF. A simple estimator was applied to the catch and harvest totals obtained from the surveyed anglers to obtain estimated for Total Catch and Total Harvest for all non-returning anglers participating in the 2015 NPSRF. Estimated totals are listed in columns 5 and 6 of Table 3.

Table 3. 2015 NPSRF Non-returning Angler Phone Survey Results with Total Catch & Harvest estimates.

Species	Caught	Harvest	%Harvested	Estimated Total Catch	Estimated Total Harvest
Northern Pikeminnow ≥ 228 mm	148	104	70.3%	644	453
Northern Pikeminnow <228 mm	528	120	22.7%	2298	522
Smallmouth Bass	948	66	7.0%	4127	287
Peamouth	392	103	26.3%	1706	448
Yellow Perch	193	26	13.5%	840	113
White Sturgeon	170	1	0.6%	740	4
Sculpin	166	25	15.1%	723	109
Sucker (unknown)	69	31	44.9%	300	135
Catfish (unknown)	56	1	1.8%	244	4
Channel Catfish	49	9	18.4%	213	39
Walleye	40	23	57.5%	174	100
Starry Flounder	32	0	0%	139	0
Bluegill	31	5	16.1%	135	22
Bullhead (unknown)	27	1	3.7%	118	4
Crappie	19	3	15.8%	83	13
Chiselmouth	11	7	63.6%	48	30
Chinook Salmon (adult)	11	4	36.4%	48	17
Trout (unknown)	11	4	36.4%	48	17
Chinook Salmon (juvenile)	10	0	0%	44	0
Steelhead (adult)	10	5	50%	44	22
Carp	10	2	20%	44	9
Steelhead (juvenile)	4	0	0%	17	0
Largemouth Bass	3	0	0%	13	0
Sockeye Salmon (adult)	2	2	100%	9	9
American Shad	2	1	50%	9	4
Mountain Whitefish	2	0	0%	9	0
Sunfish (unknown)	2	0	0%	9	0
Pumpkinseed	1	0	0%	4	0

N=6,669 n=1,532

Fork Length Data

The length frequency distribution for harvested northern pikeminnow (≥ 200 mm) from the 2015 NPSRF is presented in Figure 10. Fork length data from a total of 116,895 northern pikeminnow (58.4% of total harvest) were taken during the 2015 NPSRF. The mean fork length for all measured northern pikeminnow (≥ 200 mm) in 2015 was 277.91 mm (SD= 62.9 mm), up from 274.8 in 2014.

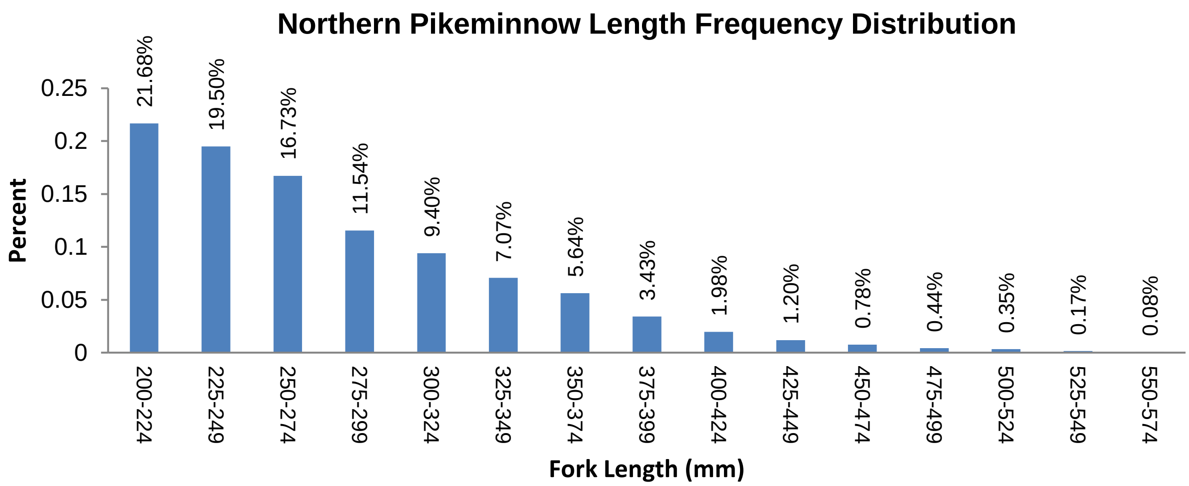


Figure 10. Length frequency distribution of northern pikeminnow ≥ 200 mm FL from 2015 NPSRF.

Angler Effort

The 2015 NPSRF recorded total effort of 24,040 angler days spent during the season, an increase of 4,532 angler days from the previous year (Dunlap et al. 2015) (Figure 11). When total effort is divided into returning and non-returning angler days, 17,371 angler days (72%) were recorded by returning anglers, and 6,669 were non-returns. The percentage of returning anglers in 2015 was the same as during the 2014 NPSRF. In addition, 60.9% of total effort, and 84.2% of returning angler effort (14,635 angler days), was attributed to successful anglers who harvested at least 1 northern pikeminnow in 2015.

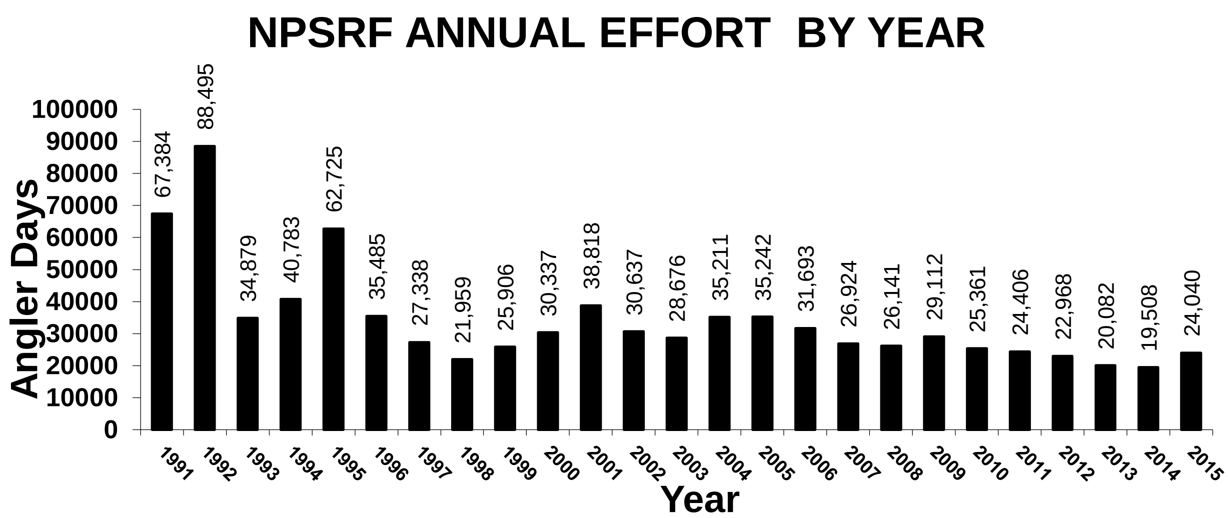


Figure 11. Annual Northern Pikeminnow Sport-Reward Fishery Effort.

Effort by Week

Mean weekly effort for the 2015 NPSRF was 1,045 angler days during the season, with the peak occurring in week 22 during the fifth week of the season (Figure 12). When we compare weekly effort totals for 2015 with last season, weekly effort totals from all but 2 weeks exceeded those of 2014 (Figure 12). Peak weekly effort in 2015 once again occurred on the same week as peak harvest (week 22) (Figure 13) and overall mean weekly effort increased from 848 in 2014 to 1,045 in 2015 (Dunlap et al. 2015). Weekly effort totals for the 2015 NPSRF were lower than historical 1991-2014 effort levels, but generally followed the same seasonal pattern (Figure 14).

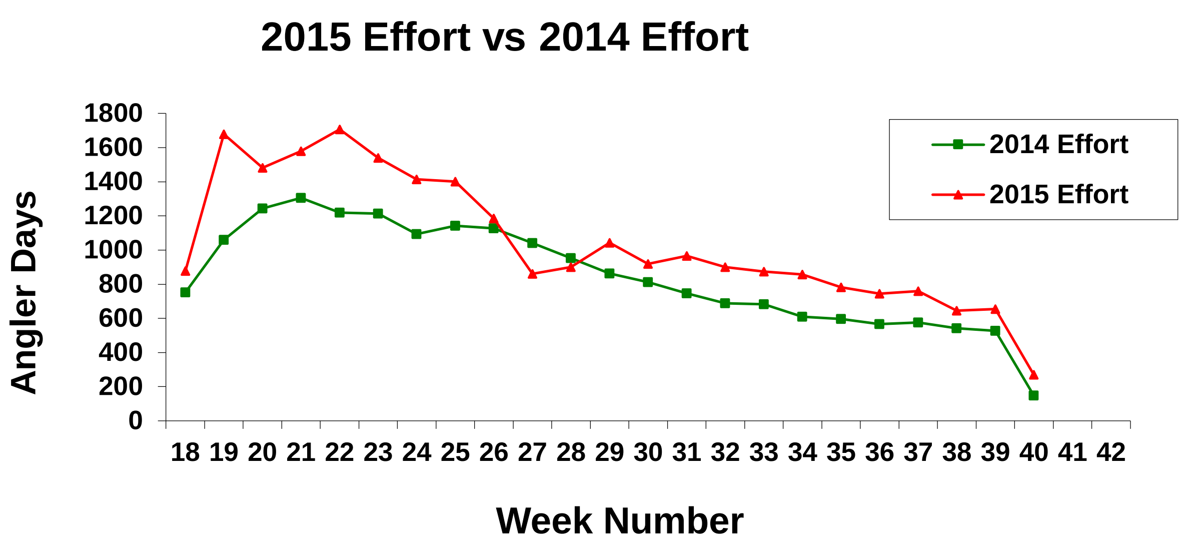


Figure 12. 2015 Northern Pikeminnow Sport-Reward Fishery Effort vs 2014 Effort.

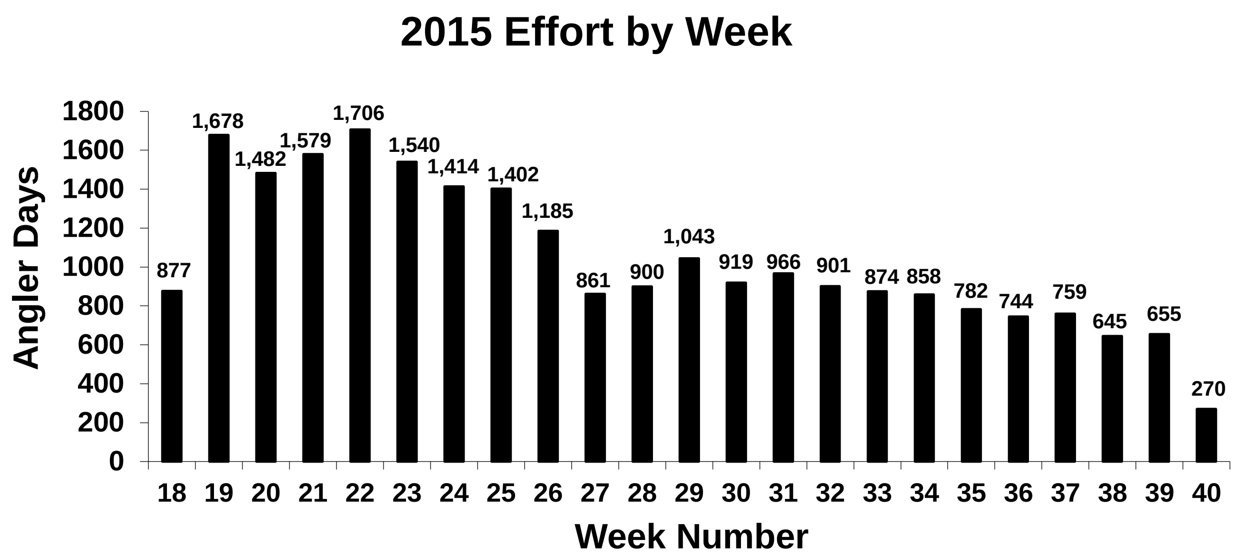


Figure 13. 2015 Weekly Northern Pikeminnow Sport-Reward Fishery Effort.

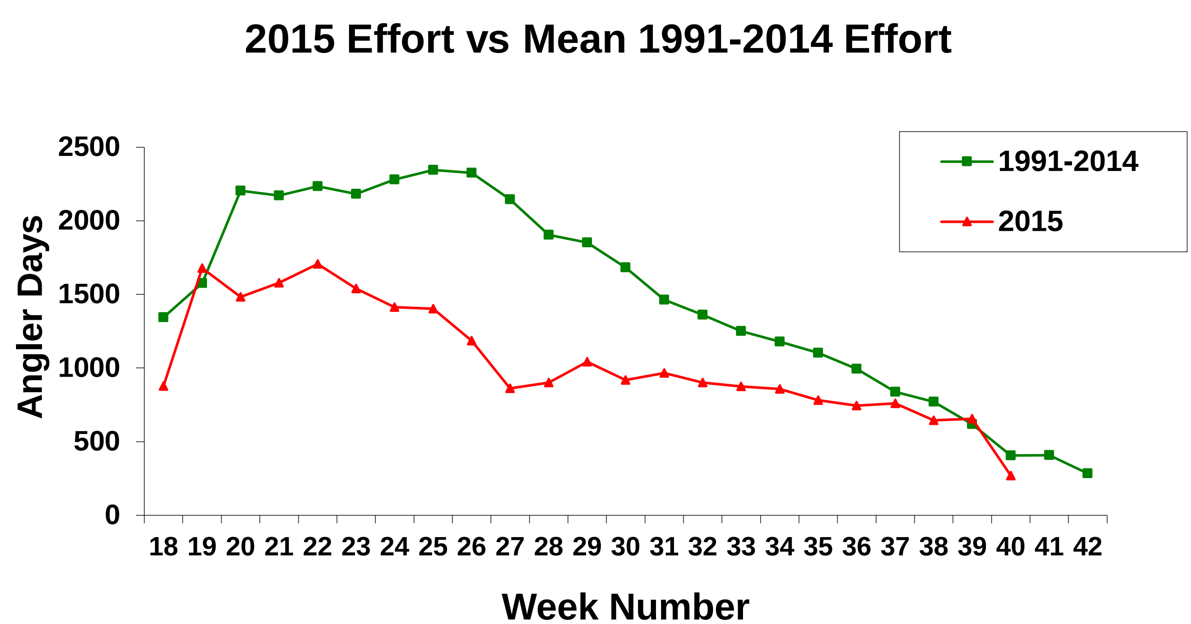


Figure 14. 2015 NPSRF Weekly Effort vs. Mean 1991-2014 Effort.

Effort by Fishing Location

Mean annual effort by fishing location for the 2015 NPSRF (returning anglers only) increased by 24% from 1,164 angler days in 2014 to 1,448 angler days in 2015. Effort totals ranged from 7,017 angler days spent in fishing location 01 (below Bonneville dam) to only 8 angler days spent in fishing location 11 on the Snake River (Lower Granite Dam to the mouth of the Clearwater River) (Figure 15). Effort increased 49.7% below Bonneville Dam (fishing location 01) from 4,686 angler days recorded in 2014 to 7,017 in 2015 and increased at nine of the twelve NPSRF fishing locations.

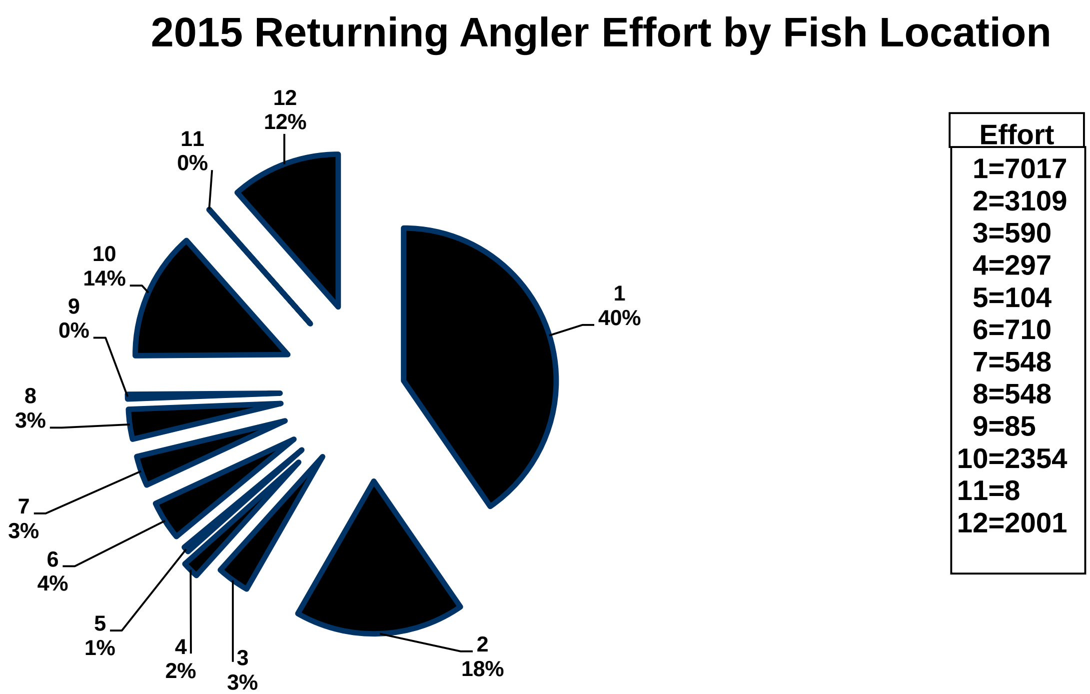


Figure 15. 2015 NPSRF Angler Effort by Fishing Location (returning anglers only).*

*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 2015 NPSRF was 1,202 angler days compared to 929 angler days in 2014. Effort totals ranged from 2,718 angler days at The Dalles station to 76 angler days at the Maryhill station (Figure 16). Effort during the 2015 NPSRF increased at fifteen of the twenty registration stations and decreased at five stations, most notably at The Dalles station where effort decreased 653 angler days from 2014.

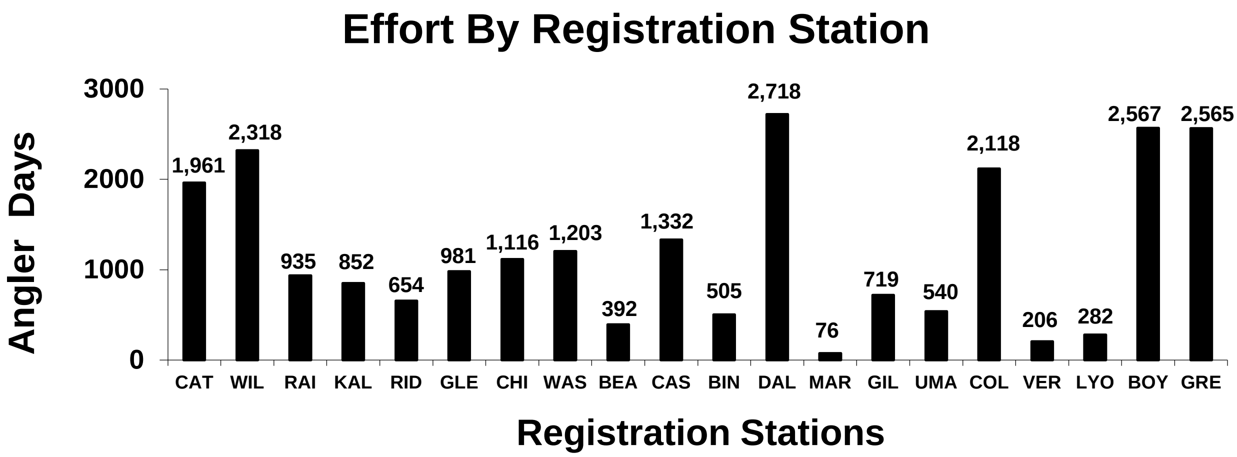


Figure 16. 2015 Northern Pikeminnow Sport-Reward Fishery Angler Effort by Registration Station. CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, POR-Portco, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, MAR-Maryhill, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Catch Per Angler Day (CPUE)

The 2015 NPSRF recorded an overall (returning + non-returning anglers) catch per unit of effort (CPUE) of 8.33 northern pikeminnow harvested per angler day during the season. This catch rate was the NPSRF's second highest to date (8.41 CPUE in 2014) (Dunlap et al. 2015) (Figure 17). Angler CPUE has increased steadily throughout the NPSRF's 25 year history although there was a slight downturn in CPUE in 2015 as a result of an increase in angler effort and in an influx of new anglers. Returning angler CPUE during the 2015 NPSRF was 11.53 northern pikeminnow per angler day, down from the 2014 CPUE of 11.74. We estimate that CPUE for non-returning anglers is 0.10 reward size northern pikeminnow per angler day based on 2015 NPSRF phone survey results.

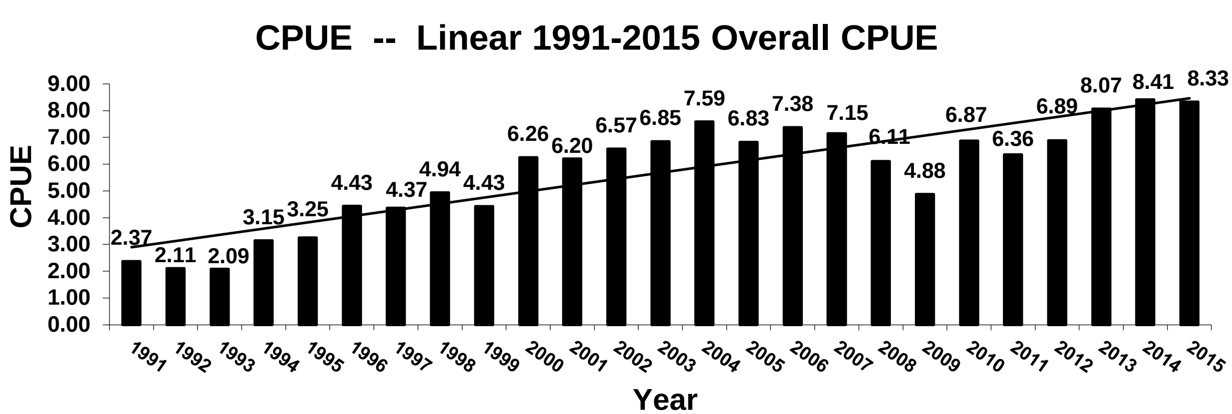


Figure 17. Annual NPSRF CPUE (returning + non-returning anglers) for the years 1991-2015.

CPUE by Week

Mean angler CPUE by week for the 2015 NPSRF was 8.91 fish per angler day compared to 8.72 in 2014. CPUE ranged from 5.4 in week 18 (May 1-May 3) to a peak of 13.7 in week 37 (September 7-September 13) (Figure 18). As has historically been the case, weekly CPUE for the 2015 NPSRF followed a two peak pattern where catch rates spike upward near peak harvest (week 22) and then again late in the season (Winther et al. 2011).

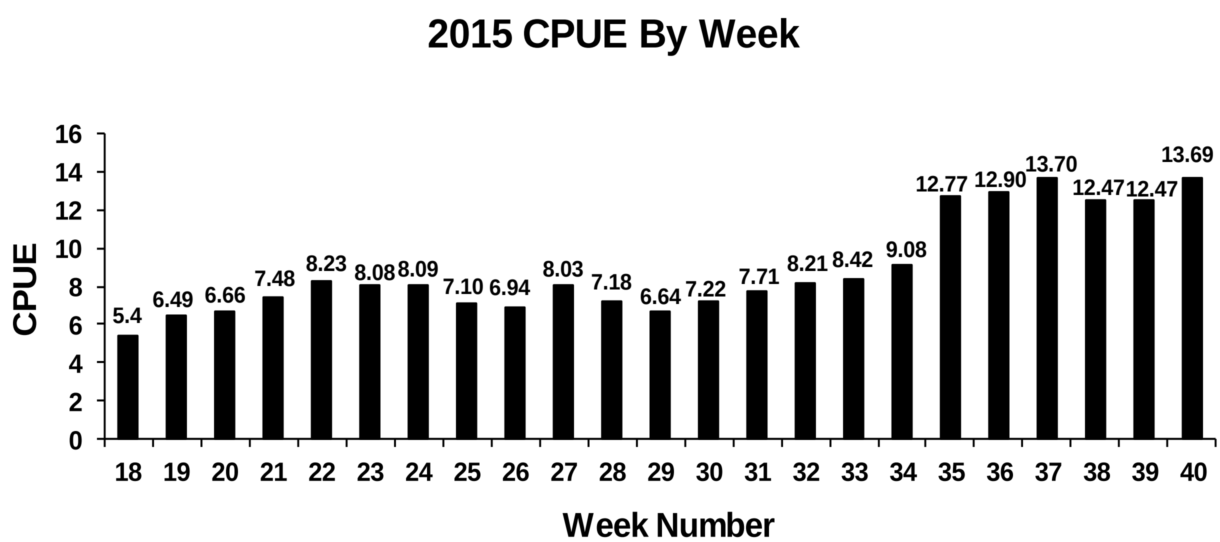


Figure 18. 2015 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Week.

CPUE by Fishing Location

Angler success rates for the 2015 NPSRF, as indicated by CPUE, are available for returning anglers only and varied by fishing location. Success rates ranged from a high of 21.01 fish per angler day in fishing location 08 (Ice Harbor Reservoir) to 0.5 fish per angler per day in fishing location 11 (Lower Granite Dam to the mouth of the Clearwater River) (Figure 19). Catch rates were down from 2014 at all but three of the twelve fishing locations. Locations 02, 08, and 10 were the only locations with an increase in CPUE. The average CPUE by fishing location was 9.33 northern pikeminnow per angler day in 2015 compared to 10.94 in 2014.

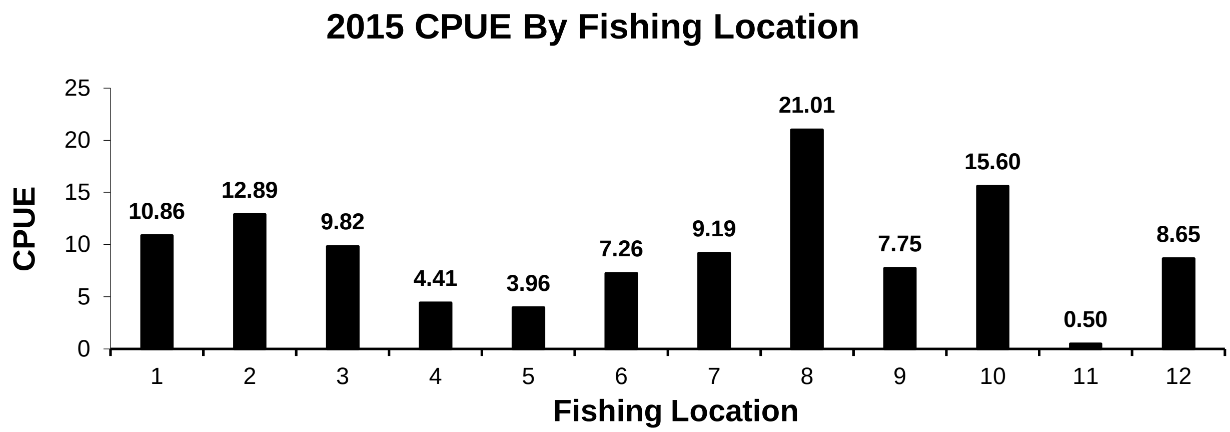


Figure 19. 2015 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Fishing Location.*
*Fishing Location Codes for Columbia River; 1 = Below Bonneville Dam, 2 = Bonneville Reservoir, 3 = The Dalles Reservoir, 4 = John Day Reservoir, 5 = McNary Dam to the mouth of the Snake River, 6 = Mouth of the 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 2015 NPSRF was the Boyer Park station where anglers averaged 14.04 northern pikeminnow per angler day (Figure 20). The registration station with the lowest CPUE was the Maryhill station with a CPUE of 3.7 northern pikeminnow per angler day. The station average for angler CPUE was 8.33, down from 8.47 in 2014. Angler CPUE by registration station increased at ten stations during the 2015 NPSRF. The largest increase in CPUE occurred at Washougal where the 2014 CPUE of 4.92 more than doubled to 9.06 in 2015.

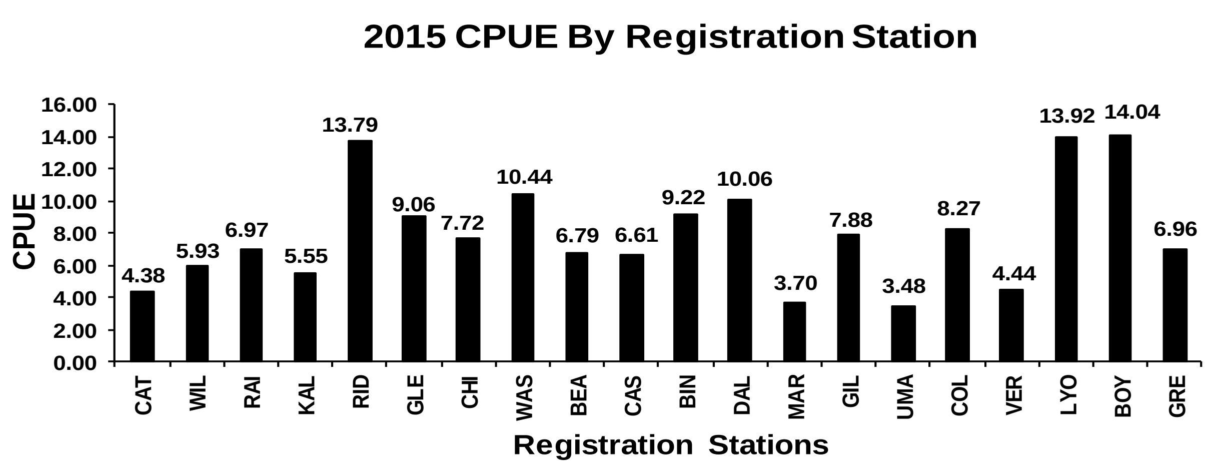


Figure 20. 2015 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Registration Station.
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, POR-Portco, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, MAR-Maryhill, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Angler Totals

There were 3,210 separate anglers who participated in the 2015 NPSRF, an increase of 15.8% (437 participants) from 2014 (Dunlap et al. 2015). One thousand, three hundred and eighty-eight of these anglers (43.2% of total vs. 42% in 2014) were classified as successful since they harvested at least one reward size northern pikeminnow (for which a voucher was issued) during the 2015 season. Of the successful anglers, 75.1% (1,043 anglers) sent in their vouchers to PSMFC for payment (PSMFC 12/10/15 Angler Payment Summary) while 345 anglers (24.9%) did not. The average successful angler harvested 144 northern pikeminnow during the 2015 NPSRF compared to 141 in 2014. When we break down the 1,388 successful anglers by tier, 986 anglers (71.04%) harvested fewer than 25 northern pikeminnow and were classified as Tier 1 anglers (Figure 21). With the updated angler reward system used in 2015, the percentage of Tier 1 anglers contracted from 84% of successful anglers to 71% of successful anglers despite the fact that the number of individual anglers changed very little (from 977 anglers in 2014 to 986 anglers in 2015). At the same time, the percentage of Tier 2 anglers more than doubled from 8.2% in 2014 to 17% of total anglers in 2015. Likewise, the percentage of Tier 3 anglers (known as "highliners") increased from 7.8% in 2014 to 12% in 2015. This increase in the percentage of anglers at tiers 2 and 3 is important to achieving NPSRF harvest and exploitation objectives because under the new 2015 reward structure, Tier 1 anglers (who catch less fish) make up a smaller percentage of the overall successful angler population. This means that Tier 2 and Tier 3 anglers (who are much more proficient at harvesting northern pikeminnow), comprise a larger percentage of the NPSRF's overall successful angler population.

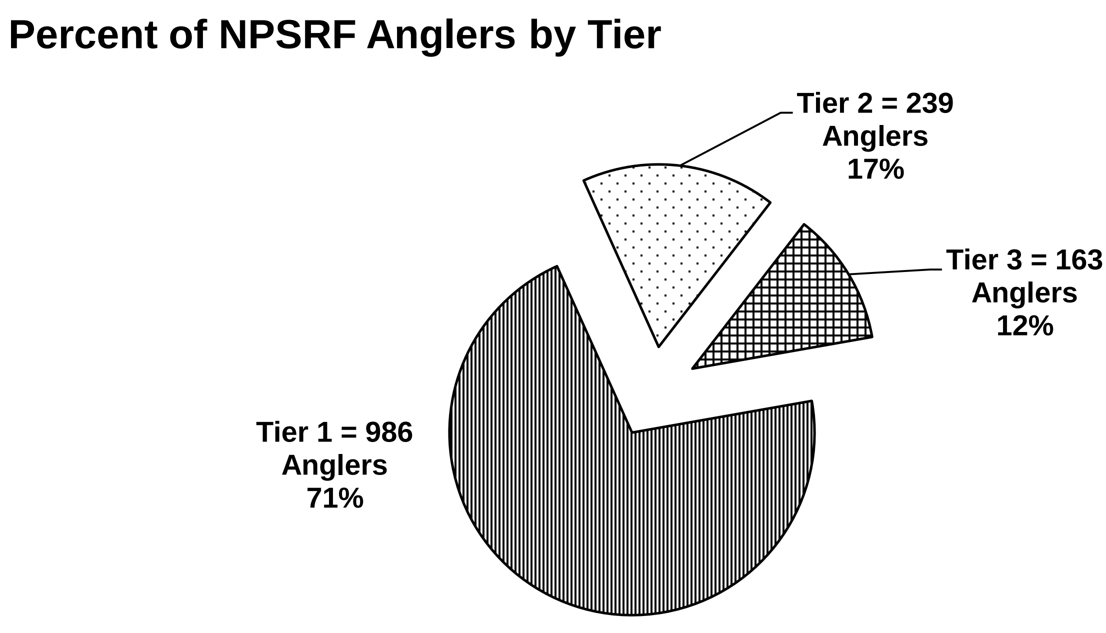


Figure 21. 2015 NPSRF Anglers by Tier (returning only) Based on Total # of Fish Harvested.

While Tier 1 anglers made up 71% of all successful NPSRF participants in 2015, they accounted for only 2.7% of total NPSRF harvest (5,345 northern pikeminnow) (Figure 22). The 239 Tier 2 anglers caught 8.6% of total harvest (17,259 fish), while 88.7% of total harvest (177,609 fish) was caught by the 163 anglers who reached Tier 3. Tier 3 anglers represented 5.1% of all participants (both returning and non-returning anglers), and 12% of successful anglers participating in the 2015 NPSRF. Average annual harvest for Tier 1 anglers was 5.4 fish, while Tier 2 anglers harvested an average of 72.2 fish per Tier 2 angler, per year. Tier 3 anglers averaged 1,090 fish per angler, per year, compared to 1,485 fish per year in 2014 (Dunlap et al. 2015).

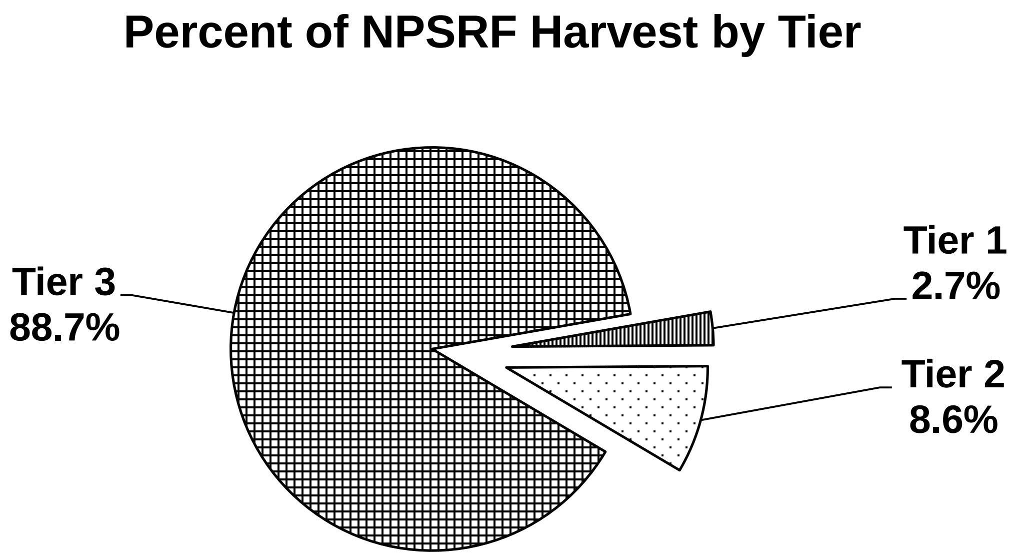


Figure 22. 2015 NPSRF Harvest by Angler Tier (Tier 1 = <u><</u>25, Tier 2 =26-200, Tier 3 = > 200).

The overall average NPSRF participant (returning + non-returning anglers) expended slightly more effort pursuing northern pikeminnow during the 2015 season than in 2014 (7.49 vs. 7.04 angling days of effort). When we look at successful anglers only, the average successful angler increased their average annual effort spent to 10.54 angler days during the 2015 NPSRF compared to 10.12 days in 2014 (Dunlap et al. 2015). When we break it down by tier, average annual effort declined at all three tier levels in 2015. Tier 3 anglers spent an average of 69 days fishing (down from 83 days in 2014), Tier 2 anglers spent an average of 22 days fishing (down from 35 days in 2014), and Tier 1 anglers spent an average of only 5 days fishing (down from 6 days in 2014). (Figure 23). Keep in mind that the 2015 effort totals reflect expanded numbers of anglers for all three tiers levels after the tiers were adjusted downward in 2015. If we were to calculate average effort using the old tier levels in effect from 1994-2014 (Tier 1 = 1-100, Tier 2 = 101-400, and Tier 3 = > 400), we would see that average effort actually increased for Tier 1 anglers from 6 days 6.8 days, and for Tier 2 anglers from 35 days to 41.6 days, while only slightly decreasing from 83 days to 81 days for Tier 3 anglers.

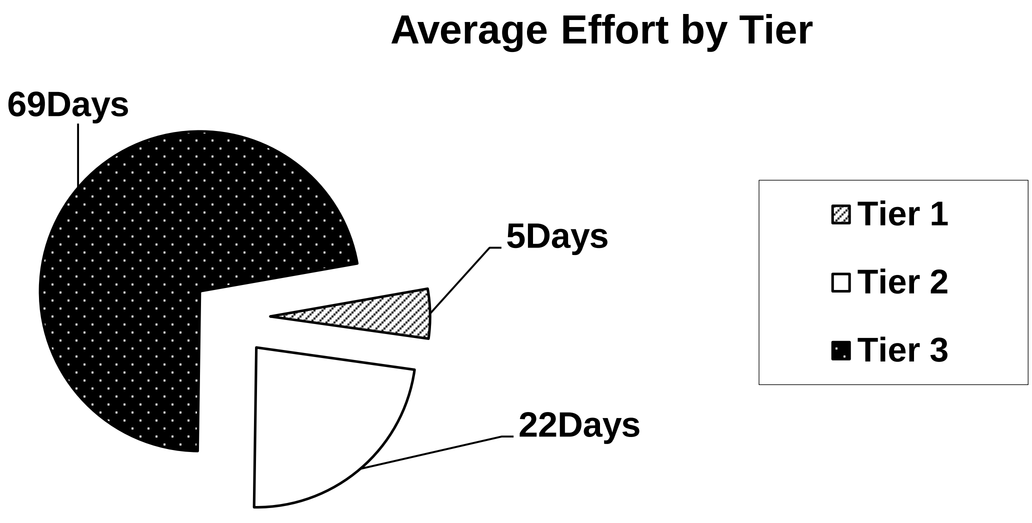


Figure 23. Average Effort of 2015 NPSRF Anglers by Tier (Tier 1 = $\leq$ 25, Tier 2 = 26-200, Tier 3 = > 200) .

Overall angler CPUE for the 2015 NPSRF decreased slightly from 2014 (Dunlap et al. 2015) and CPUE at all three tier levels decreased as well. CPUE for anglers at Tier 1 decreased from 1.76 in 2014 to 1.14 in 2015 (Figure 23). CPUE for Tier 2 anglers decreased from 5.45 in 2014 to 3.33 in 2015, and CPUE for Tier 3 anglers decreased from 17.91 in 2014 to 15.72 in 2015. Keep in mind that the 2015 CPUE totals reflect expanded numbers of anglers for all three tiers levels after the tiers were adjusted downward in 2015. If we were to calculate CPUE using the old tier levels in effect from 1994-2014 (Tier 1 = 1-100, Tier 2 = 101-400, and Tier 3 = > 400), we would see that CPUE actually increased for Tier 1 anglers from 1.76 to 1.9 and from 17.91 to 19.31 for Tier 3 anglers.

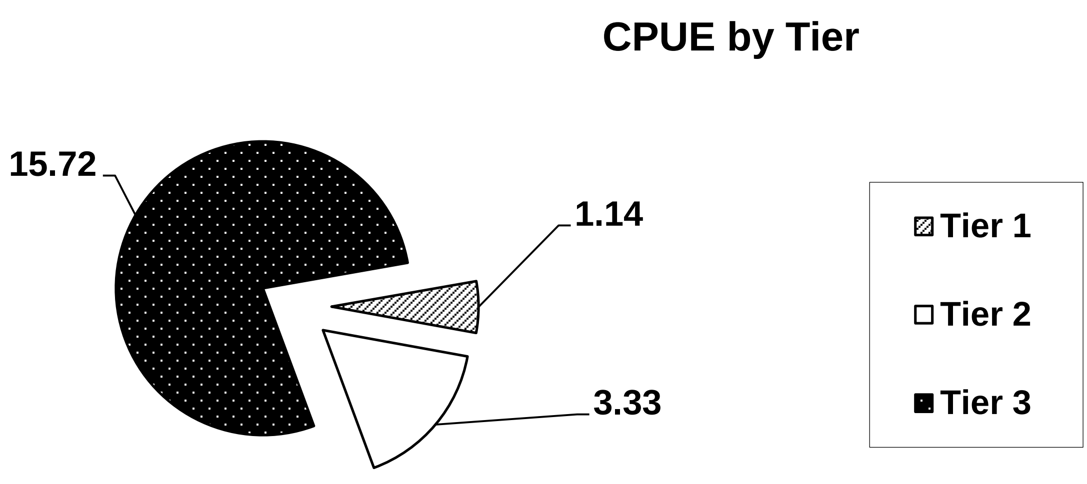


Figure 24. Average CPUE of 2015 NPSRF Anglers by Tier (Tier 1 = $\leq$25, Tier 2 =26-200, Tier 3 = > 200).

The top individual angler (based on number of fish caught) for the 2015 NPSRF harvested a record number (12,053) of northern pikeminnow which included 7 spaghetti tagged northern pikeminnow, and 10 “tag loss” northern pikeminnow worth a total earnings record of $100,453 (PSMFC 12/10/2015 Angler Reward Payment Summary). The 2015 top angler caught 2,939 more fish than he did as the top angler in 2014 and more than doubled the harvest of the 2015 second place angler. The CPUE for this year’s top angler (103.9 fish per angler day) was down from what he had as the top angler in 2014 (109.8 fish per angler day). The top angler for the 2015 season spent 33 more days of effort (116 days) than he did in 2014 as the top angler when he fished only 83 days. By comparison, the top angler in terms of participation (rather than harvest) for the 2015 NPSRF fished 145 days and harvested 2,493 northern pikeminnow.

Tag Recovery

Northern Pikeminnow Tags

Returning anglers harvested 196 northern pikeminnow tagged by ODFW with external spaghetti tags during the 2015 NPSRF compared to 172 spaghetti tags harvested in 2014 (Dunlap et al., 2015). Tag recoveries peaked in week 23 (as in 2013), one week later than peak NPSRF harvest (Figure 24). All of the 196 spaghetti tagged northern pikeminnow also retained PIT tags added by ODFW as a secondary mark. WDFW technicians also recovered an additional 161 northern pikeminnow which had ODFW PIT tags with wounds and/or scars 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 17.2% exploitation rate for the 2015 NPSRF (Barr et al. 2016).

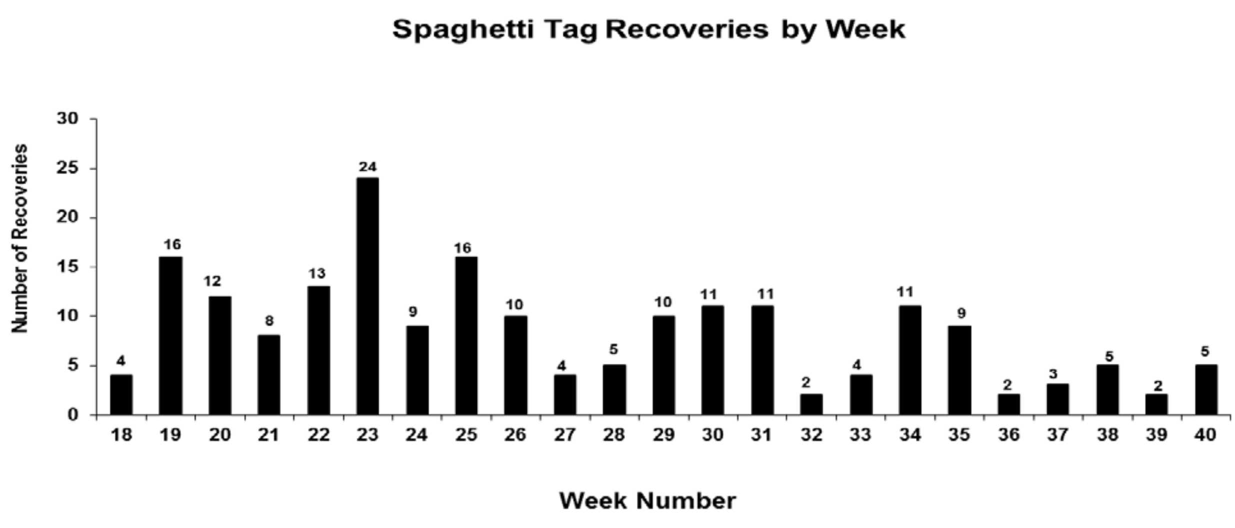


Figure 24. 2015 NPSRF Spaghetti Tag Recoveries by Week.

Ingested PIT Tags

A total of 200,213 northern pikeminnow were individually scanned for the presence of PIT tags. This represents 100% of the total harvest of reward-size fish for the 2015 NPSRF (northern pikeminnow not qualifying for rewards were also scanned whenever possible). Technicians recovered a total of 154 PIT tags from consumed smolts that had been ingested by northern pikeminnow harvested during the 2015 NPSRF, an overall occurrence ratio of 1:1,300 compared to 1:3,095 in 2014. Total ingested PIT tag recoveries in 2015 were 101 recoveries higher than the previous year. Even though the total harvest was much higher in 2015 than in 2014, the rate of occurrence for ingested PIT tags more than doubled (1:1,300 in 2015 versus 1:3,095 in 2014) (Dunlap et al., 2015). PIT tag recoveries of salmonid smolts ingested by northern pikeminnow peaked during week 21 of the season (where 33 ingested smolts were recovered) and our last recovery occurred during week 27 in early July (Figure 25).

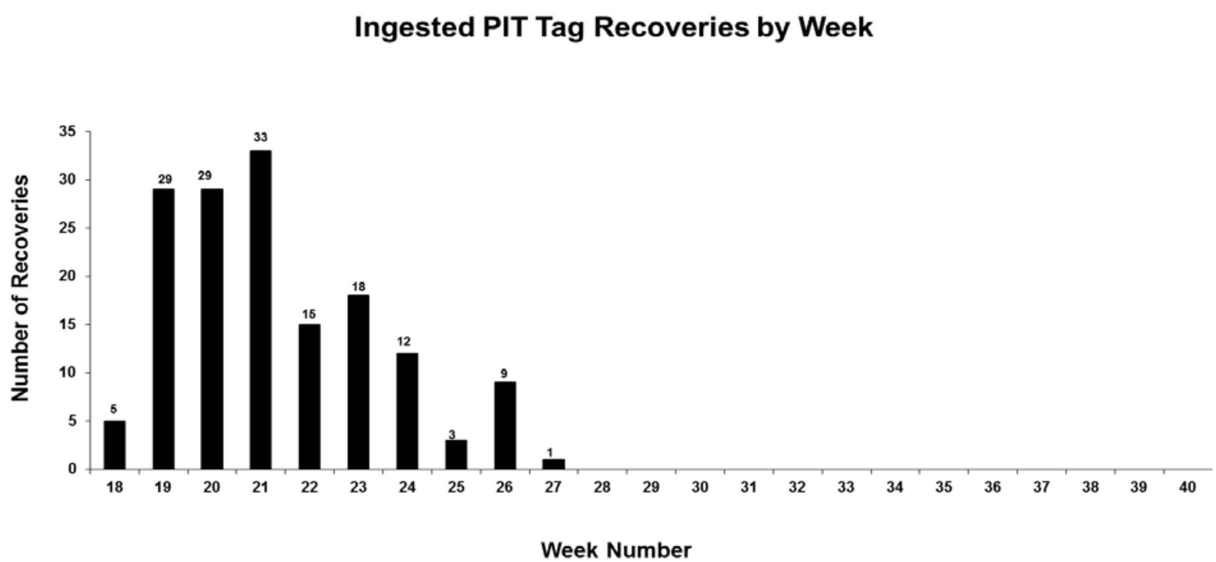


Figure 25. 2015 NPSRF Ingested PIT Tag Recoveries by Week.

PIT tag recoveries by fishing location during the 2015 NPSRF showed that northern pikeminnow harvested from Fishing locations 02 (Bonneville Reservoir) had ingested the largest number of salmonid smolts containing PIT tags (Figure 26).

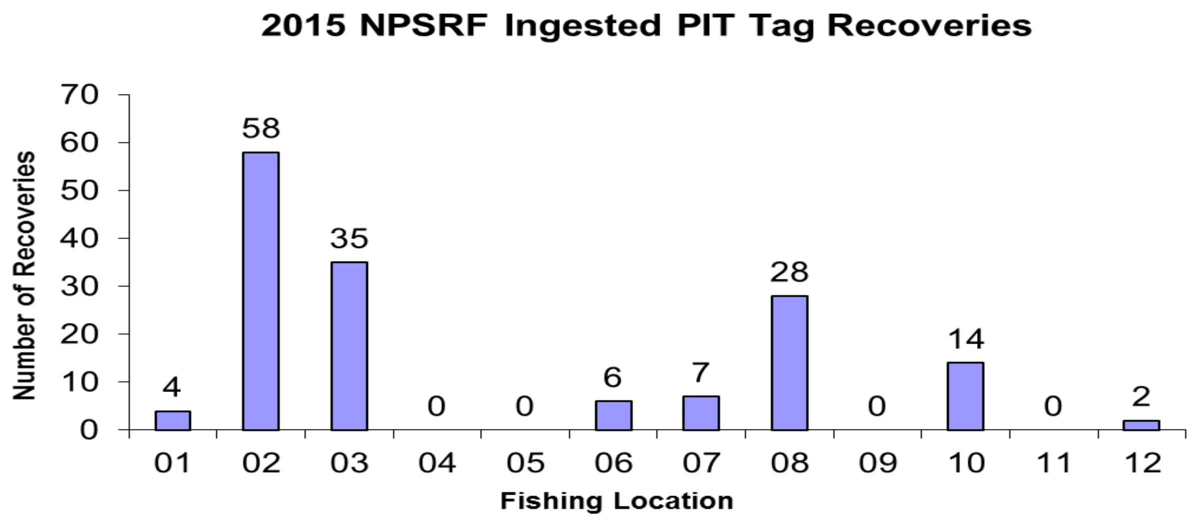


Figure 26. 2015 NPSRF ingested PIT Tag Recoveries by Fishing Location.
*Columbia River Fishing Location Codes; 1 = Below Bonneville Dam, 2 = Bonneville Reservoir, 3 = The Dalles Reservoir, 4 = John Day Reservoir, 5 = McNary Dam to the mouth of the Snake River, 6 = Mouth of the Snake River to Priest Rapids Dam. Snake River Fishing Location Codes; 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 2015 NPSRF) was obtained from PTAGIS and indicated that one hundred twenty-eight (83%) of the 154 ingested PIT tag recoveries were from chinook smolts (Figure 27). Most of the chinook PIT tags were of hatchery origin and PTAGIS queries revealed that the 128 PIT tag recoveries from chinook smolts consisted of 62 spring chinook, 34 fall chinook, 29 summer chinook, and 3 unknown wild origin chinook. PIT tag queries revealed that the other 26 PIT tags were from 16 sockeye, 5 steelhead, and 5 coho. PTAGIS also indicated that 23 of the 154 recovered PIT tags (15%) were from salmonids of wild origin, including 18 of the chinook, 2 of the sockeye, and 3 of the steelhead.

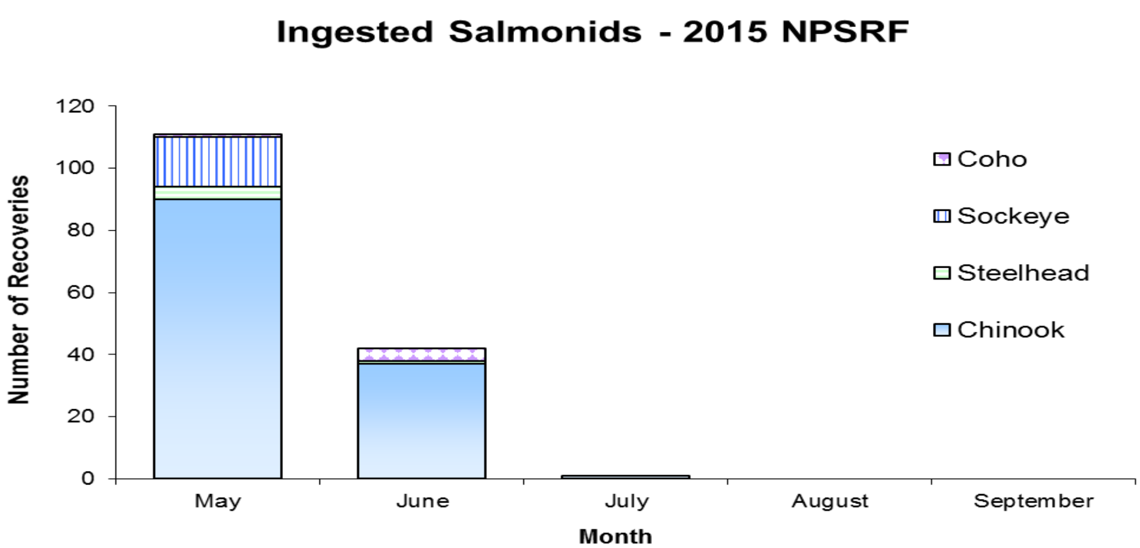


Figure 27. Recoveries of Ingested Salmonid PIT Tags From the 2015 NPSRF.

Analysis of PIT tag recovery data from the 2015 NPSRF continues to document actual northern pikeminnow predation on downstream migrating juvenile salmonids. Further data collection and analysis of PIT tag recoveries from juvenile salmonids consumed by northern pikeminnow harvested in the NPSRF may lead to a better understanding of northern pikeminnow predation on salmonid smolts and the factors affecting the vulnerability of smolts to predation while migrating through the Columbia River System.

SUMMARY

The 2015 NPSRF succeeded in reaching the NPMP's 10-20% exploitation goal for the eighteenth consecutive year, achieving an estimated exploitation rate of 17.3%. NPSRF harvest in 2015 was more than 36,000 fish higher than in 2014 and effort increased by 437 new anglers and 4,532 angler days (23.2%). In addition, the updated reward structure nearly doubled the percentage of Tier 2 and 3 anglers (more proficient anglers) from 16% to 29% of total successful anglers. Despite these increases, angler CPUE declined slightly with the influx of new anglers and additional effort. Peak weekly harvest occurred during week 22 (May 25-31), four weeks earlier than in 2014 and the historical 1991-2014 peak harvest in week 26. The Boyer Park registration station was the SRF's top station for harvest in 2015 for the first time since 2010 with 36,037 reward sized northern pikeminnow harvested, while The Dalles station had the most effort with 2,718 angler days recorded. We recovered 196 northern pikeminnow that were spaghetti tagged by ODFW, and an additional 161 northern pikeminnow which were missing spaghetti tags but retained ODFW PIT tags. Mean fork length for northern pikeminnow harvested in the 2015 NPSRF was 277.9 mm, up from 274.8 mm in 2014. Incidental catch consisted primarily of peamouth, smallmouth bass, yellow perch and sculpin (mostly released), and reflected similar catch patterns to previous seasons.

For the 2015 NPSRF, several locations stuck out as "Hot Spots" as indicated by high CPUE or harvest rates. These areas included Fishing location 08 (Ice Harbor Reservoir) on the Snake River where angler CPUE was 21.01 fish per angler day, the Boyer Park and the Lyon's Ferry registration stations were angler CPUE was 13.92 and 14.04 fish per angler day respectively, and the NPSRF's top station (Boyer Park) where anglers harvested 36,037 fish. The top angler during the 2015 NPSRF set NPSRF records for the total number of fish caught with 12,053 fish and for earnings with $100,453 in reward payments.

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. The occurrence rate ingested salmonids climbed to 1:1,300 in 2015 and was the highest rate recorded to date. Species composition of the 154 recovered PIT tags again showed that they were primarily from Chinook smolt of hatchery origin. We also recovered PIT tags from ingested sockeye (16), as well as steelhead (5), and coho (5) according to PTAGIS).

RECOMMENDATIONS

1.) Continue to use standardized season dates (May 1st-Sept 30th) for implementation of the 2016 NPSRF in order to enhance promotional opportunities, build angler familiarity, and ultimately to optimize removal of predatory northern pikeminnow from within the NPMP program area.

2.) Continue to implement angler incentives such as the higher $5 base reward level used in 2015 designed to recruit new anglers to the 2016 NPSRF. Continue to utilize the lower Tier 2 and Tier 3 levels used in 2015 designed to incentivize current, proficient anglers to expend additional effort participating in the 2016 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 use of angler clinics, coupons, and sport show booths as tools to recruit new anglers and promote NPSRF awareness.

   c) Continue to develop video content for use in improving angler education, NPMP awareness.

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

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

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

5.) Continue to scan all northern pikeminnow for PIT tags from ingested juvenile salmonids, from northern pikeminnow tagged by ODFW as part of the biological evaluation of the NPMP, and as a way to deter fraud by identifying PIT tagged northern pikeminnow coming from outside NPSRF boundaries.

6.) Survey a minimum of 20% of non-returning NPSRF anglers to record non-returning angler catch of northern pikeminnow and all salmonids and estimate total catch and harvest of northern pikeminnow and all salmonids per NPMP protocol. Analyze and monitor this data to identify any changes in non-returning angler catch trends.

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REPORT B

Northern Pikeminnow Sport-Reward Payments – 2015

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March, 2016

INTRODUCTION

The **Northern Pikeminnow Sport Reward Program** was administered by PSMFC in 2015. The program is a joint effort between the fishery agencies of the states of Washington (WDFW) and Oregon (ODFW), and the Pacific States Marine Fisheries Commission (PSMFC). WDFW was responsible for 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. ODFW 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.

CHANGES FOR THE 2015 SEASON

The 2015 season ran from May 1, 2015 through September 30, 2015.

PSMFC maintained an accounting system during the season to determine the appropriate reward amount due each angler for particular fish. For 2015, the reward amount for the three standard payment tiers *increased* from $4, $5 and $8 per fish to $5, $6, and $8 per fish. In addition, the seasonal cumulative number of paid fish required for entering the second and third payment-tier levels was *lowered* from 100 & 400 fish (in 2014) to 25 & 200 fish (in 2015).

ONE-TIME $10 BONUS COUPON

Prior to the opening of the season, coupons were issued to anglers in the pikeminnow database who participated in the program within the past 5 years (2010 – 2014) and to those who signed up for our mailing list at the various sportsmen's shows. The 2015 Coupon was worth a *one-time $10 bonus* when attached to a voucher for qualifying pikeminnow caught and turned in for the reward payment. A total of 858 anglers attached the *one-time $10 bonus coupon* to their reward voucher before submission for payment. The season total paid for *$10 bonus coupons* was $8,580

PARTICIPATION AND PAYMENT

A total of 1,388 anglers who registered were successful in catching one or more fish in 2015. Of those anglers; 1,043 caught one or more fish, submitted their voucher prior to the payment deadline (with no unresolved issues preventing payment) and received payment during the season.

In 2015 a total of 200,213 fish were harvested in the sport-reward fishery. Of this total, 198,610 fish were submitted for payment and paid prior to the 2015 payment deadline (To obtain payment, vouchers must have been received no later than November 15, 2015). In addition, any *received* vouchers with issues preventing payment (missing information, voiding of voucher for program violations, etc.) not resolved by November 15, 2015 also became null and void.

TAGGED FISH PAYMENTS

Registered anglers caught and submitted a total of 195 tagged fish (showing an external spaghetti tag) to station technicians. For each tagged fish, the angler was issued a special tag voucher. The tag was placed in a special tag envelope which was stapled to the tag voucher. It was the angler's responsibility to then mail both the tag and voucher to ODFW for verification. Once the tag was verified, the information was forwarded to PSMFC for payment of the special $500 tagged fish reward. The season total paid for tag rewards was $97,500.

TAG-LOSS BONUS PAYMENT

All tagged northern pikeminnow initially have both a spaghetti tag and a PIT tag. However, the special $500 tagged fish reward was valid only for fish that still retained the original spaghetti tag. That said; all qualifying northern pikeminnow submitted by registered anglers were scanned to check for the presence of a PIT tag. When a PIT tag was detected on a fish with no spaghetti tag, the fish was considered a *standard* fish (and paid at the standard tier rate of $5, $6, and $8 per fish) but was also flagged for verification (by ODFW) of a valid program PIT tag. Upon positive confirmation by ODFW; the angler was then sent an additional $100 *bonus* check and congratulatory letter which included the tagging date and approximate area of release. A total of 161 tag-loss fish qualified for and were paid the *bonus* reward of $100. The season total paid for tag-loss *bonus* was $16,100

TOTAL ACCOUNTING

Total payments for the season of regular vouchers, *$10 bonus coupons*, tag vouchers and *tag-loss bonus* payments was $1,588,259. This is the second highest total Northern Pikeminnow Sport Reward program payment since the program began in 1991.

All IRS Form 1099-MISC Statements were sent to the qualifying anglers for tax purposes in the fifth week of January, 2016. Appropriate reports and copies were provided to the IRS by the end of February, 2016.

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

2015 SPORT REWARD PAYMENTS SUMMARY

	Fish	Incentives	Reward
Fish paid @ tier 1 ($5 each):	14,047		$70,235
Fish paid @ tier 2 ($6 each):	39,550		$237,300
Fish paid @ tier 3 ($8 each):	144,818		$1,158,544
Tags paid (@ $500 each):	195		$97,500
Coupons issued (@ $10 each):		858	$8,580
Tag-loss issued (@ $100 each):		161	$16,100
Total:	198,610		$1,588,259

Anglers @ tier 1	*648*
Anglers @ tier 2	*232*
Anglers @ tier 3	*163*
Number of separate anglers	*1043*
Anglers with 10 fish or less:	*513*
Anglers with 2 fish or less:	*237*

	Total Fish	$500 Tags	Tag Loss Tags	Coup.	Total Reward Paid
1.	12,053	7	$1,000	$10	$100,453
2.	5,272	5	$ 500	$10	$44,721
3.	5,156	9	$ 700	$10	$45,961
4.	5,038	6	$1,000	$10	$43,841
5.	4,613	8	$ 400	$10	$40,825
6.	4,441	7	$ 300	$10	$38,857
7.	4,044	8	$ 300	$10	$36,173
8.	3,557	0	$ 100	$10	$28,141
9.	3,513	0	$ 300	$10	$27,989
10.	3,439	4	$ 500	$10	$29,565
11.	3,193	1	$ 400	$0	$26,011
12.	3,177	5	$ 200	$10	$27,661
13.	3,129	3	$ 400	$10	$26,493
14.	3,128	1	$ 100	$10	$25,201
15.	3,073	3	$ 100	$0	$25,735
16.	2,931	3	$ 100	$10	$24,609
17.	2,850	0	$ -	$10	$22,385
18.	2,738	1	$ 200	$10	$22,181
19.	2,732	2	$ 100	$10	$22,525
20.	2,493	1	$ -	$10	$20,021
	80,570	74	$6,700	$180	$679,348

Report C

System-wide Predator Control Program: Fisheries and Biological Evaluation

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ABSTRACT

Since 1990, the Northern Pikeminnow Management Plan (NPMP) has applied targeted removal fisheries in the Columbia and Snake Rivers to restructure populations of northern pikeminnow (*Ptychocheilus oregonensis*) in an effort to reduce predation on out-migrating juvenile Pacific salmon and steelhead (*Oncorhynchus spp.*). During 2015 (1 May–30 September), the Oregon Department of Fish and Wildlife evaluated the continued efficacy of the program and assessed potential consequences of the fisheries through a combination of field work and laboratory and data analyses. This report augments historical information with current data and seeks to 1) estimate rates of exploitation of northern pikeminnow; 2) quantify potential reduced predation resulting from the targeted removal fisheries; 3) characterize population parameters of northern pikeminnow, smallmouth bass (*Micropterus dolomieu*) and walleye (*Sander vitreus*) in The Dalles and John Day reservoirs; and 4) assess evidence of possible intra- and inter-specific compensatory responses by northern pikeminnow, smallmouth bass and walleye related to the sustained removal of northern pikeminnow from the lower Columbia and Snake rivers. To quantify exploitation during 2015, we used standardized boat electrofishing runs to tag and release northern pikeminnow throughout the lower Columbia and Snake rivers. Analyses of recaptures indicated that system-wide exploitation of northern pikeminnow greater than or equal to 250 mm FL in the Sport Reward Fishery during 2015 was 17.2% (95% confidence interval, 12.3–22.1%). This value was within the NPMP targeted range of 10-20%, above the historical average (13.7 ± 3.0% s.d.), and greater than the previous four years of Program implementation. Based on this level of exploitation, we estimated 2015 predation levels were 29% (range: 15-47%) lower than pre-program levels. Model projections assuming continuation of the current fishery, population structure, and mean rates of exploitation suggest predation on juvenile salmon by northern pikeminnow will remain at a relatively stable reduced level through 2019. Predation behavior by northern pikeminnow caught in the Dam Angling fishery in the tailraces of The Dalles and John Day dams was similar to previous years with the greatest consumption of juvenile salmonids and lamprey coinciding with their outmigration peaks. Northern pikeminnow caught and removed at the dams continue to be larger on average than the fish caught in the SRF. Abundance index estimates for 2015 in most areas of The Dalles and John Day reservoirs indicate a continued decrease since the early 1990s in the number of northern pikeminnow greater than or equal to 250 mm FL. We were unable to sample during 2015 summer months (June and July) because of potential warm temperature impacts to ESA-listed salmon and steelhead. Overall, highly variable index values for the predators considered in our study provide no obvious indication of a long term compensatory response to the targeted removal of northern pikeminnow. Yet, given the dynamic nature of these systems both biotic and abiotic, we encourage continued monitoring efforts to assess trends in predator populations throughout the Columbia and Snake rivers to help elucidate potential local and net (system-wide) affects.

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 factors including habitat degradation and overexploitation (Nehlsen et al. 1991; Wismar et al. 1994), hydroelectric and flood control activities (Raymond 1988), and predation on out migrating juveniles (Rieman et al. 1991; Collis et al. 2002). Escalating concern in the 1980s surrounding the impacts of predation on juvenile salmon prompted researchers to examine more closely the degree to which predation by resident fishes in particular may constrain juvenile salmon survival in the Columbia River Basin. To this end, the John Day Reservoir in the Columbia River was selected as a "model" system to test several hypotheses given: (1) the reservoir was known to be an important area for rearing of subyearling Chinook salmon, (2) passage and residualism of juvenile salmonids was considered an issue in the reservoir and (3) John Day reservoir supported substantial populations of resident predatory fishes (Poe and Rieman 1988). Based on information existing at that time (i.e., Hjort et al. 1981), four species – smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), channel catfish (*Ictalurus punctatus*) and northern pikeminnow (*Ptychocheilus oregonensis*) – were identified as potentially important sources of juvenile salmon mortality. Ultimately, research in John Day Reservoir provided evidence that of the species considered, northern pikeminnow was the most abundant and most dominant predator on juvenile salmon, accounting for 78% of the total loss observed during the study period (Beamesderfer and Rieman 1991; Poe et al. 1991; Rieman et al. 1991).

While data indicated predation by northern pikeminnow contributed appreciably to juvenile salmon mortality in John Day reservoir, questions remained surrounding impacts of northern pikeminnow predation in other areas of the lower Columbia and Snake rivers. To elucidate these questions, a suite of indices were developed to allow rapid assessment of the extent of predation by northern pikeminnow throughout the system. From 1991–1993 researchers applied these indices to data collected in other Columbia River reservoirs (1990 and 1993), the Columbia River downstream of Bonneville Dam (1991) and several Snake River reservoirs (1992) to characterize abundance, consumption, and predation (Ward et al. 1995). Results from these evaluations showed, although variable in time, predation by northern pikeminnow on juvenile salmonids was problematic in areas throughout the lower Columbia and Snake River reservoirs. With the extent of the issue identified, work was conducted to further examine management strategies that could limit predation based on the thesis that even modest exploitation of northern pikeminnow (i.e., 10-20%) could precipitate a disproportionate reduction in predation (i.e., up to 50%; Rieman and Beamesderfer 1990). Ultimately, assessments of various management strategies identified targeted removal fisheries as a favorable option to address this issue and provided the foundation for the contemporary Northern Pikeminnow Management Program (NPMP).

From its inception, the NPMP has operated based on two underlying objectives: (1) implementation of the predator control program (see reports A, B and D) and (2) evaluation of the predator control strategy. To address the latter, since the early 1990s, researchers from the Oregon Department of Fish and Wildlife (ODFW) have sampled standardized areas in the Columbia and Snake rivers to evaluate the efficacy of targeted removals to reduce predation and to assess possible compensatory consequences of the program (e.g., intra- and inter-specific responses to management actions) that may be related to sustained removals of northern pikeminnow. This report augments historical information with data collected during 2015 in areas of the Columbia and Snake rivers and wherever possible, evaluates temporal and spatial changes. Specific goals for this reporting period were to:

(1) estimate rates of exploitation of northern pikeminnow and quantify potential reduced predation resulting from the targeted removal fisheries;
(2) characterize population parameters of northern pikeminnow, smallmouth bass and walleye in The Dalles and John Day reservoirs; and
(3) assess evidence of possible intra- and inter-specific compensatory responses by northern pikeminnow, smallmouth bass and walleye related to the sustained removal of northern pikeminnow from the lower Columbia and Snake rivers.

METHODS

Sampling during 2015 was conducted using Smith-Root™ 18-EH model electrofishing boats equipped with a 5.0 or 7.5 GPP electrofisher powered by either a Kohler Power Systems™ or Briggs and Stratton™ gas generator. When engaged, the electrofishing unit applies pulsed direct current (DC) current at a rate of 60 pulses·sec^{-1}; pulsed DC is applied to maximize capture efficiency with minimal injury to fish. Boats are configured with anodes suspended from two boom arms extending forward from the bow. Each boom arm supports a single array composed of six electrodes. The boat hull functions as the cathode. Electrofishing controls are set according to federal guidelines where peak output does not exceed 800 volts at water conductivity between 100 and 300 µS/cm (NMFS 2000). The targeted average current during all electrofishing events was 3 – 4 amperes. All controls were standardized across boats with minor adjustments to the duty cycle to achieve target output. Program electrofishing protocols were developed to induce taxis while avoiding tetany, minimize fish exposure to electric current, and limit interactions with species listed under the Endangered Species Act (ESA).

Fishery Evaluation and Predation Reduction

Field Procedures

To address our 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 637 (Priest Rapids Dam) and in the Snake River from rkm 122 (Little Goose Dam) to rkm 251 (Figure 1). Four sampling events consisting of 900 seconds of electrofishing effort were conducted within each river kilometer. The efficacy of boat electrofishing tends to be limited to a maximum depth of approximately 10 feet; thus, sampling was conducted primarily along shallow shoreline areas. Sampling occurred from 3 April to 18 June 2015 between the hours of 18:00 and 5:00, except in the Hanford Reach of the Columbia River (rkm 557–637), where safe river navigation necessitated daytime sampling. A total of 46.7 rkm in the Columbia River and 35.4 rkm in the Snake River were not sampled due to weather related constraints. Sampling plans were adjusted in the field to ensure, to the extent possible, weather related sampling disruptions affected only sampling in areas with historically low catch rates. Ideally, all tagging would be performed prior to the start of the Sport Reward and Dam Angling fisheries, but due to time constraints this was unachievable. All fish captured downstream of John Day Dam (rkm 306) were tagged prior to the start of the fisheries (1 May 2015), upstream of John Day Dam pikeminnow were tagged concomitant with the fisheries.

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 external loop tags. Each loop tag was inserted through the pterygiophores just below the midpoint of the dorsal fin. All loop-tagged fish were also marked with a 134.2 MHz ISO passive integrated transponder (PIT) tag inserted into the dorsal sinus.

Working with Washington Department of Fish and Wildlife (WDFW), tag recovery information from the Sport Reward and Dam Angling fisheries. The Sport Reward Fishery occurred daily between 1 May and 30 September 2015 (see Report A). Participating anglers received payment for all harvested northern pikeminnow greater than or equal to 230 mm (9 in) total length (TL).

This size criterion for total length corresponds approximately to the minimum FL (i.e., 200 mm) of northern pikeminnow marked during tagging operations. The reward payment schedule consisted of three tiers (see Report B). Further, anglers were eligible for a $500 reward for each external loop tagged fish and $100 for each “tag loss” fish retaining only the internal PIT tag that was returned to a check station. Given this, we assumed 100% of the northern pikeminnow marked with an external and/or a PIT tag removed from the fishery were submitted to a check station for reward payment.

In addition to the Sport Reward Fishery, an NPMP-administered Dam Angling Fishery (see Report D) was conducted between 1 May and 11 October 2015 in the powerhouse tailrace areas of The Dalles and John Day dams. A team of anglers used hook and line to remove northern pikeminnow; all fish were examined for presence of external and PIT-tags. Tagged northern pikeminnow removed in this fishery were accounted for when estimating exploitation rates for the Sport Reward Fishery (see Data Analysis).

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) beginning in the year 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 long-term 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) as

$$u_j = \frac{R_j}{M_j}, \tag{1}$$

where R_j is the number of tagged fish recaptured during the season in area j and M_j is the number of fish tagged in area j. Beginning in 2014, the NPMP incentivized the return of tag-loss northern pikeminnow; or those fish for which an external tag had been lost in the environment, but a functioning PIT tag remained present. Thus, a correction for tag retention was not necessary to estimate 2015 exploitation rates as it was in early program years.

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

$$u_j \pm \frac{z \cdot \sqrt{R_j}}{M_j}, \tag{2}$$

where z is a 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:

$$u_{weekly_j} = \frac{R_{ij}}{M_{ij}}, \tag{3}$$

where R_{ij} is the number of tagged fish recaptured in area j during the i^{th} week and 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. To assuage positive bias associated with insufficient mixing, for few instances where fish were captured during the same week in which they were released, we excluded those recaptures from the analysis.

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:

$$u_{annual_j} = \sum_{i=1}^{n_j} \frac{R_{ij}}{M_{ij}}, \tag{4}$$

where R_{ij} and M_{ij} 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

$$u_{annual_j} \pm t \cdot \sqrt{n_j} \cdot s_j, \tag{5}$$

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.

We applied 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) northern pikeminnow population size structure before removals by fisheries, (2) area- and size-specific annual exploitation rates, (3) an estimate of natural mortality, (4) area- and size-specific abundance estimates and (5) area-specific estimates of consumption of juvenile salmon by specific size classes of northern pikeminnow. Based on estimated levels of abundance and consumption for the current year, the model estimates system-wide total annual loss of juvenile salmon to northern pikeminnow predation in the following year and compares those losses to preprogram levels. As such, the model assumes removal of northern pikeminnow until October of the current year will be realized in reduced predation on out migrating juvenile salmon in spring and summer of the following year. A ten-year mean age-structure (based on catch curves) was applied for a pre-program baseline and constant recruitment was assumed. Since its development, the model has been revised to include FL 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 estimate the potential predation during 2016 based on observed exploitation rates from 2015 and predict three future predation rates (maximum, median, and minimum) using the mean level of exploitation observed during contemporary program rules (2001; 2004–2015). See Friesen and Ward (1999) for additional model documentation.

To test for differences in the size of northern pikeminnow captured in the 2015 Sport Reward versus the Dam Angling fisheries, we applied area-specific ordinary least-squares models (‘lm’ in package ‘stats’; R Core Team 2013) to FL data using the R programming environment (R Core Team 2013). In this way, lengths of northern pikeminnow captured in the Dam Angling Fishery at The Dalles Dam were compared to those of fish harvested in the Sport Reward Fishery in Bonneville Reservoir and lengths of northern pikeminnow captured at John Day Dam were compared with those of the Sport Reward harvest in The Dalles Reservoir. A review of model assumptions (‘modelAssumptions’ in package ‘lmSupport; Curtin 2015) showed residuals from each model were non-normal and suffered from heteroscedasticity. We log transformed the data 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 standard 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 The Dalles and John Day reservoirs. Early morning (0200–1200) sampling was conducted during spring (5 May–22 May 2015) in three areas of The Dalles (forebay, rkm 307-313; mid-reservoir, rkm 329-334; and John Day Dam tailrace, km 341-347 rkm) and John Day (forebay, rkm 347-354; mid-reservoir, rkm 387-394; and the McNary Dam tailrace, rkm 461-469) reservoirs. Randomly selected fixed site transects, approximately 500 m long, in each reservoir area were sampled along both shores of the river. Effort at each transect consisted of a 15-min electrofishing period with continuous output of approximately 4 amperes. Summer sampling (scheduled for 15 June–2 July, 2015) was not conducted in 2015 because shoreline water temperatures exceeded 18°C– an environmental threshold specified in federally assigned scientific collection permits (NMFS 2000).

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 collected. Scale samples were removed from 25 fish per 25 mm FL increment for all three species in both reservoirs. All untagged northern pikeminnow greater than or equal to 200 mm FL were sacrificed and digestive tracts were collected for subsequent analyses. To this end, digestive tracts were removed by securing both ends with hemostats and pulling free 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 were collected by non-lethal gastric lavage using a modified Seaburg sampler (Seaburg 1957). Contents from the foregut of each 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 2015 Dam Angling portion of the NPMP. Digestive tracts were collected from a representative subsample of catches at each dam weekly from 20 May through 28 August 2015 (generally three 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 of the Sport Reward Fishery and northern pikeminnow collected during the Dam Angling Fishery to quantify relative consumption of juvenile salmon. Samples collected in the field and frozen were thawed in the laboratory and the contents sorted into general prey categories (i.e., fish, crayfish, other crustaceans, mollusks, insects, and vegetation). Material was weighed (blotted wet mass) to the nearest 0.01 g according to prey category. For smallmouth bass and walleye, portions of stomach contents containing fish hard structures (e.g., bones, otoliths, etc.), tissue, or other possible fish remnants were then returned to the original sample bags for chemical digestion to allow for further diagnosis of prey fish taxa. To ensure complete recovery of diagnostic structures from northern pikeminnow diet samples, in addition to the above materials, entire gastrointestinal tracts were digested. To digest soft tissues, an approximate 20 ml solution of porcine 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 placed in a desiccating oven at approximately 48°C for 24 hours. After removal from the oven, a solution of sodium hydroxide lye (NaOH, mixed at 30g per liter of tap water) was added to samples to dissolve remaining fatty materials. Contents of each bag were then poured into a 425-µm sieve and rinsed with tap water.

Hard parts remaining after chemical digestion were examined to identify prey to the lowest possible taxon under dissecting microscopes using standard keys (Hansel et al. 1988, Frost 2000, and Parrish et al. 2006). Wherever possible, paired structures were enumerated to arrive at counts of a given prey taxon in a diet sample. However, for certain prey items, only presence/absence could be evaluated. For example, ventral scutes of American shad (*Alosa sapidissima*) were encountered commonly in diet samples. Because the total number of scutes associated with an individual fish is ambiguous, both meristically and as a result of differential digestion, we assumed one fish had been consumed if no other diagnostic structures were present. The same assumption was made for instances in which lamina of lamprey (family Petromyzontidae) were encountered in stomach contents. Further, for samples where only fish vertebrae were encountered, prey fishes were identified as either salmonid or non-salmonid. Given these constraints, in addition to those related to the relative size and quality of diagnostic bones encountered, the total numbers of prey fish enumerated in samples were necessarily conservative. Lastly, to calibrate identification among analysts throughout examination, 10% of all samples were re-analyzed at random by a second reviewer.

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 (ha) of specific sampling locations in each river reach or reservoir area. 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:

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

and

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

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 for northern pikeminnow (Ward et al. 1995) and smallmouth bass (Ward and Zimmerman 1999). The abundance and consumption indices provide a means to characterize relative predation impacts. 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. Currently, no comparable model exists to evaluate walleye consumption and predation.

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 sampled both in the Dam Angling Fishery and during biological evaluation, and smallmouth bass and walleye populations sampled during biological evaluation as follows:

$$PSD_i = 100 \cdot (FQ_i / FS_i), \tag{8}$$

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) sampled during biological evaluation using the equation

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

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). For smallmouth bass, stock, quality, and preferred minimum length categories were 180, 280, and 350 mm TL, respectively and for walleye, 250, 380, and 510 mm TL, respectively (Willis et al. 1985). These minimum length categories were converted to FL using species-specific models (smallmouth bass: $TL_{SMB} = FL_{SMB} \cdot 1.040$; walleye: $TL_{WAL} = FL_{WAL} \cdot 1.060$) as lengths were recorded as FL during sampling to support the biological evaluation. Both PSD_i and $RSD\text{-}P_i$ values were calculated only when sample sizes exceeded 19 fish for a given species and sampling event. To quantify variability (95% confidence intervals) surrounding PSD_i and $RSD\text{-}P_i$ values, we applied a non-parametric bootstrap approach using the 'boot' package (Fox and Weisberg 2011) in the R programming environment (R Core Team 2013).

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 2015 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 according to the equation

$$W_r = 100 * \frac{W}{W_s}, \qquad (10)$$

where W is the mass of an individual fish and W_s is predicted standard weight. To account for potential sexual dimorphism, we calculated W_r values separately for male and female northern pikeminnow. Because sampling methodologies precluded diagnosis of sex for smallmouth bass and walleye in the field, we did not differentiate among sexes when calculating W_r for these species. As for PSD_i and $RSD\text{-}P_i$, we estimated 95% confidence intervals for W_r values using a non-parametric bootstrap approach (Fox and Weisberg 2011; R Core Team 2013).

Temporal trends in median W_r for northern pikeminnow, smallmouth bass and walleye were assessed by applying a non-parametric Mann-Kendall test (Mann 1945). To diagnose potential serial dependence among median W_r data, we reviewed autocorrelation functions (acf) and partial autocorrelation functions (pacf) applied to time series objects. If autocorrelation was found to be meaningful, trends were evaluated using a block bootstrap technique (Davidson and Hinkley 1997; McLeod 2011) after applying spline interpolation to account for data gaps. Otherwise, traditional Mann-Kendall tests were conducted. Lastly, to help visualize trends, we fit locally weighted scatterplot smoothing (LOWESS) curves to the data. All analyses were conducted in the R programming environment using the 'Kendall' (McLeod 2011) and, where necessary, the 'boot' (Fox and Weisberg 2011) packages. Tests were considered significant at $\alpha = 0.05$.

RESULTS

Sport Reward Fishery Evaluation and Predation Estimates

We tagged and released 1,414 northern pikeminnow greater than or equal to 200 mm FL throughout the lower Columbia and Snake rivers during 2015, of which 791 were known to be greater than or equal to 250 mm FL (Table 1). Seven fish were tagged without recording length and thus were not incorporated in calculations of size-specific rates of exploitation. One-hundred thirty three northern pikeminnow tagged in 2015 were recaptured during the Sport Reward Fishery; one tagged northern pikeminnow was recaptured during dam angling activities. Of the 133 recaptured fish, one fish recovered in McNary Reservoir was at large for less than one week and thus was excluded in analyses of exploitation. Fish tagged in 2015 and subsequently recaptured in the Sport Reward Fishery were at large from 1 to 167 days (mean = 74 ± 45 days s.d.). Sport Reward Fishery recaptures greater than or equal to 250 mm FL accounted for 85% of all 2015 tag recoveries (Table 1). The median length of the Sport Reward Fishery catch was 261 mm FL (E.C. Winther, WDFW, personal communication).

System-wide exploitation of northern pikeminnow greater than or equal to 200 mm FL during the Sport Reward Fishery was 12.4% (95% confidence interval 8.9–15.9%; Table 2). Tag returns were sufficient ($n \geq 4$) to calculate area-specific exploitation estimates for the Columbia River downstream of Bonneville Dam and in Bonneville and Lower Granite reservoirs, where rates ranged from 12.9 to 15.6% (Table 2). For northern pikeminnow within the 200–249 mm FL size class, system-wide exploitation was estimated to be 4.5% (95% confidence interval 1.5–7.5%). Area-specific rates of exploitation for this size class could be estimated only for Lower Granite Reservoir (10.6%; Table 3). The system-wide exploitation rate for northern pikeminnow greater than or equal to 250 mm FL exceeded those of the other size classes (17.2%, 95% confidence interval 12.3–22.1%; Figure 2; Table 4). Area-specific exploitation rates of those fish greater than or equal to 250 mm FL were: 16.7% for the Columbia River downstream of Bonneville Dam, 14.3% for Bonneville Reservoir, and 24.4% for Lower Granite Reservoir (Table 4).

We applied 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-estimated median reduction in predation on juvenile salmonids relative to pre-program levels for 2015 was 29% (range: 15- 47%) and for 2016 will be 32% (range: 17–49%; Figure 3). Model projections based on continuation of the current fishery, population structure, and mean rates of exploitation suggest predation on juvenile salmon by northern pikeminnow will remain relatively stable through 2019.

Biological Evaluation

We conducted a total of 245 electrofishing runs during 2015 in the forebay, mid-reservoir, and tailrace sampling areas of The Dalles and John Day reservoirs to collect fish for biological evaluation (Table 5). Spring sampling coincided with the peak of yearling salmon and steelhead outmigration as evinced by smolt passage through McNary and John Day dams (Figure 4). Water temperatures exceeded the electrofishing maximum prescribed by National Marine Fisheries Service (NMFS) guidelines for anadromous waters (i.e., 18°C; NMFS 2000) in all sampling areas before the scheduled summer period (15 June–2 July, 2015), precluding field activities during the subyearling outmigration (Figure 4).

Across all sample sites, spring CPUE ranged from 0.00 to 0.15 fish·run^{-1} for northern pikeminnow, 0.35 to 4.02 fish·run^{-1} for smallmouth bass, and 0.00 to 0.43 fish·run^{-1} for walleye (Table 6). We captured considerably more smallmouth bass than northern pikeminnow in 2015 across all areas sampled. Catch rates for northern pikeminnow were greatest in the tailrace area of The Dalles reservoir. For smallmouth bass, CPUE was highest in the mid-section of The Dalles Reservoir. Further, minimum CPUE for smallmouth bass was more than double the maximum CPUE for northern pikeminnow. Walleye were encountered in the greatest numbers in the tailrace section of the John Day Reservoir, but were absent from catches in all other areas of that reservoir (Table 6).

Abundance index values calculated for northern pikeminnow in 2015 ranged from 0.04 to 0.18 in The Dalles Reservoir and 0.00 to 0.05 in John Day Reservoir. In most areas sampled, estimates were among the lowest calculated since sampling was first conducted. Exceptions to this occurred in The Dalles Reservoir tailrace where the abundance index value for 2015 was greater than the three previous years and in the John Day Reservoir tailrace where the estimate was marginally greater than 2012, yet at least an order of magnitude less than all other years prior. Further, in areas sampled during 2015, abundance index values were below the mean of estimates throughout each time series (Table 7).

Across all areas sampled during 2015, smallmouth bass abundance index values were greatest in the mid-reservoir area and lowest in the tailrace area of John Day Reservoir; a finding consistent with most previous years in which sampling was conducted. Considering estimates since 1990, values calculated for 2015 fell below the mean in most areas sampled. Although abundance index values for the current year were notably lower than 2012, across time in each area, estimates display considerable inter-annual variability (Table 8).

Walleye were encountered during 2015 in all three areas of The Dalles Reservoir and only in the tailrace area of John Day Reservoir, with the greatest abundance index value occurring in the John Day tailrace. As was found for smallmouth bass, 2015 area-specific abundance index estimates for walleye were generally lower than the preceding sampling year, and fell below the mean of all years in which sampling was conducted. However, area-specific abundance index values varied considerably across years. (Table 9).

We examined contents from the digestive tracts of 13 northern pikeminnow captured in The Dalles ($n = 9$) and John Day ($n = 4$) reservoirs to characterize consumption (Table 10). Across reservoirs and areas, all but one gut content sample examined contained food items. None of the four samples collected from John Day Reservoir contained fish, whereas all but one sample from The Dalles Reservoir contained that prey item ($\hat{p} = 0.89$; Table 10). Salmonids were the only prey taxon encountered in samples where fish prey could be identified (Table 11).

During the spring of 2015, we collected 337 and 214 diet samples from smallmouth bass in The Dalles and John Day reservoirs, respectively, with large proportions of the diet from each reservoir containing prey items ($\hat{p}_{\text{The Dalles}} = 0.86$, $\hat{p}_{\text{John Day}} = 0.89$). Proportions of all diet samples (i.e., empty and non-empty) containing prey fish was 0.22 in The Dalles Reservoir and

0.30 in John Day Reservoir (Table 10). Of all smallmouth bass diet samples analyzed from The Dalles and John Day, 0.05 and 0.14, respectively, contained salmonids (Table 10). Among diet samples collected from The Dalles Reservoir containing prey fish, sculpin (Family: Cottidae) were encountered in stomach contents most commonly ($\hat{p}$ = 0.41) followed by salmon and trout ($\hat{p}$ = 0.23). The converse was true in John Day Reservoir, where diet samples containing salmon constituted the greatest proportion ($\hat{p}$ = 0.48) followed by samples where sculpin were present ($\hat{p}$ = 0.28; Table 11).

We collected 17 walleye diet samples from The Dalles Reservoir during spring of 2015 and 16 from John Day Reservoir (Table 10). As was found for smallmouth bass, in each reservoir large proportions of samples examined contained prey items ($\hat{p}_{\text{The Dalles}}$ = 0.82, $\hat{p}_{\text{John Day}}$ = 0.88), and for walleye, a majority contained fish material ($\hat{p}_{\text{The Dalles}}$ = 0.53, $\hat{p}_{\text{John Day}}$ = 0.63; Table 10). Proportions of all diet samples containing salmonids was 0.35 in The Dalles Reservoir and 0.44 in John Day Reservoir (Table 10). When considering only diet samples containing prey fish, salmonids were encountered most frequently in both reservoirs ($\hat{p}_{\text{The Dalles}}$ = 0.67, $\hat{p}_{\text{John Day}}$ = 0.70). Suckers ($\hat{p}$ = 0.22; Family: Catostomidae) and minnows ($\hat{p}$ = 0.22; Family: Cyprinidae) were observed commonly in samples from The Dalles Reservoir, whereas neither of these taxa were encountered in diet samples from John Day Reservoir. In contrast, sculpins (Family: Cottidae) were consumed by an appreciable proportion of fish sampled in John Day Reservoir ($\hat{p}$ = 0.30), but absent from diet samples collected in The Dalles Reservoir (Table 11).

Consumption and predation indices were evaluated for northern pikeminnow during 2015 only in the tailrace area of The Dalles Reservoir due to sample size constraints (i.e., $n \leq 5$). The consumption index value calculated for this reservoir section (2.88) exceeds all previous estimates across areas within both reservoirs (Table 12). Despite the magnitude of the consumption index, the predation index value (0.42) for The Dalles Dam tailrace is not appreciably high when compared to other estimates across space and time (Table 13).

Consumption index values for smallmouth bass sampled during the spring of 2015 ranged from 0.00 to 0.13 in The Dalles Reservoir and 0.09 to 0.23 in John Day Reservoir (Table 14). In The Dalles and John Day reservoirs, the largest estimates occurred in the forebay (0.13) and tailrace (0.23) areas, respectively. In addition, consumption index values estimated for 2015 in the mid-reservoir (0.12) and tailrace (0.23) areas of John Day Reservoir were greater than any year prior (Table 14). Predation index values calculated for smallmouth bass sampled during the spring of 2015 ranged from 0.00 to 0.48 in The Dalles Reservoir and 0.15 to 5.96 in John Day Reservoir. The highest predation index observed across years and areas occurred during spring of 2015 in the John Day mid-reservoir section (3.84; Table 15); a result of relatively high abundance and consumption in that area.

We were unable to calculate PSD for northern pikeminnow and PSD and RSP-P for walleye during 2015 due to sample size constraints (i.e., $n \leq 19$). Two of the 8 stock-size northern pikeminnow sampled in The Dalles Reservoir were of quality size while one stock-size fish was observed in John Day Reservoir. Four of 9 stock-size walleye in The Dalles Reservoir were of quality size and none were classified as preferred. Of the 8 stock-size walleye in John Day Reservoir, five were of quality size and three preferred. Since 1990, the time series of PSD values for northern pikeminnow and PSD and RSD estimates for walleye display marginal inter-annual variability (Figures 5 and 6); although this characterization remains somewhat tenuous due to data gaps occurring particularly for northern pikeminnow in later years. Similarly, although trends in PSD values calculated based on the lengths of northern pikeminnow subsampled from the Dam Angling Fishery for diet analyses were not tested directly, estimates since the inception of the NPMP for each dam appear to a long-term decrease (c.f., 1990–1995 and 2006–2015; Figure 7).

Smallmouth bass PSD values calculated using data collected in 2015 were 47 in The Dalles Reservoir and 34 in John Day Reservoir; in both cases, these values exceeded estimates from 2012 (Figure 5) and the mean of estimates since 1990 ($mean_{The\ Dalles}$ = 41±9, $mean_{John}$ Day = 29±6). Across time, PSD values for smallmouth bass in both The Dalles and John Day reservoirs displayed no obvious trends (Figure 5). Estimates of RSD for smallmouth bass in The Dalles Reservoir exceeded those calculated for John Day Reservoir in each of the last four sampling events (Figure 6). Further, while the 2015 estimate of RSD for The Dalles Reservoir (27) was the highest observed since 1990, the value calculated in 2015 for John Day Reservoir (8) was largely consistent with the mean across the time series (Figure 6; $mean_{John}$ Day = 8±5).

Relative weight (W_r) values could not be calculated for northern pikeminnow sampled during 2015 in John Day Reservoir (Figure 8). In the Dalles Reservoir, median W_r for female northern pikeminnow exceeded that of male fish sampled (115 and 109, respectively; Figure 9). The median W_r value for smallmouth bass collected in The Dalles Reservoir (98) was greater than that estimated for fish sampled in John Day Reservoir (90) but individual W_r values varied considerably among reservoirs (Figure 10). Median W_r values for walleye collected during 2015 were comparable among the two reservoirs sampled ($W_{rThe\ Dalles}$ = 93; $W_{rJohn\ Day}$ = 91; Figure 11). Analyses of species- and location-specific W_r time series data elucidated significant and increasing trends for both female (Mann-Kendall $\tau = 0.745$, $p < 0.0001$) and male (Mann-Kendall $\tau = 0.570$, $p < 0.0015$) northern pikeminnow in The Dalles Reservoir (1990–2015; Figure 9) and female northern pikeminnow in John Day Reservoir (1990–2012; Mann-Kendall $\tau = 0.593$, $p < 0.00001$; Figure 8 and 9). In contrast, median W_r values for male northern pikeminnow sampled in John Day Reservoir displayed no statistically significant monotonic trend (1990–2012; Mann-Kendall $\tau = 0.206$, $p < 0.2667$; Figure 8). While the time-series of median W_r values for smallmouth bass sampled in The Dalles Reservoir displayed a slightly significant increasing trend (Mann-Kendall $\tau = 0.360$, $p = 0.0452$), no statistically meaningful monotonic pattern was uncovered for that species in John Day Reservoir (Mann-Kendall $\tau = -0.114$, $p = 0.5352$; Figure 10). No statistically significant temporal trend was identified for walleye in The Dalles Reservoir (Mann-Kendall $\tau = 218$, $p = 0.2139$), yet median W_r for walleye sampled in John Day Reservoir increased significantly with time (Mann-Kendall $\tau = 0.502$, $p = 0.0046$; Figure 11).

During 2015, 985 northern pikeminnow digestive tracts were collected from fish harvested in the Dam Angling Fishery. These fish ranged in size from 184 to 600 mm FL ($mean_{The\ Dalles}$ = 315, $mean_{John\ Day}$ = 349 mm; Table 16). At both dams, large proportions of the 811 digestive tracts examined contained food ($\hat{p}_{\text{The Dalles}} = 0.75$ and $\hat{p}_{\text{John Day}} = 0.79$). Fish were observed in larger proportions of diet samples at both dams than all other prey types (Table 17). Juvenile lamprey were encountered in the greatest proportion ($\hat{p}$ = 0.54 – 0.60) of pikeminnow diet samples during May and June followed by salmon and steelhead ($\hat{p}$ = 0.33 – 0.35) and American shad ($\hat{p}$ = 0.01 – 0.05). Juvenile salmon and steelhead were observed relatively infrequently during July (0.13) and August (0.01). American shad were encountered at relatively low rates until July and

August when proportions of samples containing the taxon increased to 0.55 and 0.77, respectively (Table 18). Diversity of prey fish families consumed by northern pikeminnow was greatest during July and included five native and three non-native taxa. At John Day Dam, weekly consumption index estimates peaked during the week of June 30th (statistical week 27) and generally coincided with peak subyearling Chinook salmon passage rates (Figure 12). Consumption of salmonids by northern pikeminnow at The Dalles Dam peaked during the following week (statistical week 28) presumably reflecting a lag in run-timing resulting from the geographic distance between John Day and The Dalles dams.

Fork lengths of northern pikeminnow captured in the 2015 Sport Reward Fishery in Bonneville Reservoir (mean = 276 ± 60 mm s.d.) differed significantly from those of fish captured in the Dam Angling Fishery at The Dalles Dam (mean = 309 ± 61 mm; $p < 0.0001$). Similarly, lengths of northern pikeminnow captured in the Sport Reward Fishery in The Dalles Reservoir (mean = 329 ± 62 mm) were significantly smaller than those of fish captured in the Dam Angling Fishery at John Day Dam (mean = 340 ± 70 mm; $p < 0.0001$).

The greater size of individuals caught in the Dam Angling Fishery relative to catches in the Sport Reward Fishery in Bonneville and The Dalles reservoirs is further evinced by greater stock densities in The Dalles and Bonneville pools. Proportional stock densities of the Sport Reward catches were 12 (95% CI 12 – 13) and 22 (95% CI 21 – 23) in Bonneville and The Dalles reservoirs respectively compared to 15 (95% CI 14 – 16) and 26 (95% CI 25 – 28) for dam angling catches.

DISCUSSION

The 2015 estimate of the system-wide exploitation (17.2 ± 4.9%, 95% CI) for northern pikeminnow greater than or equal to 250 mm FL is the highest reported since 2010 (18.8%; Table 4, Figure 2) and falls towards the upper end of the target exploitation range (i.e., 10–20%) expected to precipitate reduced predation on juvenile salmon (Rieman and Beamesderfer 1990). This increase during 2015 is likely due, at least in part, to recent changes to the Sport Reward Fishery incentive system, instituted to increase participation that had been waning in the two years prior (Report B). Since its inception, the NPMP has operated under the tenet that even modest exploitation (i.e., 10-20%) of the most piscivorous size-classes of northern pikeminnow could lead to a disproportionate reduction in predation (Rieman and Beamesderfer 1990) while serving to maintain viable populations of the native northern pikeminnow. With increased efforts to achieve program objectives in addition to a highly dynamic environment (see below), the need to ensure a balance between maximizing reductions in predation and maintaining sustainable harvest of northern pikeminnow returns to focus. While the estimate of exploitation for 2015 remains within program goals and the bounds of variability throughout the time series, the notable increase in exploitation between 2013/14 and 2015, lends some support to the argument that continued evaluation of the sport reward program is necessary not only to evaluate the efficacy of the program to reduce predation of juvenile salmon, but also to ensure the population viability of a native species.

To quantify the efficacy of the NPMP since the early 1990s, ODFW has applied a model that considers the cumulative effects of sustained exploitation on predation by northern pikeminnow (Friesen and Ward 1999). According to the structure of this model, exploitation in a given year will be manifest in the subsequent year as limits to recruitment of individuals to larger size classes (local or system-wide) in the northern pikeminnow population. In this way, a reduction in predation in the present is dependent on our ability to restructure the population during both the current and previous years. Thus, the higher exploitation rate for 2015 following two years (e.g., 2013 and 2014) of lower than average exploitation should avert any reduction in efficacy of the NPMP that could have resulted from continued system-wide exploitation at lower levels. This is highlighted by a strengthened reduction in predation estimated for 2016 compared to 2015 and 2014 (Figure 3). Given the fragmented structure of the Columbia and Snake River systems, it is likely insufficient to consider the whole without also considering variability contributed by individual reservoirs or reaches. As reported previously (Tinus et al. 2015), review of the sensitivities of our model appears to indicate area-specific exploitation downstream of Bonneville Dam may have a disproportionate influence on predation reduction, due presumably to high densities of juvenile salmon and steelhead in that area and a related functional feeding response. To maintain the efficacy of the NPMP, we recommend continued annual evaluation of exploitation rates and estimates of reductions in predation and suggest efforts continue to examine differential area-specific contributions to predation reduction.

The 2015 Dam Angling Fishery accounted for 3.9% of the total northern pikeminnow harvest; a value comparable to that for 2014. Although the proportion of total fish harvested by the Dam Angling Fishery may be small, the relative impact on northern pikeminnow predation reduction efforts could be substantial. Northern pikeminnow collected during the 2015 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)

provided evidence that larger northern pikeminnow consumed a disproportionately greater number of juvenile salmonids than smaller fish predators. Given both the apparent discrepancy in length distributions among Dam Angling and Sport Reward fisheries and the putative size-related bias in consumption of juvenile salmonids in the tailrace areas relative to other areas of the reservoir, dam anglers may have better opportunity to harvest 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. The relatively few tags that are recovered in the Dam Angling Fishery may further provide some evidence dam anglers are harvesting a unique sub-set of the overall pikeminnow population. 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 (see below) 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 increased abundance, condition factor, consumption and predation indices, or a shift in population size-structure toward larger individuals (Knutsen and Ward 1999). Analyses to elucidate temporal trends in W_r data indicated a persistent increase in condition of both male and female northern pikeminnow in The Dalles Reservoir and female northern pikeminnow in John Day Reservoir (Figures 8 and 9). Similarly, median W_r values for smallmouth bass and walleye exhibit significant increasing trends in one but not both reservoirs sampled. While it remains unclear whether these results are indicative of an intra- or inter-specific compensatory mechanism, our findings from 2015 support results from 2014, underscoring the possibility of differential responses to sustained removal not only in space (i.e., reservoir/area-specific), but also demographically and among species.

Abundance index estimates for 2015 in most areas of The Dalles and John Day reservoirs highlight a continued decrease since the early 1990s in the number of northern pikeminnow greater than or equal to 250 mm FL (Table 7). Perhaps the most notable fluctuation in abundance has occurred in the tailrace area of John Day Reservoir, where initial index values were substantially higher (e.g., 10.00 in 1990 and 10.89 in 1991) than estimates calculated several years after inception of the program (Table 7). Persistent harvest of larger individuals resulting in decreased abundance presumably has also led to a shift in size-structure of northern pikeminnow populations toward smaller individuals. Rieman and Beamesderfer (1990) proposed that a decreasing trend in PSD may underscore the effect of the Sport Reward Fishery as evinced by the direction of change in the size-structure of the northern pikeminnow population. Although the time series of PSD values for northern pikeminnow assessed during biological evaluation in The Dalles and John Day reservoirs is constrained in time and provides little insight into the presence of a trend (Figure 5), estimates for fish captured in the Dam Angling Fishery in the Dalles Reservoir, appear to have decreased since the beginning of the program (Figure 7). Whether this decrease is significant, given variability surrounding the estimates, remains unclear. To elucidate a shift in size-structure over time using metrics such as PSD, more consistent time series are essential. To this end, future analyses will consider the feasibility of augmenting data collected during the biological evaluation with other sources, including the fishery evaluation, in the hopes of gaining a better understanding of associations between continued harvest and functional dynamics of the populations.

A compensatory response by other piscivores in the Columbia Basin to the sustained removal of northern pikeminnow could offset the net benefit of the removals (Ward and Zimmerman 1999). As reported in earlier work (Poe et al. 1991; Zimmerman 1999; Naughton et al. 2004), juvenile salmon constitute a small but consistent portion of smallmouth bass diets in the Columbia River. In 2015 we observed a rise in the proportion of salmonids found in the diets of smallmouth bass containing prey fish, specifically in the John Day Reservoir (Table 11). Yet, abundance index estimates for smallmouth bass were the lowest recorded since 1992 in the mid John Day Reservoir and notably lower than 2012 (Table 8). Further, predation index values for smallmouth bass remain relatively low in most areas (Table 15). Ward and Zimmerman (1999) suggested primary evidence of a compensatory response by smallmouth bass would likely be a shift in diet towards greater proportions of juvenile salmon. However, as stated above, indication of a compensatory response may become apparent at one or multiple scales (localized spatial, system-wide, sex-specific, etc.).

In 2015 the greatest indication of a potential compensatory response could be seen as a substantial increase in the smallmouth bass predation index in the mid John Day Reservoir. However, a one year increase does not denote a trend and uncertainty due to sample or process error remains unclear. Our biological sampling efforts represent snapshots in time, intended to coincide temporally with peak salmonid prey abundance during spring (yearling outmigrants) and summer (subyearling Chinook) and alternate between reservoirs every third year. Within John Day Reservoir particularly, the three area index transects are but a small portion of the 122 km between John Day and McNary dams. We were unable to sample during summer because of potential warm temperature impacts to ESA-listed salmon and steelhead. Our mid-reservoir smallmouth bass sample coincidentally included the largest average predator weight ever observed in that location, the third highest average water temperature (14.0 ^{o}C) and the highest average number of salmon prey per smallmouth bass predator (0.12). Higher predation index values can be an artifact of sampling large predators in warm water at peak prey densities (see Equation 7). Vigg et al (1991) found temperature as the most influential single variable regulating consumption rates. This phenomenon highlights the importance of continued monitoring of smallmouth bass abundance and consumption to aid in the characterization of potential compensatory responses to sustained removal of northern pikeminnow among various strata. Changes in predation impacts could occur independently from the NPMP due to environmental factors. With prospects of climate change effects, biotic and abiotic dynamics within food webs, fish communities, and their environment could change and influence the efficacy of management actions to conserve fisheries including attempts at predator control and responses to invasive species.

It is important to acknowledge environmental factors and limits to resources (e.g., time, money) can introduce additional uncertainty into the time series we rely upon to evaluate dynamics within and among predator communities. Guidelines surrounding temperature maxima can limit our ability at times, to sample waters with populations of ESA-listed salmonids. Inter-annual fluctuations in water levels can impact available shoreline habitat in which to sample. Flow regimes, water clarity, and changes in wind velocity can affect our ability to locate and catch fish over short time scales and subsequently impact catch-per-unit-effort. While these factors can affect catches through time, it likely has an equal affect among species and does not change our ability to evaluate inter-specific compensatory responses in a given year. Similarly, factors including time, money and staffing constrain sampling during the biological evaluation component of the NPMP to a three-year rotation. While it is difficult, and in some cases impossible, to control for these externalities in our sampling design, we must nonetheless recognize added sources of uncertainty (e.g., data gaps) when assessing dynamics in space and time and understand the limits to our scope of inference.

The abundance of walleye in specific areas of The Dalles and John Day reservoirs (i.e., tailrace of John Day and McNary dams) evaluated during 2015 was low compared to previous years. Yet, results from our examination of walleye stomach contents, although constrained by sample size, were consistent with past studies conducted throughout the Columbia River in which juvenile salmon were identified as an important component of walleye diets (Poe et al. 1991; Vigg et al. 1991; Zimmerman 1999). This is further substantiated in work conducted by Takata et al. (2007) and Gardner et al. (2013) who found, in The Dalles and John Day reservoirs specifically, juvenile salmon were consumed commonly by walleye. While abundance data from the current study may suggest the predatory burden imposed by walleye on juvenile salmon could be minimal, it is essential to note these data are constrained in both space and time. Given evidence (e.g., diet composition, population dynamics, etc.) provided by others in different areas and over varying periods, it seems plausible that relatively small shifts in population structure could result in an increased predatory impact of walleye in the lower Columbia River system. In light of the predatory potential of walleye on juvenile salmon, and apparent variability therein, further monitoring of demographic characteristics and diets is necessary to detect any increased impacts to juvenile salmon and assess with greater precision long-term trends.

Data collected during 2015 provided no unambiguous indication of the presence of a compensatory response. Previous evaluations of the NPMP also detected no responses by the predator community related directly 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 detect such a response should one occur (Beamesderfer et al. 1996). Thus, continued monitoring to assess the indirect implications of the Northern Pikeminnow Management Program seems warranted. Such monitoring will also serve to evaluate the effectiveness of management actions to conserve fisheries in a context of environmental variability forced by climate change.

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TABLES

Table 1. Numbers of northern pikeminnow tagged and recaptured in the Sport Reward Fishery during 2015 by location and size class.

	200–249 mm FL		≥ 250 mm FL		Combined	
Reach/Reservoir	Tagged	Recaptured	Tagged	Recaptured	Tagged	Recaptured
Below Bonneville Dam	106	2	438	73	544	75
Bonneville	37	3	127	18	164	21
The Dalles	20	0	11	1	32[b]	1
John Day	44	0	23	2	67	2
McNary	219	1[a]	87	0	307[b]	1
Little Goose	62	1	18	0	80	1
Lower Granite	128	13	87	19	220[b]	32
Areas combined	616	20	791	113	1,414	133

Note: [a]Recaptured in McNary Reservoir during the same week in which it was tagged, and therefore not included in calculations of exploitation to avoid violating mark-recapture assumptions (i.e., incomplete mixing).

[b]Fork Lengths for seven tagged northern pikeminnow (The Dalles Reservoir = 1, Lower Granite Reservoir = 5, McNary Reservoir = 1) were not recorded. Thus, these fish were not included in calculations of size-specific exploitation rates (i.e., 200–249 mm or ≥250mm).

Table 2. Time series of annual exploitation rates (%) of northern pikeminnow (≥ 200 mm) in the Sport Reward Fishery by location.

Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	Little Goose	Lower Granite	All areas
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	9.0	*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	6.9	4.7	9.6
2014	7.7	8.5	5.5	*a*	11.3	11.1	3.7	9.0
2015	13.8	12.9	*a*	*a*	*a*	*a*	15.6	12.4
mean (s.d.)	14.3 (4.4)	10.1 (2.3)	14.2 (6.9)	*a*	11.1 (5)	15 (9.9)	15.4 (17.5)	12.9 (2.8)

Note: *a* = no exploitation calculated (n ≤ 3)
dashes (–) indicate no sampling conducted.
Sport Reward Fishery regulations changed in 2000 to allow angler retention of northern pikeminnow ≥ 200 mm FL. During prior years (1991-1999) of the Sport Reward Fishery, retention was limited to northern pikeminnow ≥ 250 mm FL.

Table 3. Time series of annual exploitation rates (%) of northern pikeminnow (200–249 mm) in the Sport Reward Fishery by location.

Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	Little Goose	Lower Granite	All areas
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
2014	3.0	*a*	*a*	*a*	3.7	11.0	*a*	5.3
2015	*a*	*a*	*a*	*a*	*a*	*a*	10.6	4.5
mean (s.d.)	7.8 (4.9)	7.7 (3.5)	10.5	*a*	7.1 (3.7)	9.7 (5.8)	6 (6.6)	6.9 (2.8)

Note: *a* = no exploitation calculated (n ≤ 3).
dashes (–) indicate no sampling conducted.
Sport Reward Fishery regulations changed in 2000 to allow angler retention of northern pikeminnow ≥ 200 mm FL. During prior years (1991-1999) of the Sport Reward Fishery, retention was limited to northern pikeminnow ≥ 250 mm FL.

Table 4. Time series of annual exploitation rates (%) of northern pikeminnow (≥ 250 mm) in the Sport Reward Fishery by location.

Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	Little Goose	Lower Granite	All areas
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	*a*	22.4	2.9	6.4	13.4
1996	12.7	6.1	15.5	*a*	18.2	8.9	11.7	12.1
1997	7.8	8.0	5.8	*a*	16.5	*a*	15.5	8.9
1998	8.2	7.8	12.8	*a*	13.6	*a*	12.1	11.1
1999	9.6	13.9	16.1	3.7	15.9	*a*	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
2014	9.2	6.9	*a*	*a*	17.9	*a*	11.3	11.5
2015	16.7	14.3	*a*	*a*	*a*	*a*	24.4	17.2
mean (s.d.)	13.8 (4.5)	9.8 (3.3)	14.2 (5.3)	3.1 (0.5)	14.5 (6.4)	12.1 (9.9)	13.4 (6.2)	13.7 (3)

Note: *a* = no exploitation calculated (n ≤ 3).
dashes (–) indicate no sampling conducted.

Table 5. Number of 15-minute boat electrofishing runs by sampling year and location conducted during biological evaluation in The Dalles and John Day reservoirs, 1990–2015. FB = forebay; Mid = mid-reservoir; TR = tailrace.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	62	34	56	56	60	54
1991	-	-	-	61	58	59
1992	-	-	-	68	62	64
1993	37	38	26	44	43	46
1994	92	-	48	91	43	74
1995	62	-	35	74	94	82
1996	59	-	31	54	52	71
1999	-	-	71	52	-	62
2004	-	-	18	28	17	68
2006	78	95	74	75	80	76
2009	76	60	79	65	95	70
2012	64	80	70	67	66	77
2015	36	48	40	40	44	37

Note: dashes (–) indicate no sampling conducted.
2015 sampling effort was reduced due to water temperatures exceeding 18°C, a federally mandated limit (NMFS 2000).

Table 6. Catch per unit effort (CPUE) for northern pikeminnow (≥250 mm FL), smallmouth bass (≥200 mm FL), and walleye (≥200 mm FL) by season and location captured during biological evaluation in The Dalles and John Day reservoirs, 2015. FB = forebay; Mid = mid-reservoir; TR = tailrace.

Species,	The Dalles Reservoir			John Day Reservoir		
Season	FB	Mid	TR	FB	Mid	TR
Northern pikeminnow,						
Spring	0.03	0.02	0.15	0.00	0.00	0.03
Summer	–	–	–	–	–	–
Smallmouth bass,						
Spring	2.78	4.02	1.15	2.28	2.50	0.35
Summer	–	–	–	–	–	–
Walleye,						
Spring	0.03	0.15	0.23	0.00	0.00	0.43
Summer	–	–	–	–	–	–

Note: dashes (–) indicated no sampling conducted; standard effort = 15 minute boat electrofishing run at 4 amperes. Summer sampling in 2015 was precluded by water temperatures exceeding 18^{0}C, a federally mandated limit (NMFS 2000).

Table 7. Annual abundance index values (catch per 15-minute electrofishing run, scaled to surface area) for northern pikeminnow (≥ 250 mm FL) during spring in The Dalles and John Day reservoirs, 1990–2015. FB = forebay; Mid = mid-reservoir; TR = tailrace.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	1.13	1.80	4.62	0.57	3.38	10.00
1991	—	—	—	1.22	5.06	10.89
1992	—	—	—	2.45	3.27	1.50
1993	1.30	2.80	0.76	0.82	1.78	1.38
1994	0.65	—	—	0.90	2.56	0.94
1995	1.03	—	—	0.57	0.41	0.62
1996	0.61	—	—	0.33	2.67	0.97
1999	—	—	0.18	0.57	—	0.34
2004	—	—	0.98	0.00	0.00	0.33
2006	0.38	1.27	0.06	0.16	1.15	0.32
2009	0.14	0.66	0.00	0.08	0.41	0.20
2012	0.14	0.34	0.08	0.08	1.84	0.00
2015	0.04	0.08	0.18	0.00	0.00	0.05
mean (s.d.)	0.6 (0.47)	1.16 (1.02)	0.86 (1.56)	0.6 (0.67)	1.88 (1.58)	2.12 (3.73)

Note: dashes (–) indicate no sampling conducted.

Table 8. Annual abundance index values (catch per 15-minute electrofishing run, scaled to surface area) for smallmouth bass (≥ 200 mm FL) during spring in The Dalles and John Day reservoirs, 1990–2015. FB = forebay; Mid = mid-reservoir; TR = tailrace.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	0.76	2.16	0.77	2.77	44.61	0.08
1991	—	—	—	4.00	62.60	0.59
1992	—	—	—	2.12	9.80	0.17
1993	3.77	17.95	2.79	2.86	60.59	0.77
1994	1.83	—	—	6.20	38.35	1.15
1995	5.26	—	—	6.20	51.86	0.52
1996	4.15	—	—	2.12	71.28	0.32
1999	—	—	0.95	1.14	—	0.24
2004	—	—	0.00	11.01	58.81	1.00
2006	6.37	20.66	2.41	9.30	120.49	3.10
2009	1.92	5.29	1.23	5.38	84.94	0.55
2012	6.74	20.08	2.10	7.91	104.75	0.85
2015	3.61	15.94	1.36	7.42	49.01	0.66
mean (s.d.)	3.82 (2.07)	13.68 (7.95)	1.45 (0.93)	5.27 (3.07)	63.09 (29.72)	0.77 (0.77)

Note: dashes (–) indicate no sampling conducted.

Table 9. Annual abundance index values (catch per 15-minute electrofishing run, scaled to surface area) for walleye (≥200 mm FL) during spring in The Dalles and John Day reservoirs, 1990–2015. FB = forebay; Mid = mid-reservoir; TR = tailrace.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	0.00	0.36	0.46	0.00	0.00	0.32
1991	—	—	—	0.00	1.26	0.89
1992	—	—	—	0.00	0.00	1.17
1993	0.48	2.80	1.77	0.00	1.78	1.08
1994	0.00	—	—	0.00	0.00	1.91
1995	0.11	—	—	0.13	0.00	1.24
1996	0.16	—	—	0.00	0.00	1.81
1999	—	—	0.56	0.00	—	0.92
2004	—	—	0.00	0.00	5.77	1.50
2006	0.07	0.42	0.53	0.00	0.00	3.84
2009	0.17	0.66	0.43	0.00	2.04	1.10
2012	0.03	0.17	0.28	0.00	2.45	2.27
2015	0.04	0.58	0.27	0.00	0.00	0.86
mean (s.d.)	0.12 (0.15)	0.83 (0.98)	0.54 (0.53)	0.01 (0.04)	1.11 (1.74)	1.45 (0.88)

Note: dashes (–) indicate no sampling conducted.

Table 10. Number (n) of northern pikeminnow, smallmouth bass, and walleye (≥200 mm FL) digestive tracts examined from The Dalles and John Day reservoirs during spring 2015, and proportion of samples containing food, fish, and salmonids (Sal).

	northern pikeminnow					smallmouth bass					walleye				
Reach/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}	$\hat{p}_{Food}$	$\hat{p}_{Fish}$	$\hat{p}_{Sal}$
The Dalles Reservoir	9	0	1.00	0.89	0.44	291	46	0.86	0.22	0.05	14	3	0.82	0.53	0.35
John Day Reservoir	3	1	0.75	0.00	0.00	191	23	0.89	0.30	0.14	14	2	0.88	0.63	0.44
All	12	1	0.92	0.62	0.31	482	69	0.87	0.25	0.09	28	5	0.85	0.58	0.39

Table 11. Proportion of diet samples containing specific prey fish families collected from northern pikeminnow, smallmouth bass, and walleye during spring in The Dalles and John Day reservoirs, 2015.

	northern pikeminnow	smallmouth bass		walleye	
Common name (Family)	The Dalles Reservoir	The Dalles Reservoir	John Day Reservoir	The Dalles Reservoir	John Day Reservoir
suckers (Catostomidae)	0.00	0.00	0.02	0.22	0.00
sunfishes (Centrarchidae)	0.00	0.01	0.00	0.00	0.00
sculpins (Cottidae)	0.00	0.41	0.28	0.00	0.30
minnows (Cyprinidae)	0.00	0.05	0.02	0.22	0.00
perches (Percidae)	0.00	0.01	0.00	0.00	0.00
salmon and trout (Salmonidae)	0.50	0.23	0.48	0.67	0.70
unidentified	0.50	0.36	0.25	0.11	0.00

Note: Multiple families may be represented in the gut contents of some individual fish. See Table 11 for sample sizes.

Table 12. Annual consumption index values for northern pikeminnow (≥ 250 mm FL) that were captured during indexing years in spring from The Dalles and John Day reservoirs by river reach, 1990–2015. FB = Forebay; Mid = Mid-reservoir; TR = Tailrace.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	0.79	0.00	0.81	1.49	0.00	2.29
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	2.26	0.00	0.96
1993	0.09	0.20	0.00	—	—	—
1994	0.20	—	—	1.74	*a*	0.49
1995	0.00	—	—	1.49	*a*	1.06
1996	0.00	—	—	*a*	*a*	0.50
1999	—	—	0.47	1.35	—	1.66
2004	—	—	*a*	*a*	*a*	0.00
2006	0.00	0.54	*a*	*a*	*a*	0.32
2009	*a*	*a*	*a*	*a*	*a*	*a*
2012	*a*	*a*	*a*	*a*	*a*	*a*
2015	*a*	*a*	2.88	*a*	*a*	*a*
mean (s.d.)	0.18 (0.31)	0.25 (0.27)	1.04 (1.27)	1.67 (0.36)	0 (0)	0.91 (0.76)

Note: *a* = sample size insufficient (n≤5) to calculate consumption index.
dashes (–) indicate no sampling conducted.

Table 13. Annual predation index values for northern pikeminnow (≥ 250 mm FL) that were captured during indexing years in spring from The Dalles and John Day reservoirs by river reach, 1990–2015. FB = Forebay; Mid = Mid-reservoir; TR = Tailrace.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	1.17	0.00	5.13	2.18	0.00	22.55
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	5.59	0.00	4.87
1993	0.14	0.43	0.00	—	—	—
1994	0.14	—	—	2.36	*a*	0.67
1995	0.00	—	—	0.79	*a*	0.67
1996	0.00	—	—	*a*	*a*	0.48
1999	—	—	0.35	0.41	—	0.71
2004	—	—	*a*	*a*	*a*	0.00
2006	0.00	0.41	*a*	*a*	*a*	0.06
2009	*a*	*a*	*a*	*a*	*a*	*a*
2012	*a*	*a*	*a*	*a*	*a*	*a*
2015	*a*	*a*	0.42	*a*	*a*	*a*
mean (s.d.)	0.24 (0.46)	0.28 (0.24)	1.48 (2.44)	2.27 (2.04)	0 (0)	3.75 (7.76)

Note: *a* = sample size insufficient (n≤5) to calculate predation index value.
dashes (–) indicate no sampling conducted.

Table 14. Annual consumption index values for smallmouth bass (≥ 200 mm FL) during spring in The Dalles and John Day reservoirs, 1990–2015. FB = forebay; Mid = mid-reservoir; TR = tailrace.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	0.60	–	0.00	0.08	0.00	*a*
1991	–	–	–	*a*	*a*	*a*
1992	–	–	–	0.09	0.00	–
1993	0.00	0.03	0.00	–	–	–
1994	0.00	–	–	0.06	0.00	0.00
1995	0.01	–	–	0.00	0.00	0.00
1996	0.00	–	–	0.00	0.00	0.00
1999	–	–	0.00	0.04	–	0.00
2004	–	–	*a*	0.07	0.04	*a*
2006	0.00	0.01	0.00	0.00	0.01	0.02
2009	0.04	0.02	0.00	0.00	0.00	0.00
2012	0.12	0.02	0.06	0.03	0.01	0.04
2015	0.13	0.00	0.03	0.09	0.12	0.23
mean (s.d.)	0.1 (0.19)	0.02 (0.01)	0.01 (0.02)	0.04 (0.04)	0.02 (0.04)	0.04 (0.08)

Note: *a* = sample size insufficient (n≤5) to calculate consumption index.
dashes (–) indicate no sampling conducted.

Table 15. Annual predation index values for smallmouth bass (≥200 mm FL) during spring in The Dalles and John Day reservoirs, 1990–2015. FB = forebay; Mid = mid-reservoir; TR = tailrace.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	0.45	0.00	0.00	0.23	0.00	*a*
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	0.18	0.00	*a*
1993	0.00	0.59	0.00	—	—	—
1994	0.00	—	—	0.37	0.00	0.00
1995	0.05	—	—	0.00	0.00	0.00
1996	0.00	—	—	0.00	0.00	0.00
1999	—	—	0.00	0.05	—	0.00
2004	—	—	*a*	0.80	2.27	*a*
2006	0.00	0.30	0.00	0.00	1.12	0.07
2009	0.09	0.11	0.00	0.00	0.27	0.00
2012	0.84	0.45	0.12	0.25	1.44	0.03
2015	0.48	0.00	0.04	0.67	5.95	0.15
mean (s.d.)	0.21 (0.31)	0.24 (0.25)	0.02 (0.04)	0.23 (0.28)	1.1 (1.88)	0.03 (0.05)

Note: *a* = sample size insufficient (n≤5) to calculate predation index value.
dashes (–) indicate no sampling conducted.

Table 16. Fork length (mm) characteristics of northern pikeminnow sampled annually for evaluation of diet at Bonneville (2006), The Dalles (2006-2015), and John Day (2007-2015) dams.

Dam, Year	n	Minimum	Maximum	Mean	Median
Bonneville,					
2006	22	267	544	425	438
The Dalles,					
2006	128	212	549	360	342
2007	340	229	550	343	333
2008	209	200	518	356	350
2009	223	187	545	377	370
2010	391	185	545	366	364
2011	321	219	574	366	368
2012	324	210	525	332	314
2013	226	234	534	329	314
2014	496	222	600	347	337
2015	563	184	570	315	306
John Day,					
2007	393	230	553	366	358
2008	64	265	550	377	365
2009	223	251	572	403	394
2010	384	210	575	376	376
2011	282	230	515	361	359
2012	492	230	545	344	320
2013	463	208	548	346	323
2014	363	251	578	384	365
2015	422	220	590	349	345
All dams and years	6,329	184	600	361	354

Table 17. Number (n) of northern pikeminnow (FL ≥ 250mm) digestive tracts examined from Bonneville (2006), The Dalles (2006-2015), and John Day (2007-2015) dams, and proportion of samples containing specific prey items (Sal=salmon/steelhead, 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
2014	282	207	0.58	0.46	0.07	0.13	0.08	0.19	0.47	0.19	0.42
2015	357	117	0.75	0.53	0.13	0.29	0.13	0.07	0.53	0.21	0.15
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
2014	263	100	0.72	0.44	0.31	0.27	0.01	0.18	0.46	0.14	0.36
2015	266	71	0.79	0.45	0.24	0.37	0.04	0.14	0.45	0.12	0.16

Table 18. Proportion of diet samples containing specific prey fish families for northern pikeminnow collected from the tailraces of The Dalles and John Day dams during May through August, 2015.

Common name (Family)	May [a]	June	July	August	Total
Lampreys (Petromyzontidae)	0.60	0.54	0.05	0.04	0.29
Shad (Clupeidae)	0.05	0.01	0.55	0.77	0.35
Salmon and Trout (Salmonidae)	0.35	0.33	0.13	0.01	0.20
Minnows (Cyprinidae)	0.00	0.00	0.12	0.01	0.03
Suckers (Catostomidae)	0.00	0.00	0.03	0.00	0.01
Sunfishes (Centrarchidae)	0.00	0.00	0.00	0.01	0.00
Perches (Percidae)	0.00	0.00	0.14	0.01	0.04
Catfishes (Ictaluridae)	0.00	0.00	0.03	0.00	0.01
Sculpins (Cottidae)	0.00	0.01	0.03	0.04	0.02
Unidentified	0.19	0.25	0.23	0.20	0.23

Note: [a] Sampling began 19 May 2015.
Multiple families were represented in the gut contents of some northern pikeminnow.

FIGURES

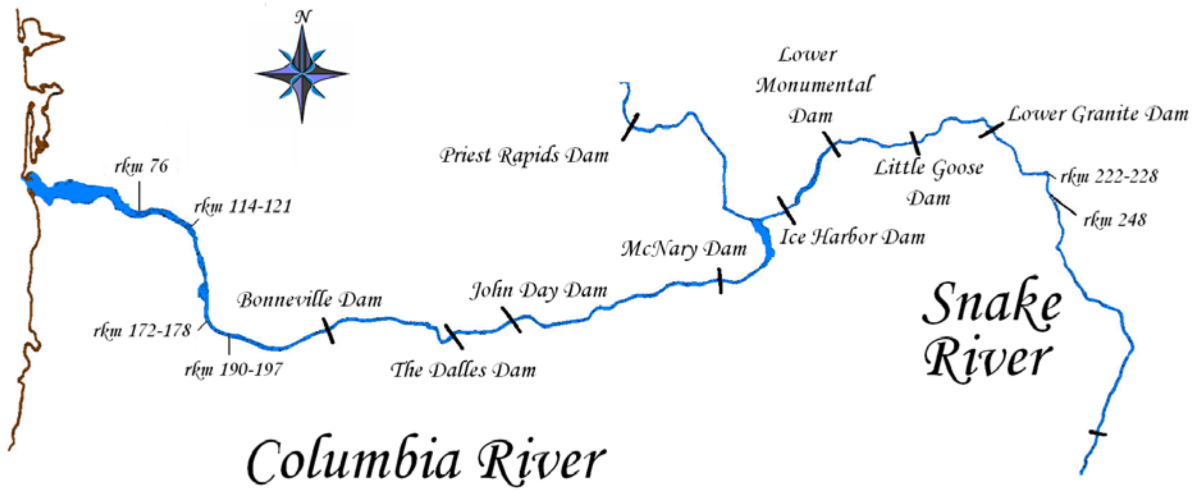

Figure 1. Study area in the Columbia and Snake rivers.

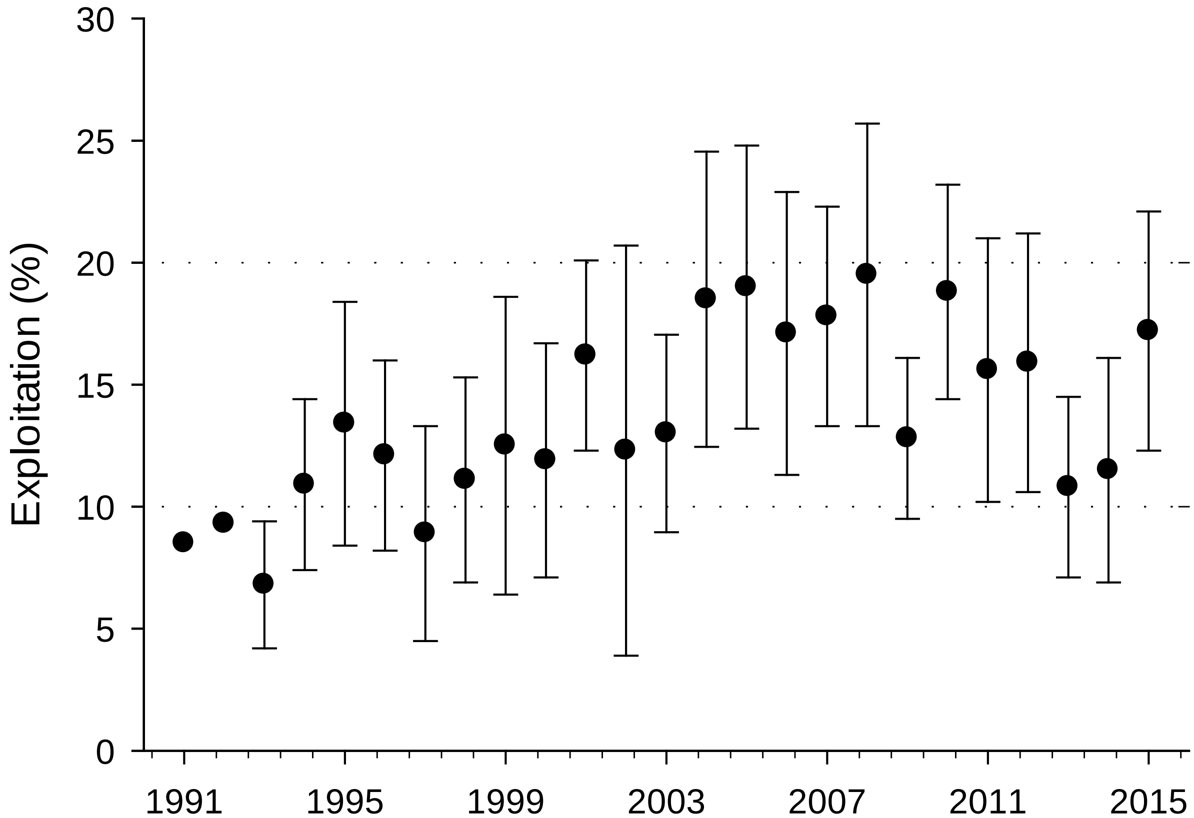

Figure 2. System-wide exploitation rates of northern pikeminnow (≥250 mm FL) in the Sport Reward Fishery, 1991–2015. Error bars represent 95% confidence intervals. Variation was not estimated for the years 1991–1992. Target exploitation is 10-20% (dashed lines).

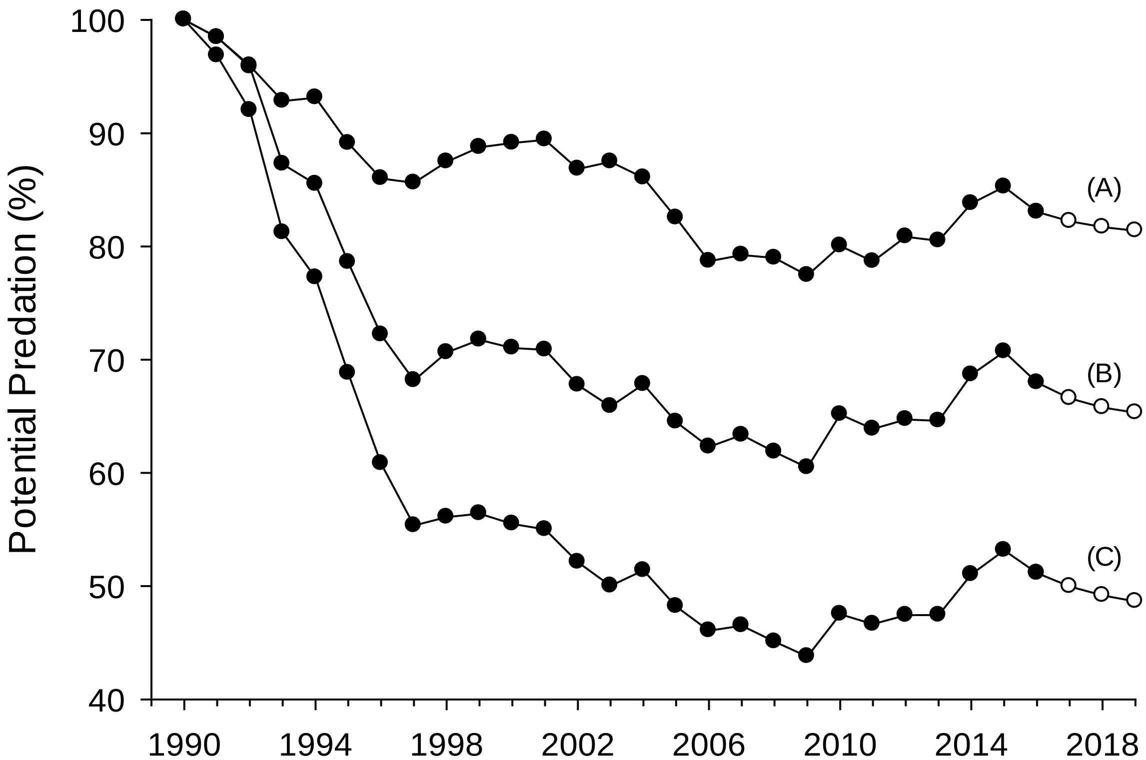

Figure 3. Maximum (A), median (B) and minimum (C) annual levels of potential predation by northern pikeminnow on juvenile salmon relative to predation levels before implementation of the Northern Pikeminnow Management Program. For the years 1991-2016, model estimates (filled circles) are based on exploitation levels from the previous year. Model forecast predictions after 2016 (open circles) are based on average exploitation estimates from years with similar fishery structure (2001, 2004-2015).

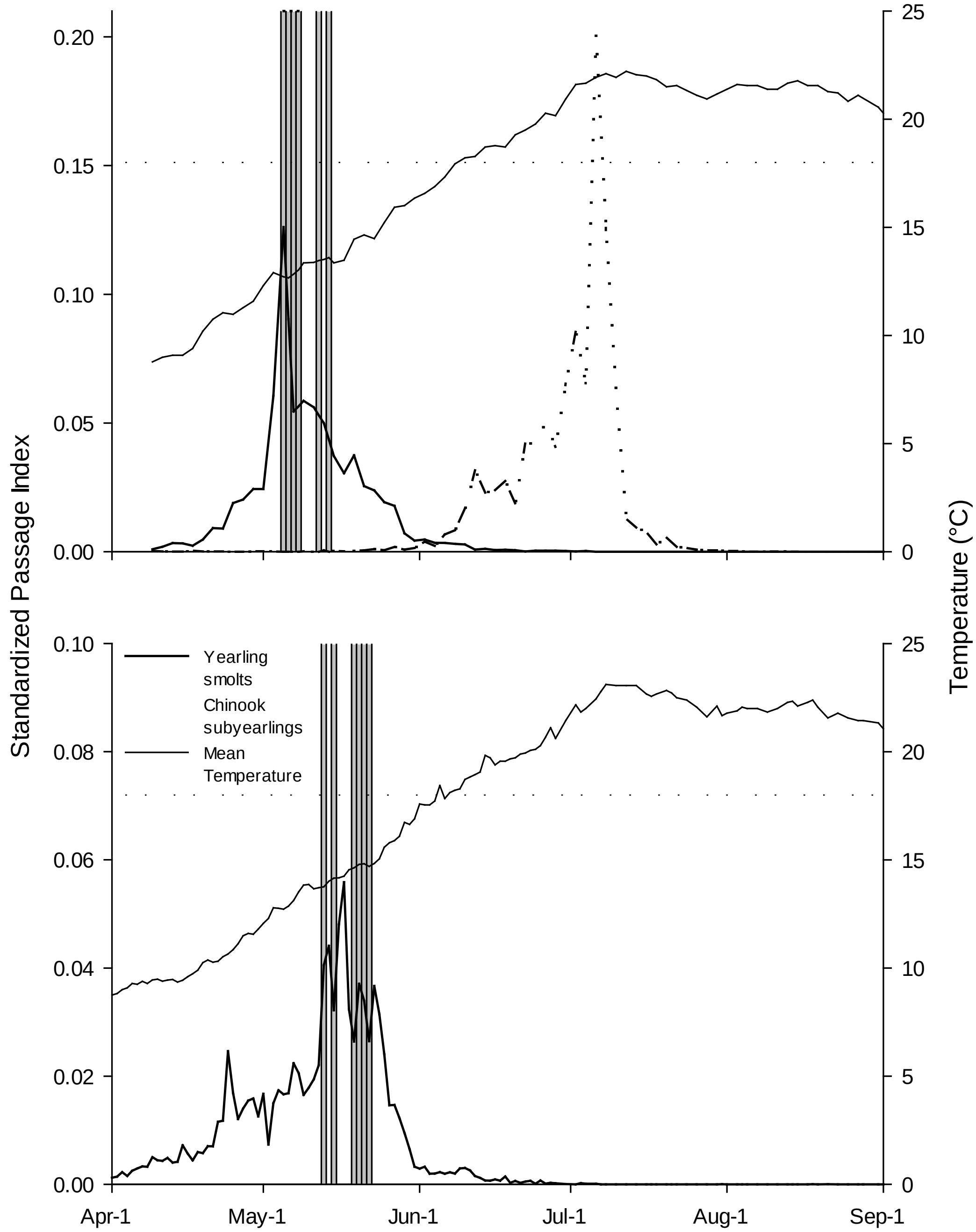

Figure 4. Periods of index sampling (shaded bars) in John Day (top panel) and The Dalles (bottom panel) reservoirs and yearling and subyearling smolt passage indices of juvenile salmon through McNary (top panel) and John Day (bottom panel) dams, 1 April – 31 August 2015. The dashed horizontal line marks the 18°C maximum electroshocking temperature threshold in anadromous waters per NOAA guidance and the thin solid line is the average daily temperature at the tailwater water quality monitoring sites of McNary (top panel) and John Day (bottom panel) dams (Source: adapted from Fish Passage Center unpublished data).

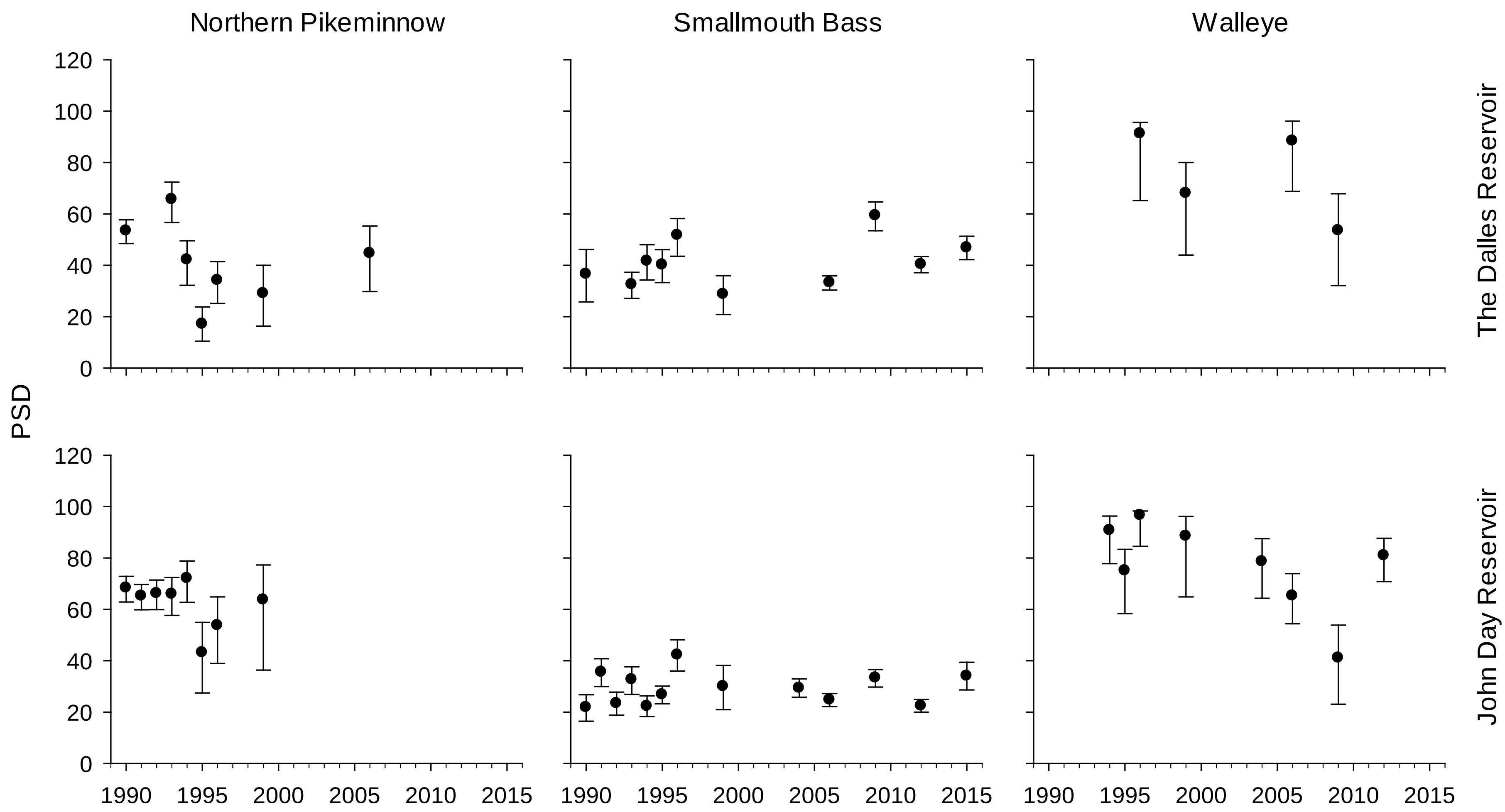

Figure 5. Proportional stock density estimates for northern pikeminnow, smallmouth bass and walleye in The Dalles and John Day reservoirs, 1990–2015. Data were collected during Biological Evaluation sampling. Error bars represent 95% bootstrap confidence intervals.

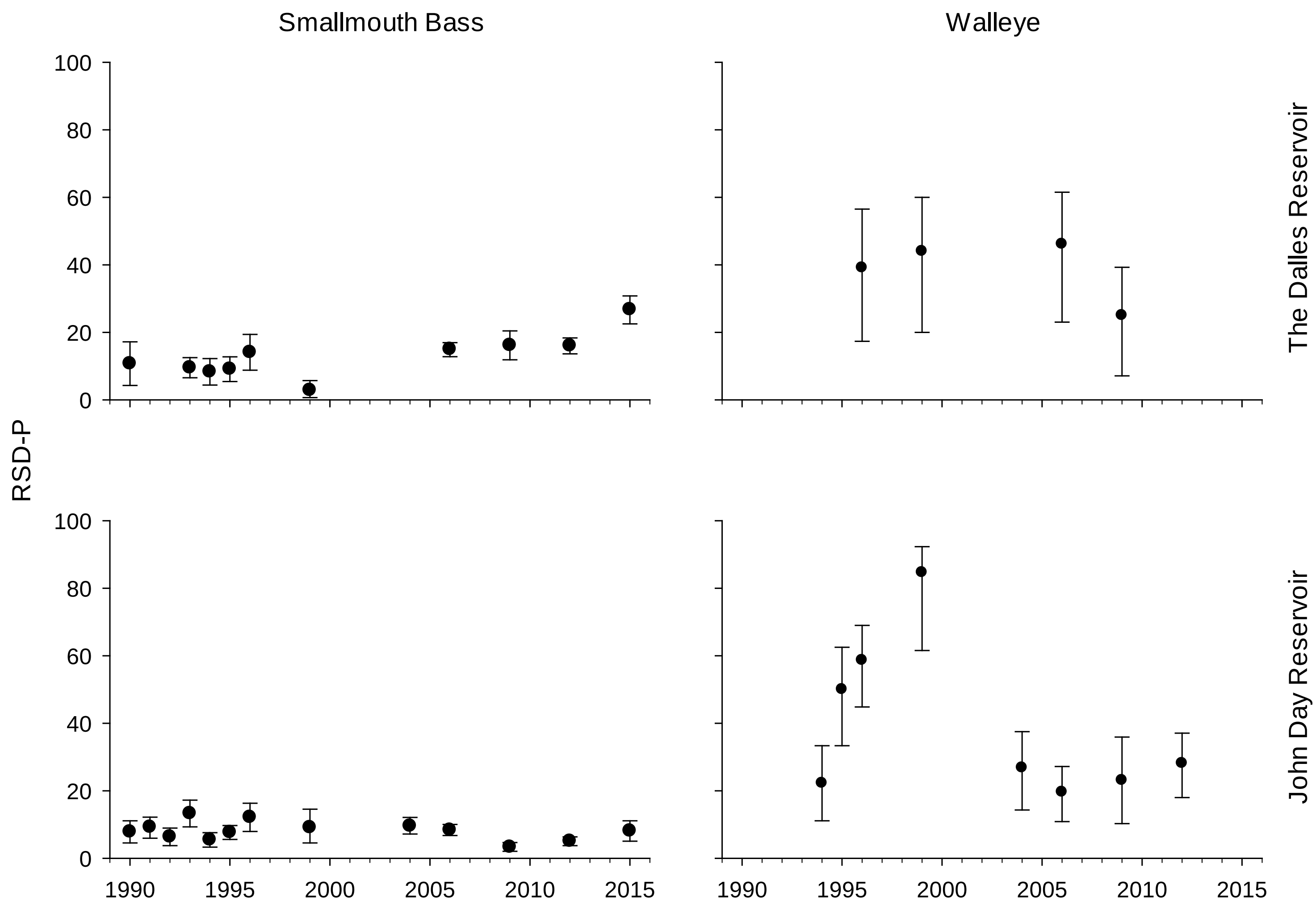

Figure 6. Relative stock density estimates for smallmouth bass and walleye in The Dalles and John Day reservoirs, 1990–2015. Data were collected during Biological Evaluation sampling. Error bars represent 95% bootstrap confidence intervals.

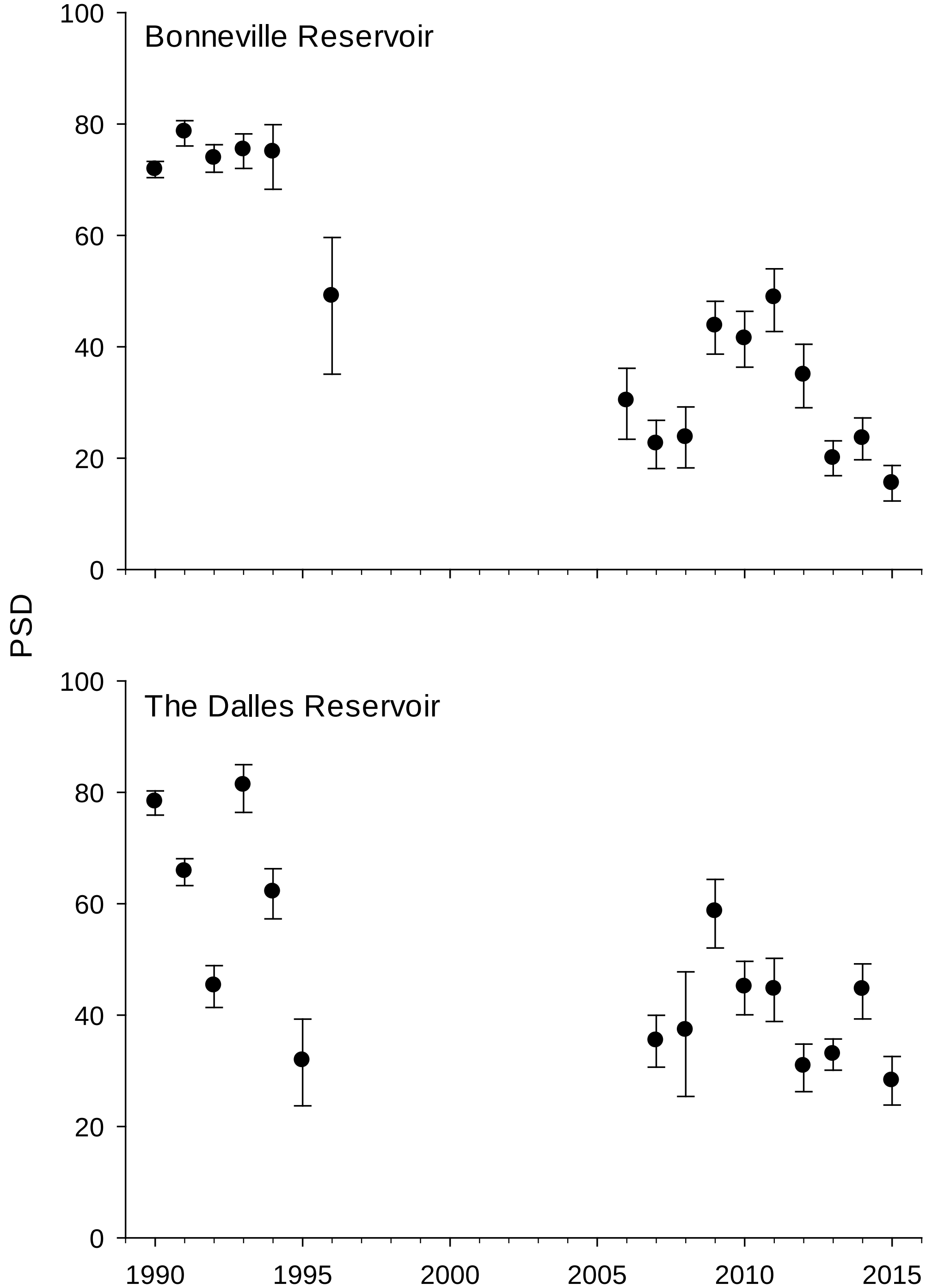

Figure 7. Proportional stock density estimates for northern pikeminnow sampled in Bonneville and John Day reservoirs during the annual Dam Angling Fishery, 1990–2015. Error bars represent 95% bootstrap confidence intervals.

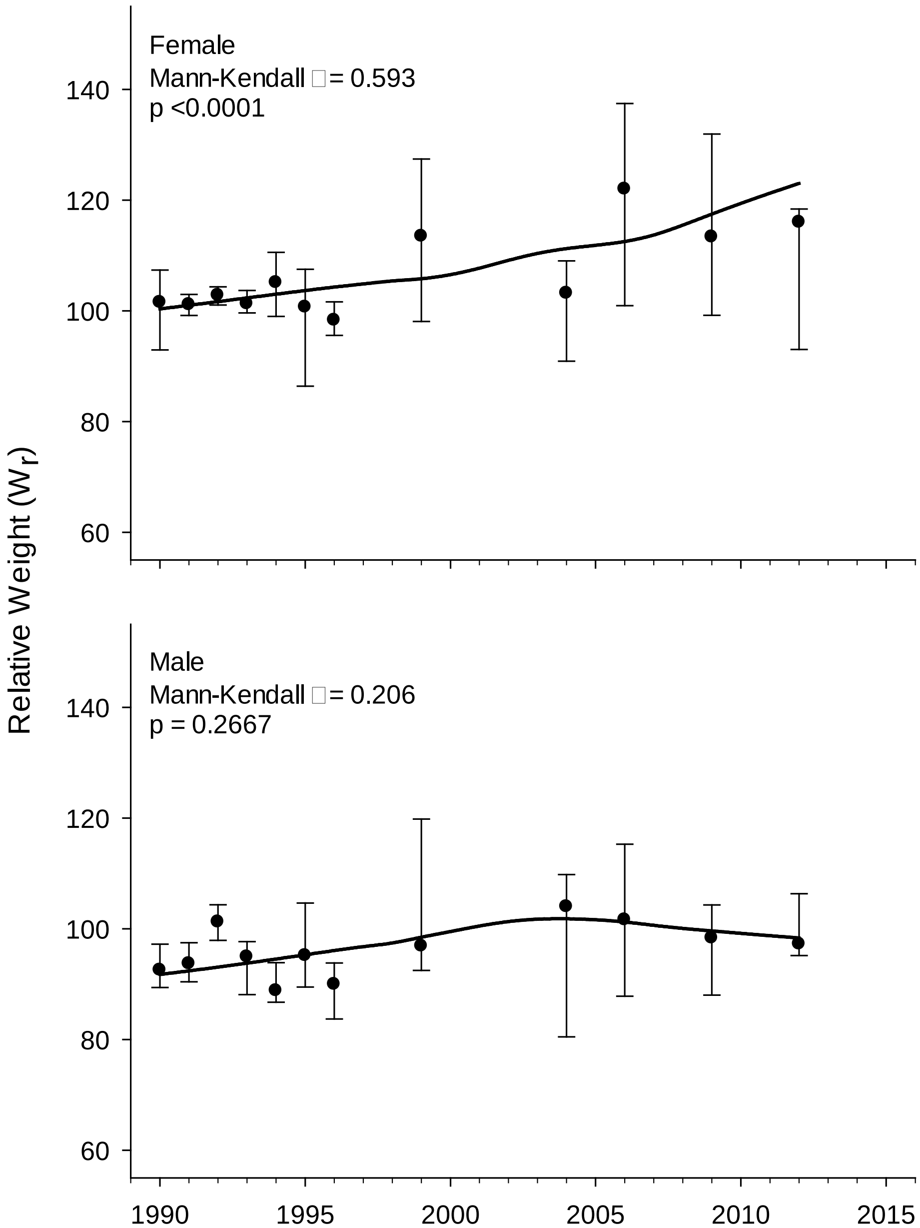

Figure 8. Median relative weight (Wr) for male and female northern pikeminnow in John Day Reservoir, 1990–2015. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or no fish were collected.

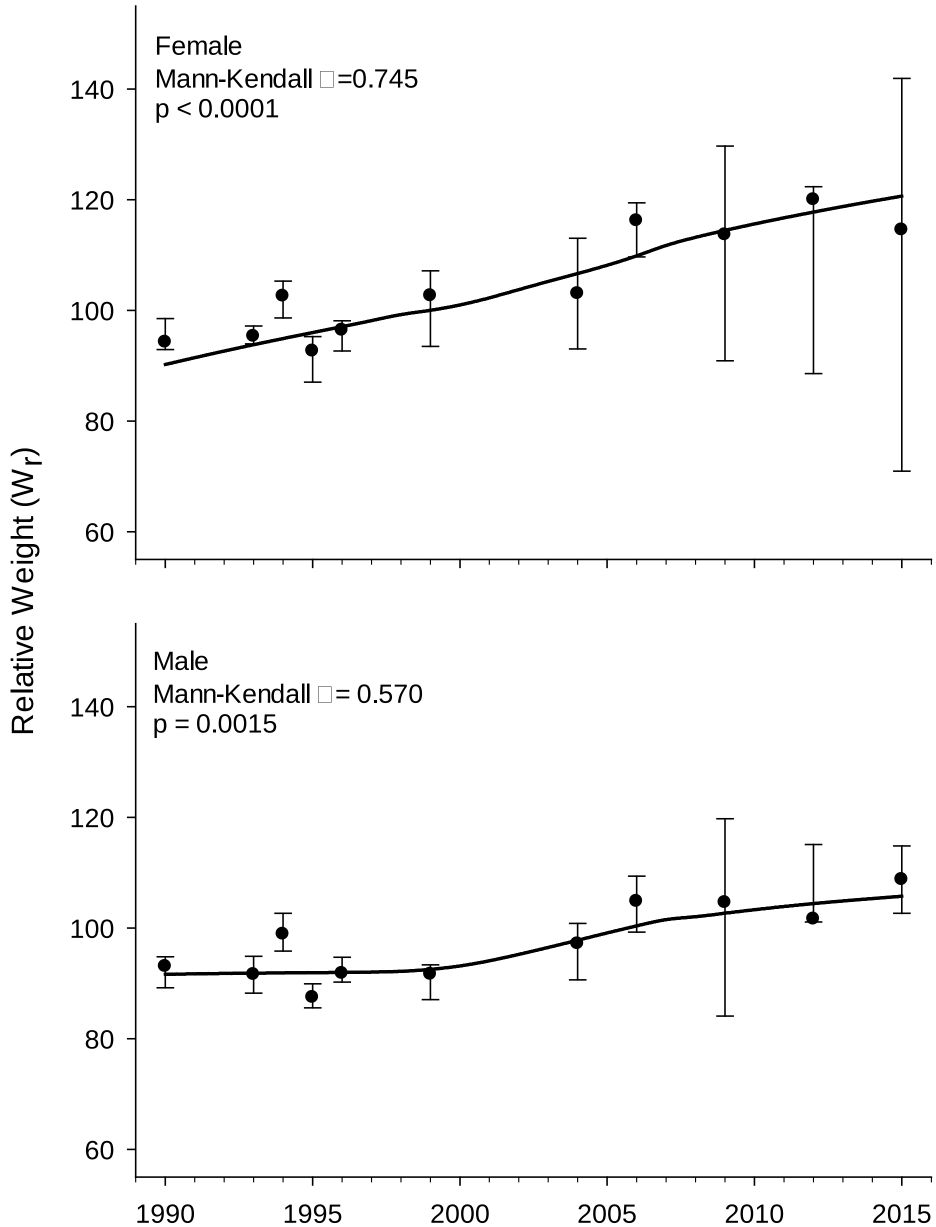

Figure 9. Median relative weight (Wr) for male and female northern pikeminnow in The Dalles reservoir, 1990–2015. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or no fish were collected.

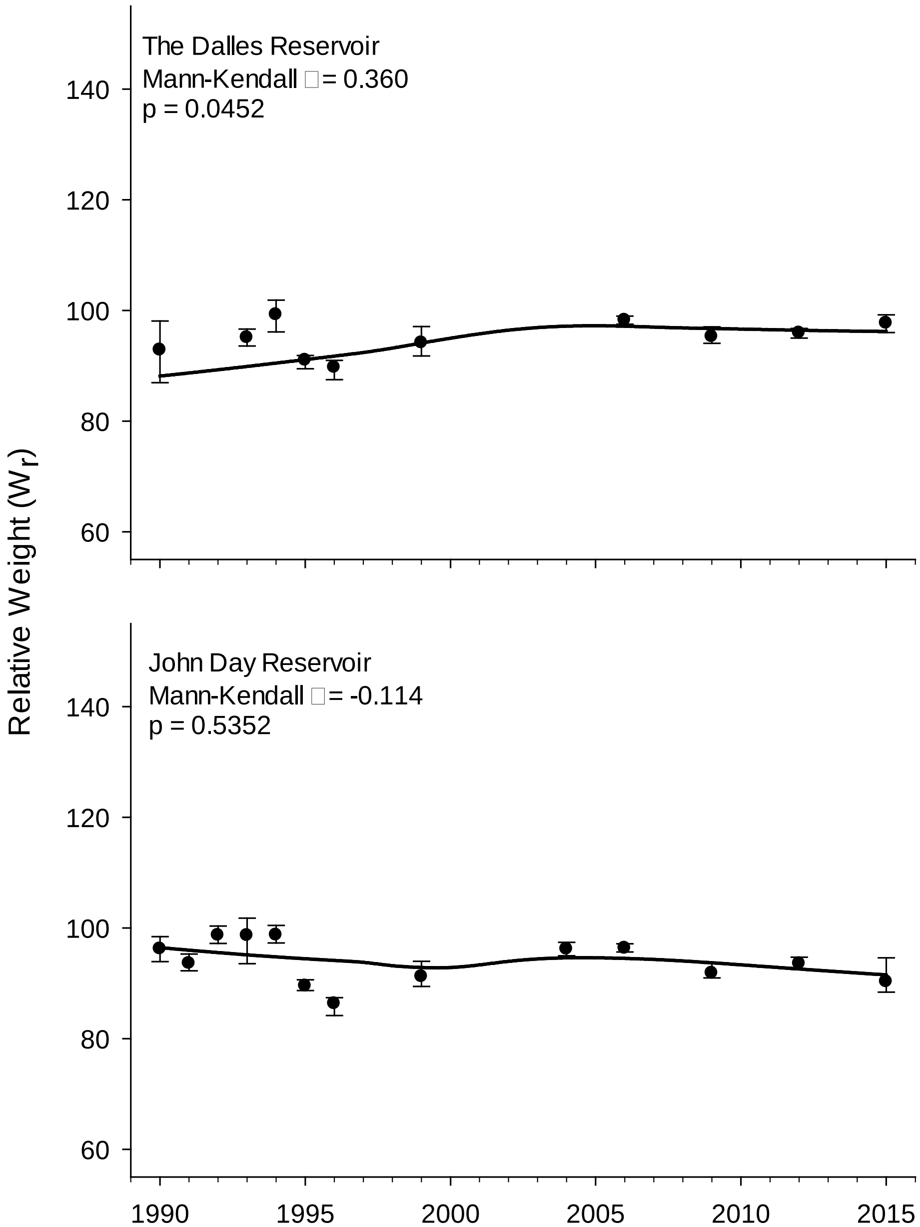

Figure 10. Median relative weight (Wr) for smallmouth bass in The Dalles and John Day reservoirs, 1990–2015. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or no fish were collected.

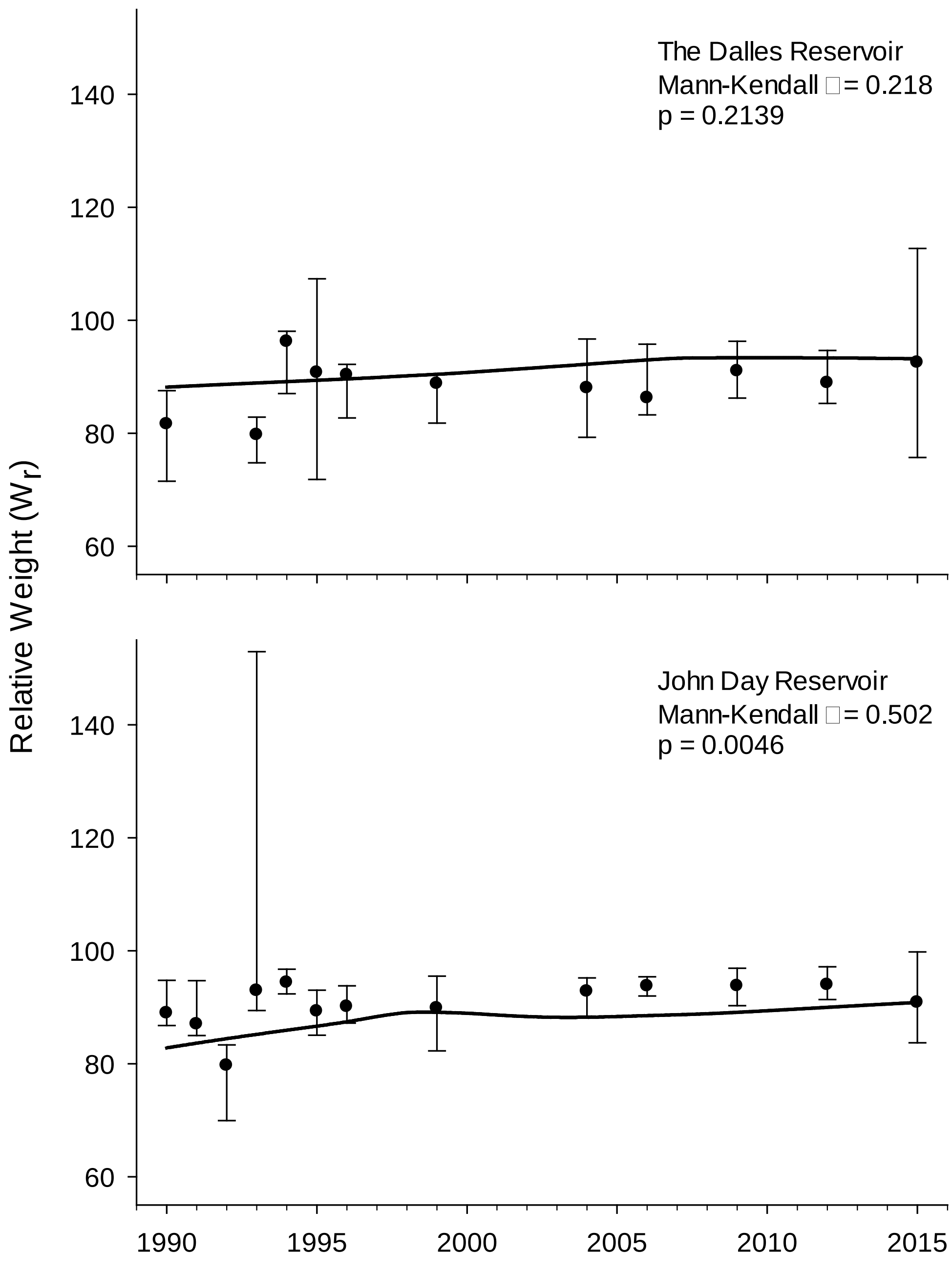

Figure 11. Median relative weight (Wr) for walleye in The Dalles and John Day reservoirs, 1990–2015. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or no fish were collected.

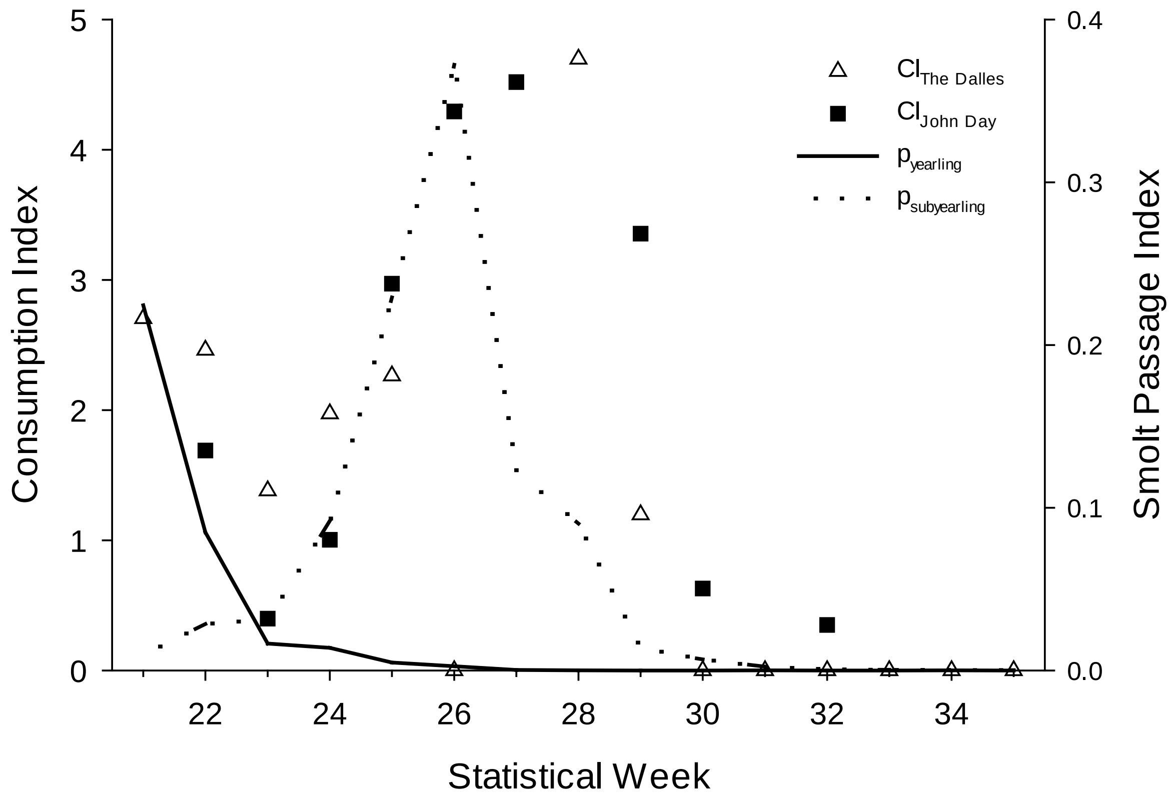

Figure 12. Mean weekly juvenile salmon consumption index for northern pikeminnow captured at The Dalles and John Day dams and smolt passage index at John Day Dam during 2015. Smolt passage data are summarized from Fish Passage Center unpublished data.

Northern Pikeminnow Dam Angling on the Columbia River

2015 Annual Report

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We appreciate the efforts of Scott Mengis as the Pikeminnow Dam Angling crew leader, along with Kyle Beckley, Tim Miller, and Bryce Doherty who served as our 2015 dam angler crew.

We also recognize Diana Murillo and Stacey Remple for their work on Dam Angler data entry and document verification, and Melissa Dexheimer for producing the Dam Angling Weekly Field Activity Reports throughout the 2015 season.

ABSTRACT

We are reporting on the 2015 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 during 23 weeks from May 5th through October 11th 2015. 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 2015 Dam Angling crew.

A Dam Angling crew of four anglers harvested 7,693 northern pikeminnow in 2015. Of those, 4,566 northern pikeminnow were harvested at The Dalles Dam and 3,127 were harvested at the John Day Dam. The crew fished a total of 2,247.75 hours during the 23 week fishery, averaging 334 fish per week and for a combined overall average catch per angler hour of 3.42 northern pikeminnow. At The Dalles Dam, the crew averaged 3.65 fish per angler hour (CPUE), and cumulatively 55 northern pikeminnow per day. At the John Day Dam, the crew averaged 3.14 fish per angler hour (CPUE) with a cumulative crew total of 43 fish per day.

Based on the success of the WDFW Dam Angling crew in implementing the Dam Angling project from 2010-14, the 2015 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 2015 were smallmouth bass *Micropterus dolomieue*, walleye *Sander vitreus* 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 (Northwest Power Planning Council 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 $\geq$ 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. 2011, Dunlap et al. 2012, Winther et al. 2013, Dunlap et al. 2014, Dunlap et al. 2015) and 2015 marks the sixth 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 in 2015.

The objectives of the 2015 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 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 2015 Dam Angling crew.

METHODS

Project Area

In 2015, 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 2015 were planned for a five month period scheduled to be from May 5th (week 19) through October 11th (week 41). 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).

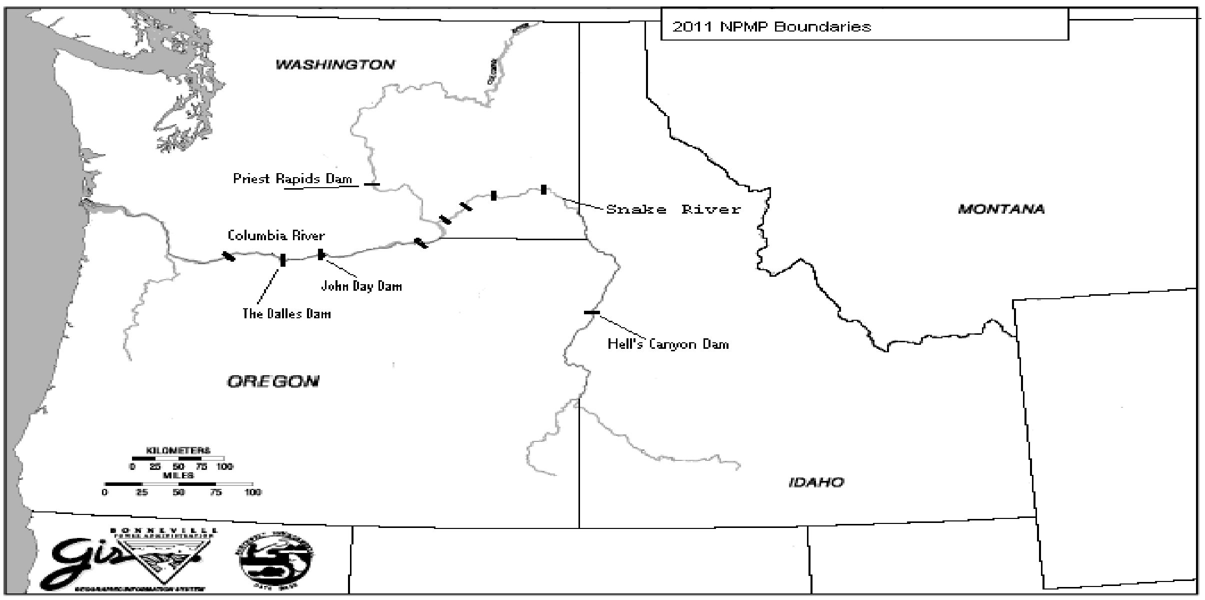

Figure 1. Northern Pikeminnow Management Program boundaries, including 2015 Dam Angling sites.

Figure 2. Angling locations for the 2015 Dam Angling crew at The Dalles Dam.

Figure 3. Angling locations for the 2015 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 continued to use our Dam Angling Strategy (DAS) established in 2011 (Dunlap et al. 2012) for allocating Dam Angler effort in 2015. The 2015 Dam Angler CPUE goal remained set at 2.0 fish/angler hour as established in our 2011 DAS. Full scale angling activities were conducted when CPUE was $\geq$ 2.0 fish/angler hour, and reduced scale angling was conducted when CPUE fell below 2.0 fish/angler hour.

The Dam Angling Crew

The four member angling crew typically worked four ten hour days a week, (usually Tuesday - Friday) during the 2015 season (Figure 4). Morning 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. Evening times ranged from 6:00 pm to 1:00 am. Starting in late July the crew switched to all angling shifts in the evening at both Dams. In addition to the three 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 John Day 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). Cannonball sinkers were attached to the swivel using four to six inch dropper line of 12# monofilament leader. Cannonball weights varied from 1-6 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 2-5” size range and included tubes, flukes, grubs and sassy shad.

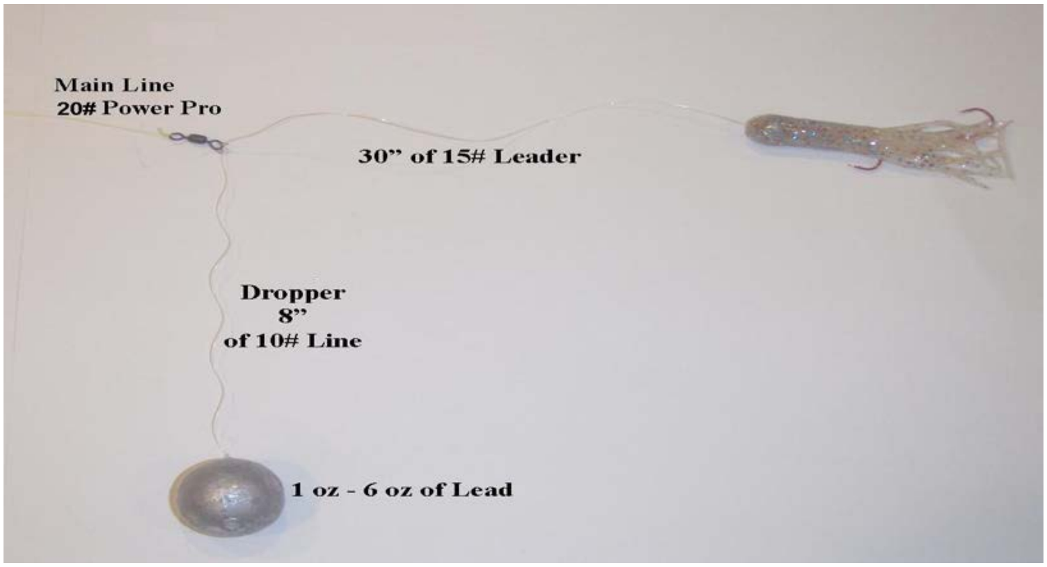

Figure 5. Example of typical rigging used by 2015 NPMP Dam Anglers.

Figure 6. Examples of soft plastic tube baits used by 2015 NPMP Dam Anglers.

Data collection

Creel data were recorded by each individual angler for their angling day and then were combined and summarized daily with weekly totals submitted separately for each project (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 tag data were submitted to ODFW for verification.

PIT Tag Detection

All northern pikeminnow collected by Dam Anglers during 2015 were 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. 2001). 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

2015 Dam Angling Season

The 2015 Dam Angling Season took place from May 5th through October 11th. River conditions were favorable early in the season when angling activities began in week 19, with weekly harvest building through the peak in week 24, and concluding in week 41. Total harvest for The Dalles and John Day dams combined was 7,693 northern pikeminnow in 2,247.75 angling hours, with a combined CPUE of 3.42 fish per angler hour. The dam angling crew exceeded the CPUE goal of 2.0 fish/angler hour in the first week of the season, and remained above it for the first eight weeks of the season (Figure 7). Week 19 also represented the earliest week that our CPUE goal had been met in any of our five Dam Angling seasons (Hone et al. 2011, Dunlap et al. 2012, Winther et al. 2013, Dunlap et al. 2014, Dunlap et al. 2015).

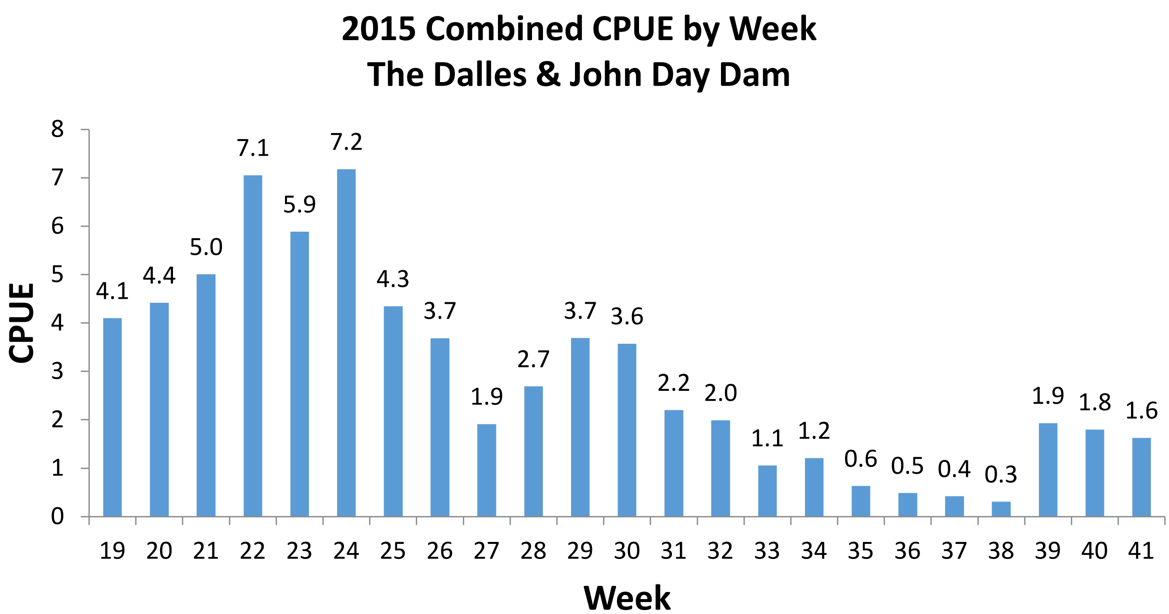

Figure 7. 2015 Weekly CPUE (fish/angler hour) of The Dalles (TD) and John Day (JD) dams Combined.

Angling Gear and Technique

The 2015 Dam Angling crew primarily targeted fishing areas and fishing times at each dam that had been productive in the past (Hone et al. 2011, Dunlap et al. 2012, Winther et al. 2013, Dunlap et al. 2014, Dunlap et al. 2015). Using the knowledge obtained during the four previous seasons in which WDFW had conducted the Dam Angling component of the NPMP, we believed that the majority of our angling success in 2015 would again come from back bouncing soft plastic lures off of the turbine decks. We did also have some limited success using small spinners fished off the rocks below The Dalles Dam in 2015. Our top producing lure in 2015 was the 3.75” Gitzit tube in Pearl White/Black Back color, which accounted for 1,041 harvested northern pikeminnow. The top 5 most productive soft plastic lures used by the Dam Angling crew in 2015 are listed in Table 1.

Table 1. Top 5 Northern Pikeminnow Lures used by 2015 WDFW Dam Angling Crew.

Northern Pikeminnow Lures

Brand/style	Size	Color	# N. Pikeminnow Caught
Gitzit/ tube bait	3.75”	Pearl White/Black Back	1,041
Gitzit/ tube bait	3.75”	Rainbow Trout	1,028
Gitzit/ tube bait	3.75”	Smoke/Black Copper Glitter	844
Gitzit/ tube bait	3.75”	Bluegill	767
Dry Creek/ tube bait	2.50”	Smoke/Purple & Copper	566

Angling Times

Time of day continued to make a difference in harvest success during the 2015 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 et al. 2011, Dunlap et al. 2012, Winther et al. 2013, Dunlap et al. 2014, Dunlap et al. 2015). Results for the 2015 season once again indicated that a most Dam Angler harvest of northern pikeminnow (62%) occurred prior to 11:00 am (Table 2).

Table 2. Combined 2015 WDFW Dam Angler Hourly Harvest Totals for The Dalles (TD) and John Day (JD) dams.

Hourly Northern Pikeminnow Harvest (combined TD and JD totals)

Time of day	Harvest	% of Harvest
4:30 a.m. to 6:00 a.m.	1033	13%
6:00 a.m. - 7:00 a.m.	858	11%
7:00 a.m. - 8:00 a.m.	815	11%
8:00 a.m. - 9:00 a.m.	763	10%
9:00 a.m. - 10:00 a.m.	709	9%
10:00 a.m. - 11:00 a.m.	618	8%
11:00 a.m. - 12:00 p.m.	552	7%
12:00 p.m. - 1:00 p.m.	361	5%
After 1 p.m.	1984	26%

Table 3. 2015 WDFW Dam Angler Hourly Northern Pikeminnow Harvest Comparison (TD vs JD).

Time of day	The Dalles Dam Harvest	The Dalles Dam % of Harvest	John Day Dam Harvest	John Day Dam % of Harvest
4:30 a.m. - 6:00 a.m.	662	14%	371	12%
6:00 a.m. - 7:00 a.m.	470	10%	388	12%
7:00 a.m. - 8:00 a.m.	486	11%	329	11%
8:00 a.m. - 9:00 a.m.	472	10%	291	9%
9:00 a.m. - 10:00 a.m.	427	9%	282	9%
10:00 a.m. - 11:00 a.m.	340	7%	278	9%
11:00 a.m. - 12:00 p.m.	301	7%	251	8%
12:00 p.m. - 1:00 p.m.	218	5%	143	5%
1:00 p.m. - 6:00 p.m.	81	2%	108	3%
6:00 p.m. - 7:00 p.m.	95	2%	30	1%
7:00 p.m. – 8:00 p.m.	99	2%	110	4%
8:00 p.m. – 9:00 p.m.	168	4%	153	5%
9:00 p.m. – 10:00 p.m.	193	4%	157	5%
10:00 p.m. – 2:00 a.m.	554	12%	236	8%
Total	4,566	100%	3,127	100%

Incidental Catch

The Dam Angling crew incidentally caught the fish species listed in Table 4 while targeting northern pikeminnow at The Dalles and John Day dams in 2015. All incidentally caught fish species were released. Incidental species most often caught were smallmouth bass *Micropterus dolomieue*, walleye *Sander vitreus* and sculpin *Cottus* spp. . The Dam Angling crew continued to note large numbers of juvenile lamprey *Entosphenus* spp. and/or *Lampetra* spp. regurgitated by northern pikeminnow caught at The Dalles Dam and John Day Dam during May and June.

Table 4. 2015 WDFW Dam Angler Incidental Catch by Project.

Incidental Catch		
Species	**The Dalles Dam**	**John Day Dam**
Smallmouth Bass	161	608
Walleye	10	86
Sculpin	49	24
White Sturgeon	3	38
Channel Catfish	2	36
American Shad	22	23
Peamouth	4	25
Chinook Salmon	0	1

Tag Recovery

All northern pikeminnow harvested by Dam Anglers in 2015 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. Two northern pikeminnow with external ODFW spaghetti tags were recovered by the Dam Angling crew in 2015. 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. 2016). The 2015 Dam Angling crew also recovered 5 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 2015 was one for every 1,538 northern pikeminnow (1:1,538), compared to 1:584 by the Dam Angling crew in 2014 (Dunlap et al. 2015).

The Dalles Dam

Harvest

The Dam Angling crew harvested 4,566 northern pikeminnow in 22 weeks at The Dalles Dam in 2015, up from 2,174 fish in 2014 (Dunlap et al. 2015). Weekly harvest for the Dam Angling crew averaged 208 fish per week and ranged from peak harvest of 610 northern pikeminnow in week 24 (June 8-12) to 14 fish in weeks 37 and 40 (Figure 8). Peak weekly harvest increased 76% from 2014 and occurred during the same week as in 2014. Peak harvest for Dam Angling was two weeks later than for the 2015 NPSRF (Winther et al. 2016).

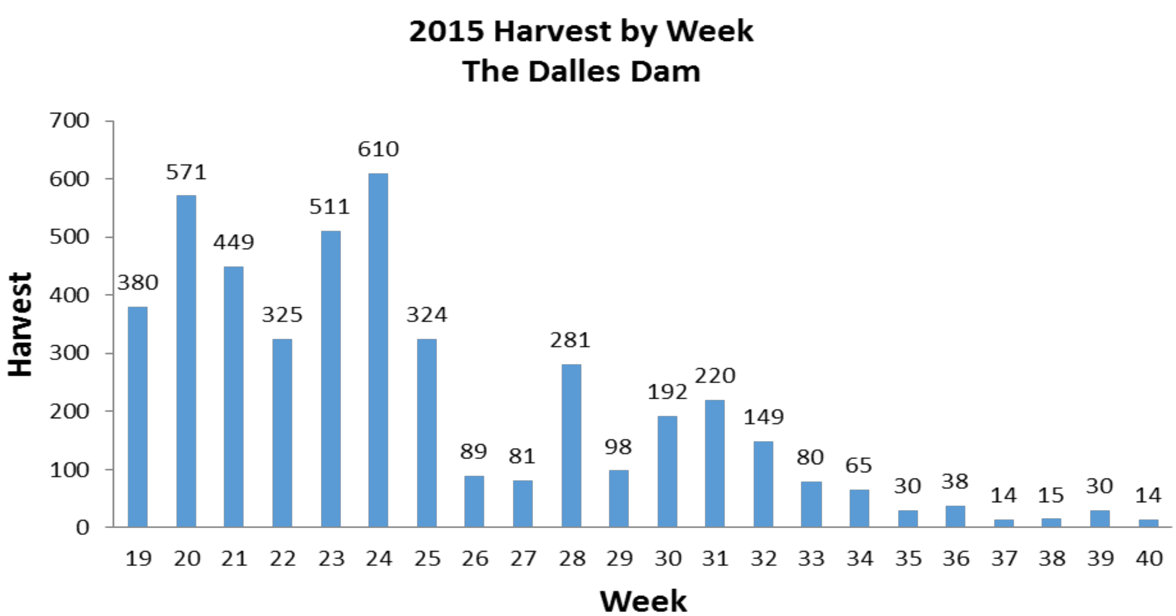

Figure 8. 2015 Weekly Dam Angler Harvest of Northern Pikeminnow at The Dalles Dam.

River outflows at The Dalles Dam early in 2015 were < 100 kcfs which was considerably lower than the 2010-2014 Dam Angling seasons (Hone et al. 2011, Dunlap et al. 2012, Winther et al. 2013, Dunlap et al. 2014, Dunlap et al. 2015). The 4,566 northern pikeminnow harvested at The Dalles Dam in 2015 included two spaghetti tagged, and eight tag loss (PIT tag only) northern pikeminnow which were from ODFW's biological evaluation of the NPMP. There were also three PIT tags recovered from juvenile salmonids that had been ingested by northern pikeminnow harvested at The Dalles Dam.

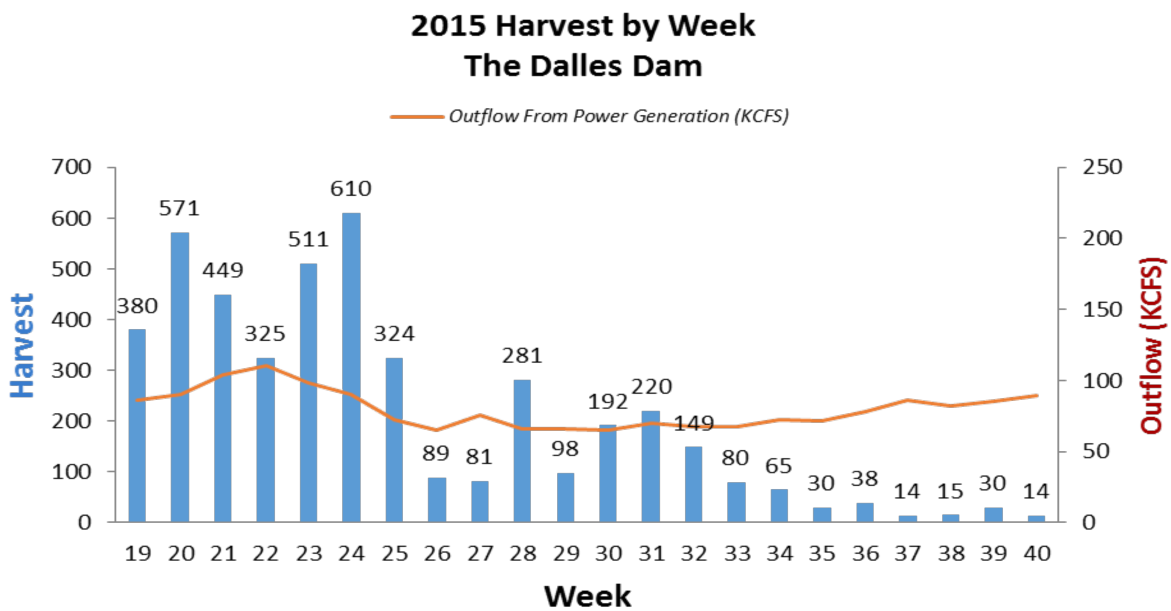

Figure 9. 2015 Weekly Northern Pikeminnow Harvest Compared to Outflow.

As was the case in past Dam Angling seasons, certain areas and/or turbines at The Dalles Dam produced better harvest than others in 2015. The angling areas between Turbine #4 (T4) and the Ice/Trash Sluiceway accounted for 68% of total harvest at The Dalles Dam in 2015 (Figure 10), with the Fishway and the rock shore above the ice trash sluiceway being the two best areas.

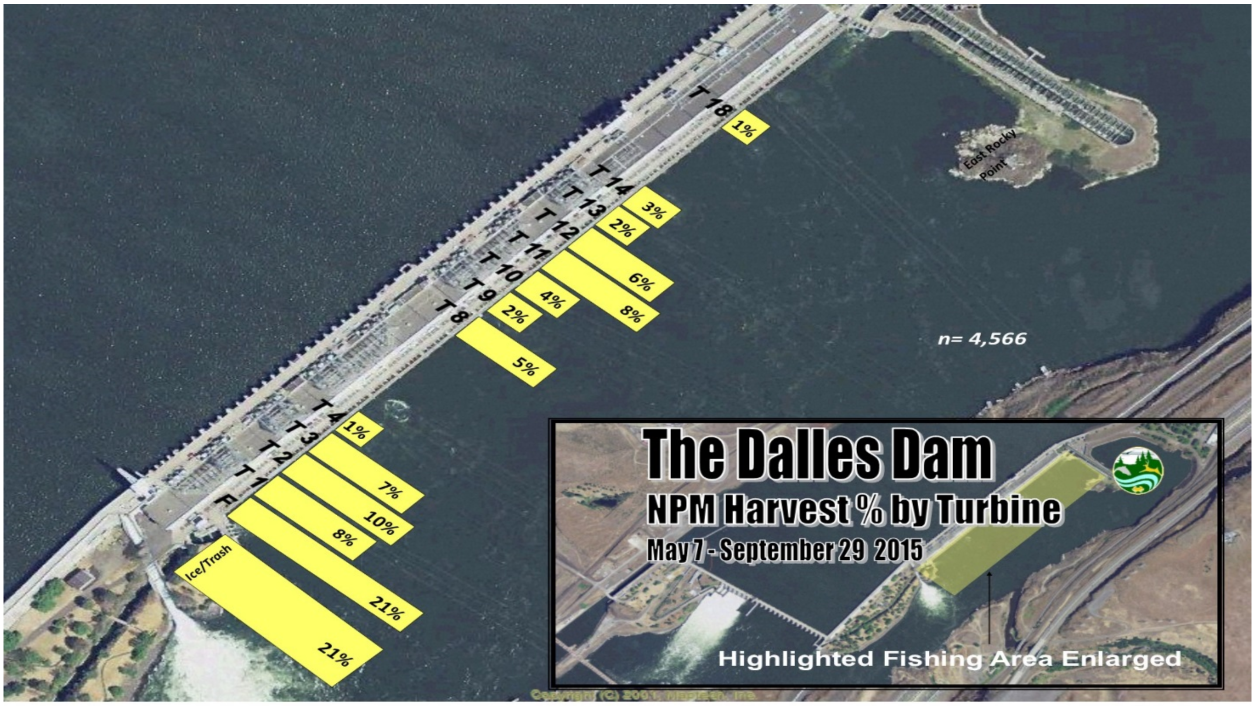

Figure 10. 2015 Overall Percent (*rounded) of Northern Pikeminnow Harvest by Area (T=turbine #, F = fishway).

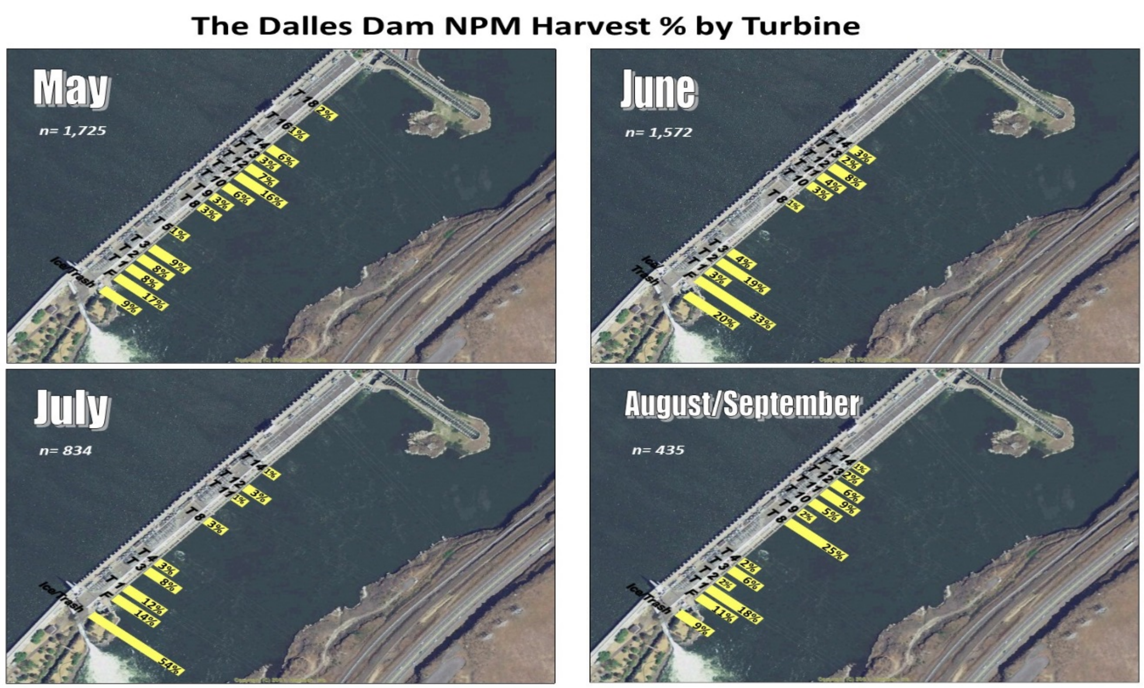

Figure 11. 2015 Monthly Harvest Percent (*rounded) by Area at The Dalles Dam (T=turbine#, F = fishway).

Incidental Catch

While the Dam Angling crew did not target other fish species in their angling activities during 2015, smallmouth bass (smb) were the most common species incidentally caught at The Dalles Dam. The Dam Angling crew caught 161 smallmouth bass at The Dalles Dam in 2015, compared to 67 in 2014. Most smallmouth bass were caught near the Ice/Trash sluiceway (Figure 12), and as in past seasons, all smallmouth bass were scanned for PIT tags and released.

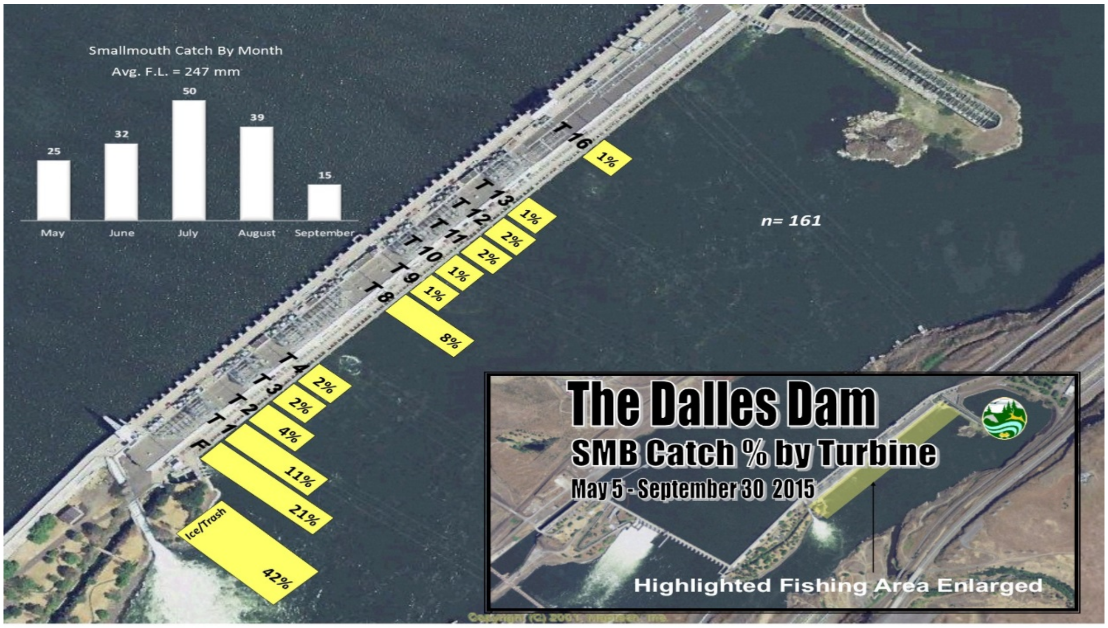

Figure 12. 2015 Incidental catch of smallmouth bass (*rounded) by Dam Angling crew at The Dalles Dam.

Effort

Total angler hours of effort at The Dalles Dam increased to 1,251.25 hours in 2015 from 758.25 hours in 2014 (Dunlap et al. 2015). In achieving that level of effort, the Dam Angling crew fished 84 days over 22 weeks in 2015, compared to 65 days over 20 weeks in 2014. Effort spent at The Dalles Dam was 56% of total overall effort spent by the Dam Angling crew in 2015.

CPUE

The Dam Angling crew harvested 4,566 northern pikeminnow in 1,251.25 angler hours at The Dalles Dam in 2015 for an overall average CPUE of 3.65 fish/angler hour. Overall CPUE at The Dalles Dam in 2015, exceeded our 2.0 fish/angler hour goal and was the Dam Angling crew's highest annual CPUE to date (Dunlap et al. 2015, Dunlap et al. 2014, Winther et al. 2013, Dunlap et al. 2012, Hone et al. 2011). Weekly CPUE was above the 2.0 CPUE goal (as defined in our DAS) for 14 of the 22 weeks fished (Figure 13) and ranged from 0.4 fish/angler hour in week 38 to 8.1 fish/angler hour in week 24.

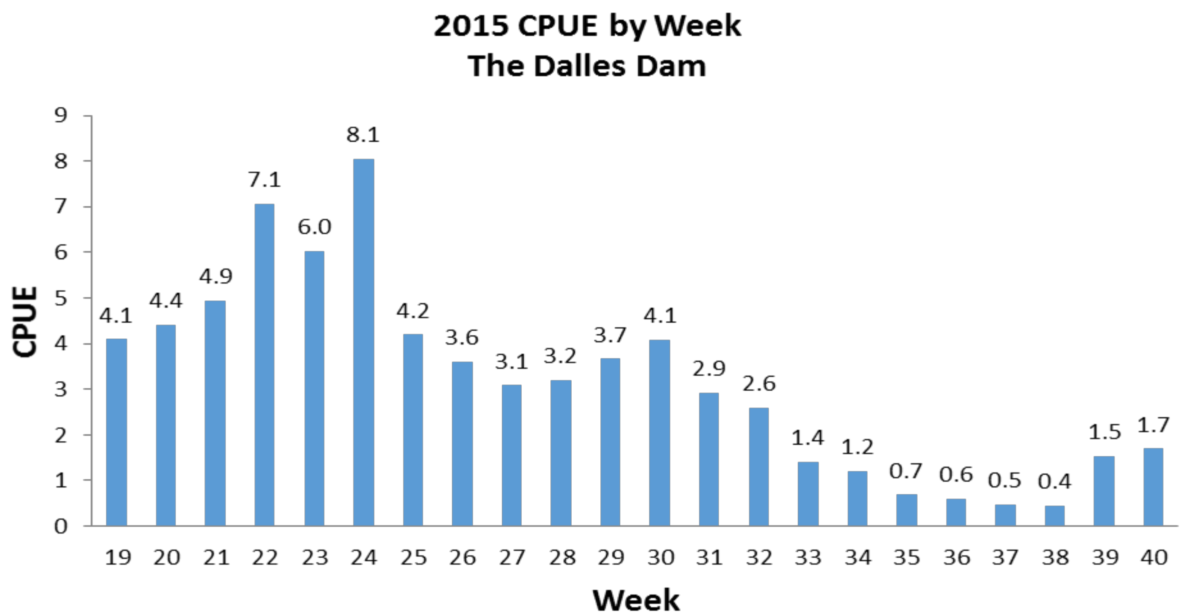

Figure 13. 2015 Weekly Dam Angler CPUE at The Dalles Dam.

Fork Length Data

Fork lengths were taken from 4,566 (100%) northern pikeminnow harvested by the Dam Angling crew at The Dalles Dam during the 2015 Season. The length frequency distribution of northern pikeminnow harvested at The Dalles Dam in 2015 is presented in Figure 14. Mean fork length for all measured northern pikeminnow at The Dalles Dam in 2015 was 308 mm (SD=61.3), down from 332.1 mm in 2014 (Dunlap et al. 2015).

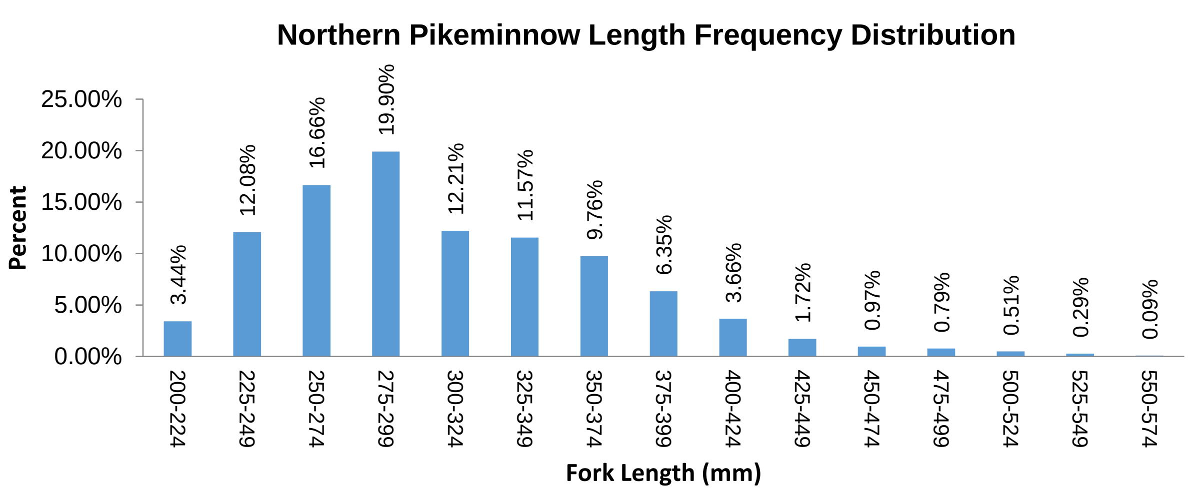

Figure 14. Northern Pikeminnow Length Frequency Distribution at The Dalles Dam in 2015.

John Day Dam

Harvest

The Dam Angling crew harvested 3,127 northern pikeminnow over 20 weeks at the John Day Dam in 2015. This was the Dam Angling crew's third highest harvest year to date at the John Day Dam. Weekly harvest averaged 156 fish per week and ranged from a peak of 483 in week 24 (June 8-12) to 3 fish in week 35 (there were also no northern pikeminnow harvested in 14 hours of effort during week 36) (Figure 15). Peak weekly harvest at the John Day Dam occurred during the same week as in 2014 (Dunlap et al. 2015) and was 2 weeks earlier than the week 22 peak for the 2015 Sport Reward Fishery (Winther et al. 2016). The 3,127 harvested northern pikeminnow included 6 spaghetti tag loss (PIT tag only) northern pikeminnow which were part of ODFW's biological evaluation of the NPMP (Barr et al. 2016). There were also 2 PIT tags recovered from juvenile salmonids that had been ingested by northern pikeminnow harvested by the Dam Angling crew.

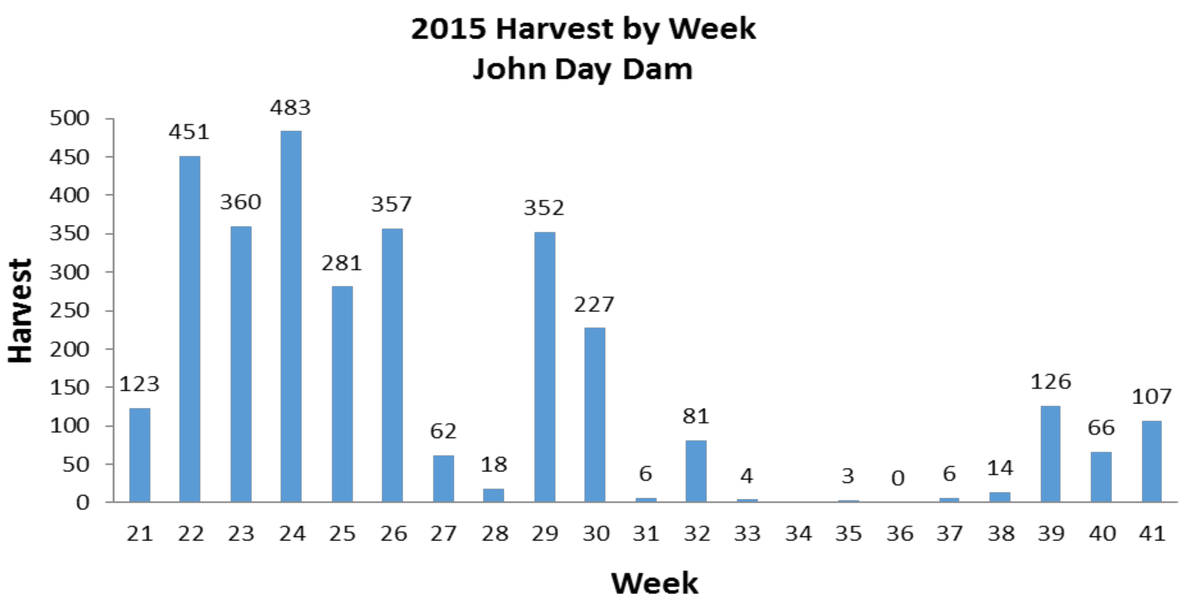

Figure 15. 2015 Weekly Dam Angler Harvest of Northern Pikeminnow at the John Day Dam.

Similar to the 2014 Dam Angling season, harvest during weeks 22-26 was especially high, accounting for 62% of total harvest at the John Day Dam in 2015 (Dunlap et al. 2015). Average outflows at the John Day Dam during this time period were below 150 kcfs (Figure 16) and created good angling conditions which resulted in high harvest rates. The low outflow levels in effect during the early part of the 2015 season had not been present during the 2010-2012 Dam Angling seasons when outflows had been above 200 kcfs and the crew harvested an average of only 31 northern pikeminnow per week (Winther et al. 2013, Dunlap et al. 2012, Hone et al. 2011).

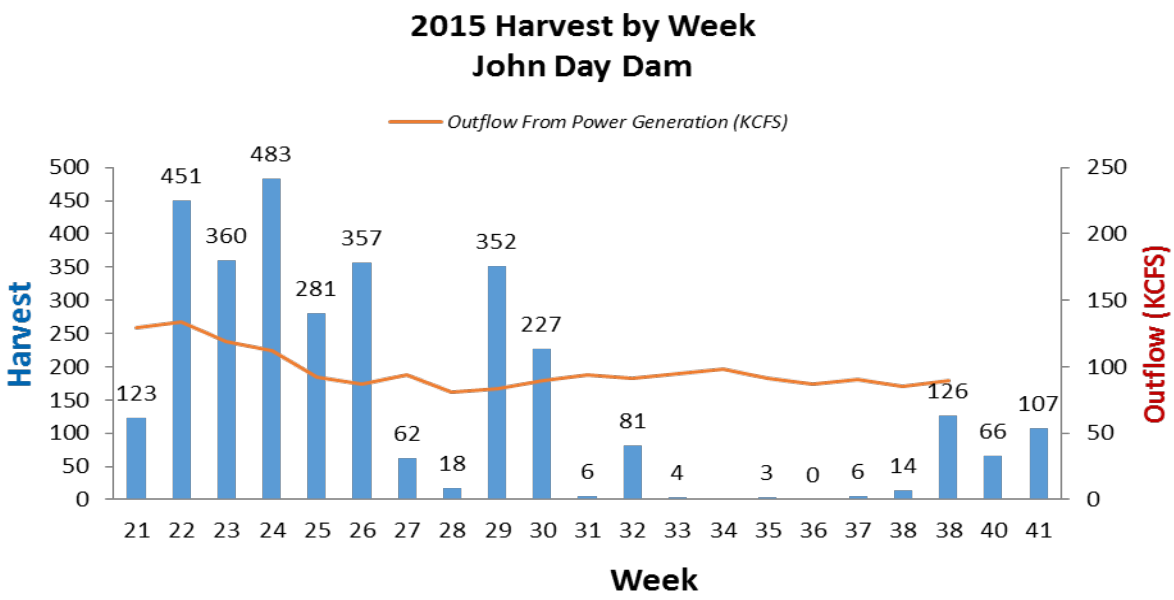

Figure 16. 2015 Weekly Dam Angler Harvest of Northern Pikeminnow at the John Day Dam vs Outflow.

During weeks 33-40, only 219 northern pikeminnow (7% of total harvest) were harvested, compared to 49% of harvest for this period in 2012 and 74% of harvest in 2011. We speculate that since water temperatures reached 70°F in week 27 and stayed above 70°F through week 36, this likely caused the Dam Angling crew to miss another late season spike in harvest at the John Day Dam as had been encountered during the cooler 2010-2012 seasons.

As documented in previous Dam Angling Reports (Dunlap et al. 2015, Dunlap et al. 2014, Winther et al. 2013, Dunlap et al. 2012, Hone et al. 2011), 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 2015, turbine #5 (T5) was the single best producing area with 38% of the total documented harvest (Figure 17). T5 was also the best producing location in 2013 and 2010 with 28% and 22% of the total harvest respectively. Turbine 11 (T11) was the top producing location in 2014 with 21% of total harvest. Turbine 10 (T10) was the top producing location in 2012 with 24% of total harvest, while Turbine 3 (T3) was the best producing location in 2011 with 20% of total harvest.

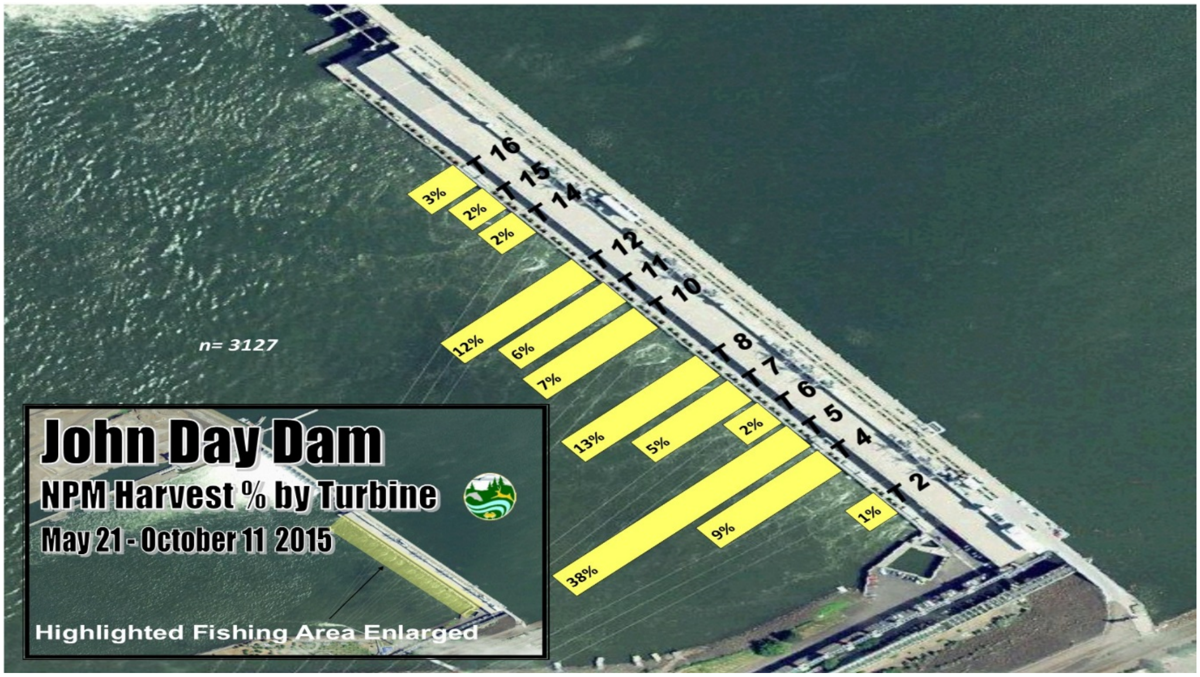

Figure 17. 2015 Overall Percent of Northern Pikeminnow Harvest by Area (T=turbine#)

One limiting factor at the John Day Dam in 2015, and which first became a real issue in 2013 (Dunlap et al. 2014) was turbine inactivity. From an angling and harvest point of view the most productive turbines are those that are actively pushing river water (Hone et al. 2011). Often during the 2015 Dam Angling season, the John Day dam would only have one turbine generating power at a time. That turbine was typically the only location where the Dam Angling crew could consistently catch northern pikeminnow. Since a single turbine can only be effectively fished by one or two Dam Anglers at a time, this created inefficient situations where the full Dam Angling crew could not all effectively fish at one time. It may also have a negative effect on angler CPUE. In response to these type of situations, we continued to experiment with using split crews and developing modified angling schedules.

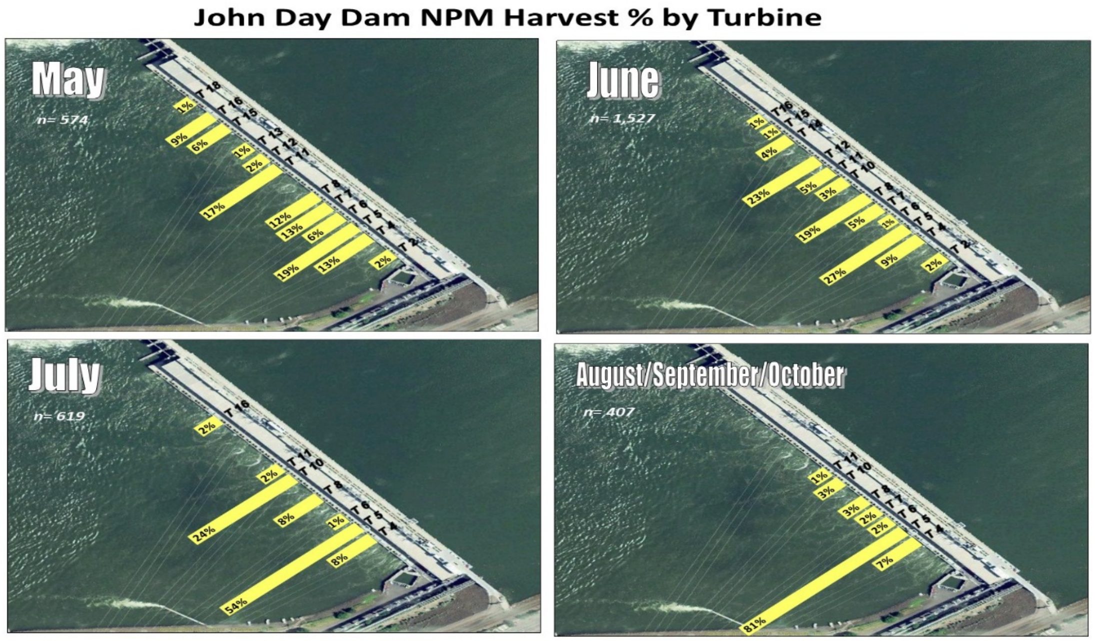

Figure 18. 2015 Monthly Percent (*rounded) of Northern Pikeminnow Harvest by Area (T=turbine#).

Incidental Catch

While the Dam Angling crew did not target fish species other than northern pikeminnow in their angling activities, smallmouth bass (smb) were the most common species incidentally caught at the John Day Dam in 2015. The Dam Angling crew caught and released 608 smallmouth bass at the John Day Dam in 2015, mostly between turbines T4 and T5 (Figure 19). The Dam Angling crew also caught and released 86 walleye (wal), and 38 white sturgeon (ws) at the John Day Dam in 2015. All incidental species caught at the John Day Dam in 2015 were released.

Figure 19. 2015 Incidental Catch (*rounded) of smallmouth bass by Dam Angling crew at the John Day Dam.

Effort

Total effort at the John Day Dam was 996.5 angler hours, down from 1,164.75 hours in 2014 (Dunlap et al. 2015), and equaling 44% of total overall effort spent by the Dam Angling crew in 2015. In achieving that level of effort, the Dam Angling crew fished 74 days over 20 weeks in 2015, compared to 72 days over 22 weeks in 2014. The crew averaged a combined 49.8 angler hours of effort per week and 13.5 angler hours of effort per day at the John Day Dam in 2015.

CPUE

The Dam Angling crew harvested 3,127 northern pikeminnow in 996.5 angler hours at the John Day Dam in 2015 for an overall average CPUE of 3.14 fish/angler hour. This CPUE was the second highest to date for Dam Angling from 2010-14 (Dunlap et al. 2015, Dunlap et al. 2014, Winther et al. 2013, Dunlap et al. 2012, Hone et al. 2011) and ranged from 0.0 fish/angler hour in week 36 to 7 fish/angler hour in week 22 (Figure 20). Peak weekly CPUE at the John Day Dam occurred during week 22. The Dam Angling crew exceeded our overall CPUE goal of 2.0 fish/angler hour (as defined in our DAS) at the John Day Dam for only 9 of the 20 weeks fished.

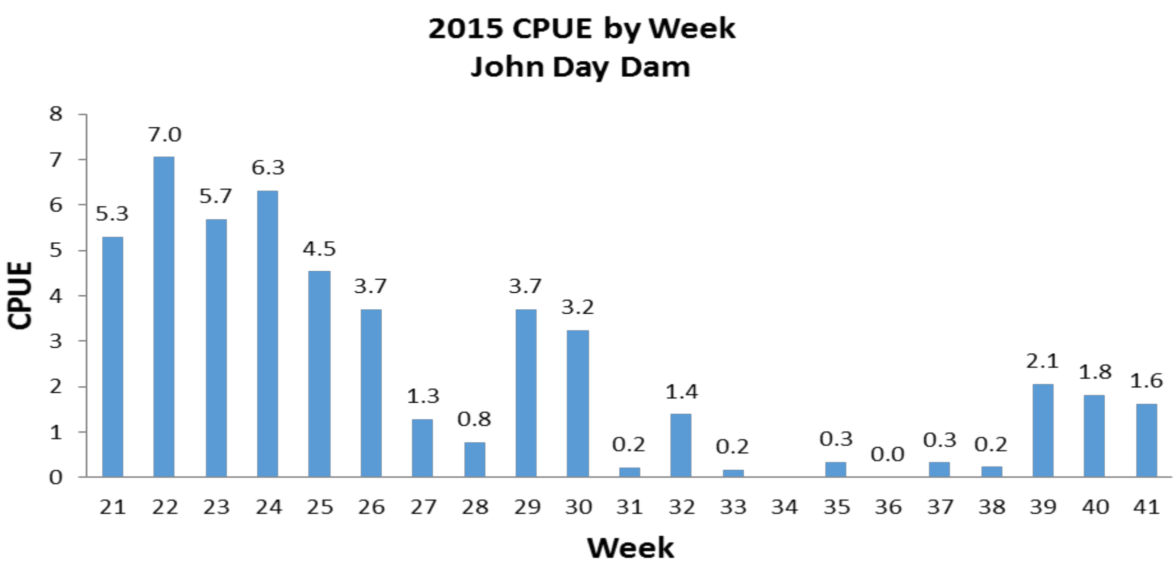

Figure 20. 2015 Weekly Dam Angling CPUE at John Day Dam.

Fork Length Data

Fork lengths were taken from 3,127 northern pikeminnow (100% of harvest) at the John Day Dam during the 2015 Dam Angling Season. The length frequency distribution of harvested northern pikeminnow from the John Day Dam in 2015 is presented in Figure 21. Mean fork length for all northern pikeminnow harvested from the John Day Dam in 2015 was 340 mm (SD=69.9) compared to 363 mm in 2014 (Dunlap et al. 2014).

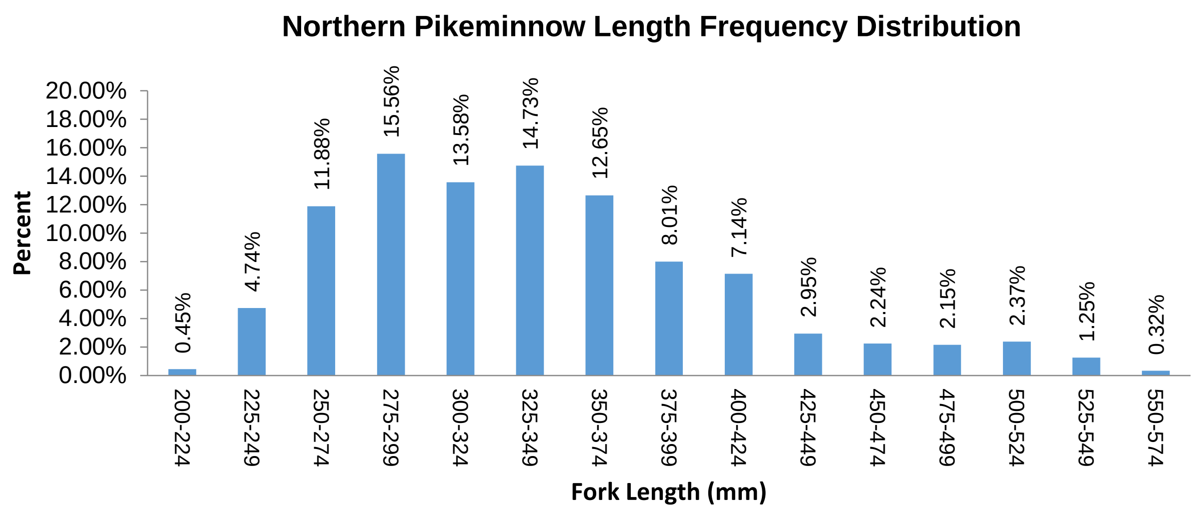

Figure 21. Northern pikeminnow Length Frequency Distribution at the John Day Dam in 2015.

SUMMARY

The Dam Angling component of the NPMP harvested more northern pikeminnow (7,693) (from the John Day and Dalles dams) during the 2015 season than in any year since 1992 (Parker et al. 1993). The 2015 Dam Angling crew also recorded not only the best year for Dam Angler CPUE since WDFW began conducting Dam Angling in 2010 (3.42), but also the highest ever dam angler CPUE to date since the NPMP initiated dam angling in 1991. Low early season river levels and warmer water temperatures created favorable river conditions which allowed the Dam Angling crew to have a fast start harvesting northern pikeminnow at both The Dalles and John Day dams. High early season harvest levels led to peak harvest week occurring four weeks into the 2015 season at both dams (week 24). After week 32, the same low water conditions that helped boost early season harvest created higher water temperatures later in the season that were not conducive to harvest as evidenced by the Dam Angling crew's inability to reach the 2.0 CPUE goal.

Despite the challenge of having peak harvest week for both dams occur during the same week, we believe the 2015 Dam Angling crew was able to effectively exploit the peak harvest opportunities at both dams using our DAS protocol for allocating angling effort between the two projects. Given that the Dam Angling crew had less than optimum angling conditions after week 32, which was exacerbated by limited areas of productive angling as a result of turbine inactivity, the fact that the 2015 Dam Angling crew still managed to set a record for total harvest was remarkable.

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 dams in 2015 were considerably larger than the mean fork length of northern pikeminnow harvested in the Sport-Reward Fishery (308 mm at The Dalles Dam, 340 mm John Day Dam and 277.9 mm in the NPSRF). Tag recovery data indicated 2 spaghetti tagged northern pikeminnow were recovered by the Dam Angling crew at The Dalles Dam, in addition to 14 northern pikeminnow with PIT tags and lost spaghetti tags that were also recovered between the two projects. Finally, the Dam Angling crew recovered 5 PIT tags from juvenile salmonids that had been ingested by northern pikeminnow with an occurrence rate of 1:1,538.

The 2015 Dam Angling crew incidentally caught 769 smallmouth bass, 96 walleye, 73 sculpin and 41 white sturgeon between the two projects while harvesting 7,693 northern pikeminnow. We also continued to see many juvenile lamprey regurgitated by northern pikeminnow harvested at both The Dalles and John Day dams early in the season 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 (Hone et al. 2011, Dunlap et al. 2012, Winther et al. 2013, Dunlap et al. 2014, Dunlap et al. 2015).

RECOMMENDATIONS FOR 2016

1.) Maintain the Dam Angling component of 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 allowed.

2.) Plan for 2016 Dam Angling activities to occur during similar times of year as the 2015 NPSRF in order to take advantage of fishery knowledge/information and to achieve efficiencies in fish handling and data collection gained during previous Dam Angling seasons.

3.) Continue to utilize and refine the Defined Angling Strategy (DAS) protocol developed in 2011 which uses a minimum CPUE goal as a tool for determining where to allocate Dam Angler effort in order to best maximize harvest of northern pikeminnow.

4.) Continue to improve data collection in the areas of scanning other incidentally caught predator fishes for PIT tags, and in scanning and enumerating juvenile lamprey regurgitated by northern pikeminnow caught by Dam Anglers in 2016.

5.) Continue to investigate and further develop northern pikeminnow angling techniques in 2016 that will improve Dam Angler CPUE and/or allow exploitation of northern pikeminnow in areas not currently fishable.

6.) Investigate the feasibility of recording data and retaining carcasses of other non-native predator fishes for other Columbia River research projects.

7.) Continue to explore the logistics of using split crews to optimize efficiencies when water conditions warrant or when there are high CPUE levels at both projects at the same time.

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APPENDIX A
Terminal lures used by 2015 Dam Angler crew