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

2018 ANNUAL REPORT
April 1, 2018 thru March 31, 2019

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

2018 Executive Summary
by

Steve Williams

This report presents results for year twenty-eight 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 accounts for a high percentage of mortality that juvenile salmonids experience from piscivorous fish 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 28-year period are subjects of this annual report.

Evaluation of the success of fisheries in achieving our target goal of a 10-20% annual exploitation rate on Northern Pikeminnow is presented in Reports A & 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 conducted. 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)**: Implement 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).

REPORT A

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

2018 Annual Report

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We are thankful to the City of Rainier for the use of the Rainier boat ramp; the City of Richland for the use of Columbia Point Park; the Cowlitz County Parks and Recreation Department for the use of the Willow Grove boat ramp; the Port of Bingen for the use of Bingen Marina; the Port of Camas/Washougal for the use of the Camas/Washougal boat ramp; the Port of Cascade Locks for the use of the Cascade Locks Marine Park; the Port of Cathlamet for the use of the Cathlamet Marina; the Port of Kalama for the use of the Kalama Marina; the Port of Ridgefield for the use of the Ridgefield boat ramp; the Port of The Dalles for the use of The Dalles Boat Basin; the Port of Umatilla for the use of the Umatilla Marina; the Portland Metro Regional Parks Department for the use of the M. James Gleason and Chinook Landing Boat Ramps ; the U.S. Army Corps of Engineers for the use of Giles French Park and the Greenbelt Boat Ramp; the Washington Department of Transportation for the use of the Vernita Bridge Rest Area; Washington State Parks for the use of Beacon Rock State Park; Wally and Joanne Knouf for the use of Lyon’s Ferry Marina; and 7 Ks of Washington for the use of Boyer Park.

We appreciate the efforts of Kyle Beckley, Kevin Clawson, Sharmon Edmonds, Mark Flahaut, Bill Fleenor, Leif Fox, Roger Fox, Chase Franklin, Joe Hauck, Ashley Jahns, Daniel Kuklok, Emily Kurszewski, Steve Lines, Christian Medeiros, Eric Meyer, Jordan Miller, Amber Santangelo, John Paul Viviano, Robert Warrington, Ted Wise, Dennis Werlau, Heather Wiedenhoft, and Megan Wusterbarth for operating the 2018 Sport-Reward fishery registration stations.

We also recognize Diana Murillo for her excellent work in computer data entry and document verification, Mike Luepke for his efficient rendering services in the lower and mid-river areas, Nancy Platt for her numerous phone survey interviews, and Dennis Werlau for producing our weekly field activity reports throughout the 2018 season.

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, 2018. The objectives of this project were to (1) implement a recreational fishery that rewards recreational anglers for harvesting Northern Pikeminnow ≥ 228 mm (9 inches) total length (TL), (2) collect, compile, and report data on angler participation, catch rates, and harvest of Northern Pikeminnow and other fish species 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 from this segment of NPSRF participants.

A total of 180,273 Northern Pikeminnow ≥ 228 mm fork length (FL) and 4,428 Northern Pikeminnow < 228 mm FL were harvested during the 2018 NPSRF season. There were a total of 3,048 different individual anglers who spent 23,979 angler days of effort participating in the NPSRF during the 2018 season. Catch per unit effort for combined returning and non-returning anglers was 7.5 fish/angler day. The Oregon Department of Fish and Wildlife (ODFW) estimated that the Northern Pikeminnow harvest activities from the 2018 NPSRF resulted in an overall exploitation rate of 16.8% (Carpenter et al. 2019).

Anglers submitted 198 Northern Pikeminnow with external ODFW spaghetti tags, each of which also had an internal ODFW PIT tag. There were also 126 Northern Pikeminnow with ODFW PIT tags only, but missing spaghetti tags. Additionally, 26 PIT tags from ingested juvenile salmonids were recovered from Northern Pikeminnow received during the 2018 NPSRF.

Peamouth *Mylocheilus caurinus*, Smallmouth Bass *Micropterus dolomieue*, and Yellow Perch *Perca flavescens* 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 Council 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, NPSRF anglers have harvested over 4.9 million reward sized Northern Pikeminnow and spent nearly 932,000 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 reverse declining angler participation seen from 2009-2014, 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 modified prior to the 2015 season (Winther et al. 2016). Reward changes raised the base reward to $5 per fish and made it easier for anglers to reach the other two higher tier levels. The goal of this action was to grow the number of proficient individual anglers (Tier 2 and Tier 3 anglers), and to incentivize these anglers to expend additional effort. At the same time, the higher base reward and more attainable 2nd and 3rd tier levels could attract and recruit additional new anglers to the NPSRF. The 2018 NPSRF also continued to reward anglers an additional amount 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 both returning anglers and a sub-sample of non-returning anglers in order to continue to monitor the total effects of the NPSRF on other Columbia basin fishes.

The objectives of the 2018 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 rates and harvest of Northern Pikeminnow and other fish species 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 fish species from this segment of NPSRF participants.

METHODS OF OPERATION

Fishery Operation

Boundaries and Season

The 2018 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, 2018.

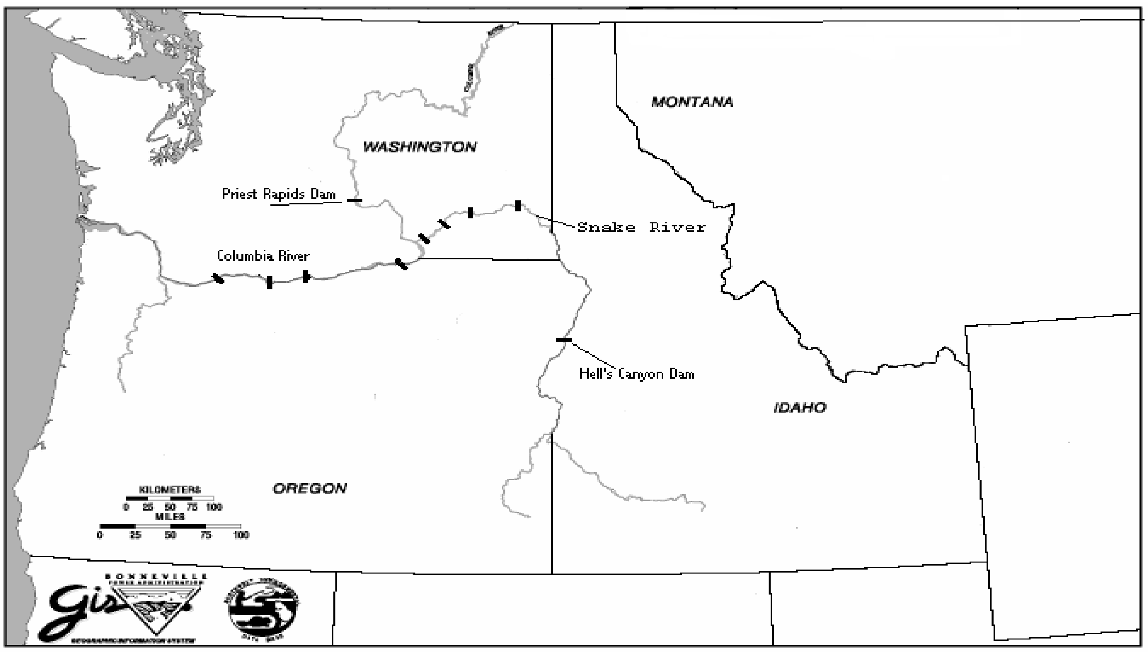
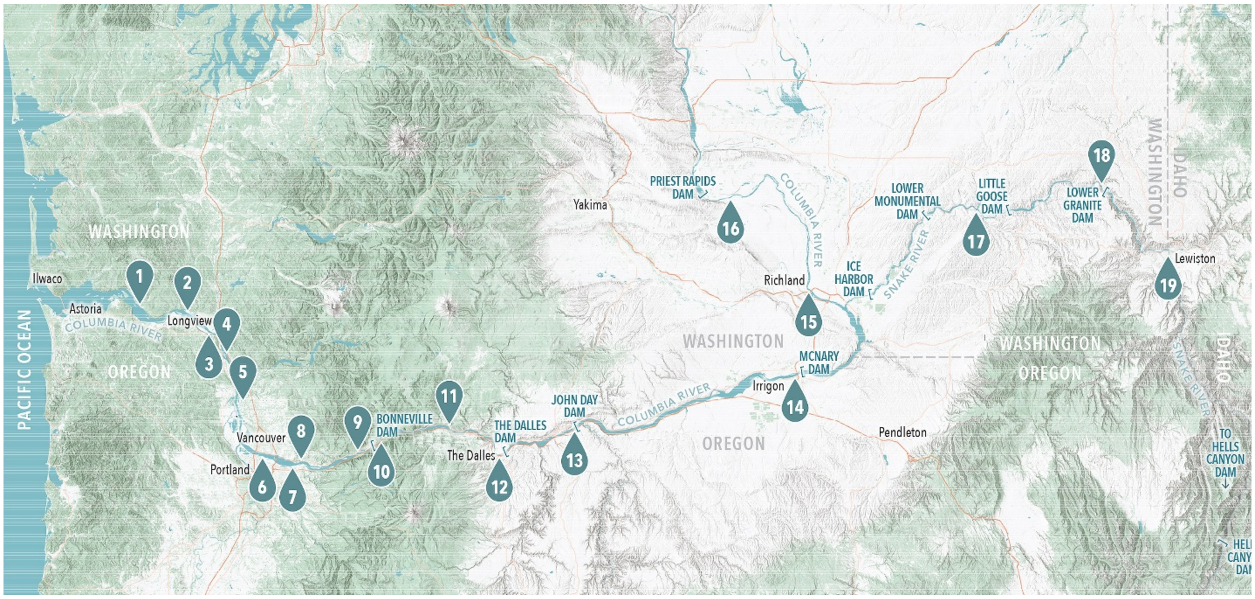


Figure 1. Northern Pikeminnow Sport-Reward Fishery Program Area

Registration Stations

Nineteen registration stations (Figure 2) were located along the Columbia and Snake Rivers within these boundaries 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 2 and 8.5 hours per day during the season. Technicians assisted in registering anglers, and in compiling data for registered anglers participating 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 angling advice and

Sport-Reward Fishery information to the public. Self-registration boxes were also located at each station so anglers could self-register when WDFW technicians were not present.



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

Figure 2. 2018 Northern Pikeminnow Sport-Reward Fishery Registration Stations and Hours

Reward System

The 2018 NPSRF rewarded anglers for harvesting Northern Pikeminnow $\geq$ 228mm TL (9 inches TL) using a 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 verified fish species (and that anglers had caught their fish in accordance with NPSRF Rules and Regulations) and issued them 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 NPSRF (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 tiered reward system used during the 2018 season reflected the changes that were made to the NPSRF's tiered reward system in 2015 (Winter et al. 2016). First developed in 1995 (Hisata et al.

1996), the tiered reward system paid anglers higher rewards per fish based on achieving designated harvest levels. Tier 1 paid anglers $5 each for their first 25 Northern Pikeminnow, Tier 2 paid anglers $6 each for fish 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 that retained a valid spaghetti tag used by ODFW for the biological evaluation of the NPMP. 2018 NPSRF anglers also continued to be paid $100 for each Northern Pikeminnow missing a spaghetti tag, but retaining the ODFW PIT tag (tag-loss).

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".

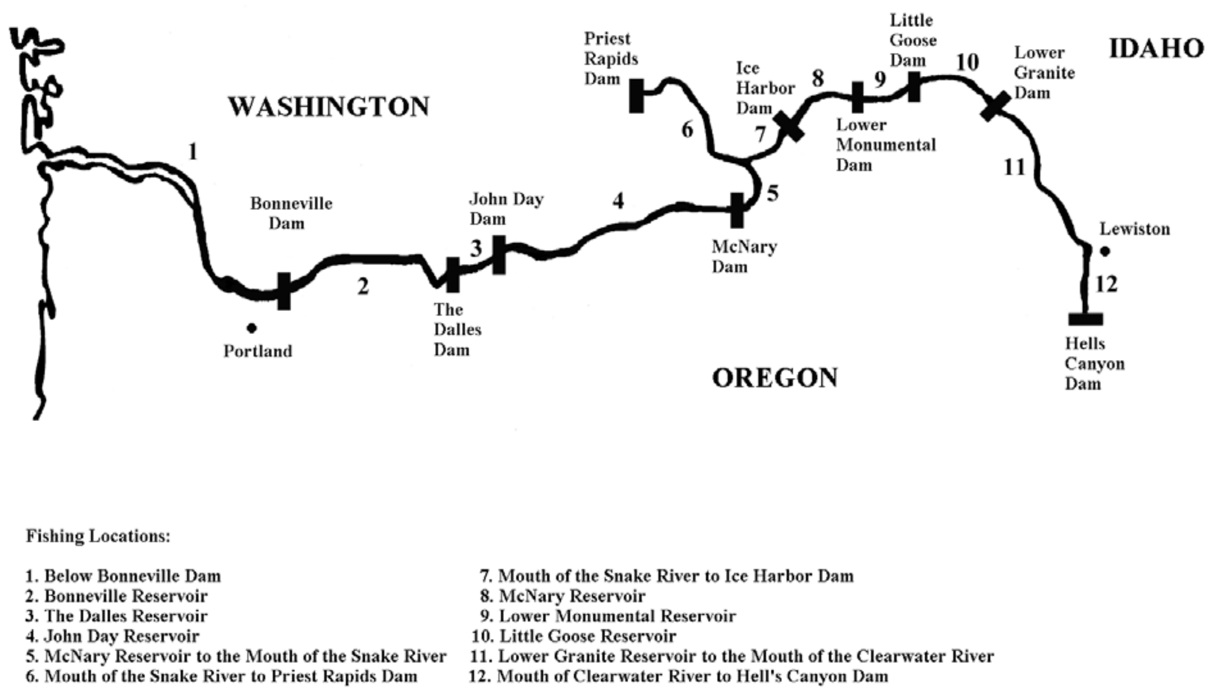


Figure 3. Fishing Location Codes used for the 2018 Northern Pikeminnow Sport-Reward Fishery

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 retained fish species were recorded from visual observation.

Non-Returning Anglers

Non-returning angler data were compiled from the pool of anglers who had registered for the NPSRF and targeted Northern Pikeminnow, but did not return to a registration station to participate in an exit interview. WDFW surveyed a minimum of 20% of the NPSRF's non-returning anglers using a telephone survey in order to obtain creel data from that segment of the NPSRF's participants. To obtain the 20% sample, non-returning anglers were randomly selected from each registration station for each week. A technician called anglers from each random sample until the 20% sample was attained. Non-returning anglers were surveyed with the same exit interview questions used for returning anglers. Anglers were asked: "did you specifically fish for Northern Pikeminnow at any time during your fishing trip?" With a "Yes" response, anglers were asked to report the number and species of adult and/or juvenile salmonids, and the number of reward size Northern Pikeminnow that were caught and harvested/released while they targeted Northern Pikeminnow. Angler catch and harvest data were not collected from non-returning anglers who did not target Northern Pikeminnow on their fishing trip. Non-returning angler catch and harvest data for non-salmonid species were not collected in 2018 per NPSRF protocol (Fox et al. 2000).

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, floy, dart, etc.), 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 Fork Length (FL), sex (determined by evisceration), and scale samples (if specified). Spaghetti tagged and tag-loss Northern Pikeminnow carcasses were then processed or labeled and frozen for data verification and/or tag recovery at a later date. Data from spaghetti tags were recorded on a tag voucher as well as on WDFW data forms. The spaghetti tag was then removed from the Northern Pikeminnow and 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 2018 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 that have been PIT tagged by other studies within the basin (Glaser et al. 2001). PIT tags have 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). 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 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 Northern Pikeminnow with positive readings. All PIT tagged Northern Pikeminnow were processed or labeled and preserved for later dissection and tag recovery. All data were verified by WDFW tag lead biologist after recovery of PIT tags and all PIT tag recovery data were provided to ODFW and the PIT Tag Information System (PTAGIS) on a regular basis. Data from verified tag-loss Northern Pikeminnow with ODFW PIT tags were forwarded to PSMFC for which anglers were paid a $100 bonus reward.

Northern Pikeminnow Processing

During biological sampling, all Northern Pikeminnow were either caudal clipped, or dissected to recover PIT tags as an anti-fraud measure to eliminate the possibility of previously processed Northern Pikeminnow being resubmitted for payment. As in recent years, all Northern Pikeminnow harvested in 2018 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 2018 NPSRF harvested a total of 180,273 reward size Northern Pikeminnow ($\geq$ 228 mm TL) over the course of a 22 week field season. Harvest was higher than mean 1991-2017 harvest of 176,913 fish, but 11,206 fish lower than 2017 harvest (Shirley et al. 2018) (Figure 4). The 2018 NPSRF harvest was estimated to equal an exploitation rate of 16.8% (Carpenter et al. 2019). In addition to harvesting 180,273 reward size Northern Pikeminnow, anglers participating in the 2018 NPSRF also harvested 4,428 Northern Pikeminnow < 228 mm TL.

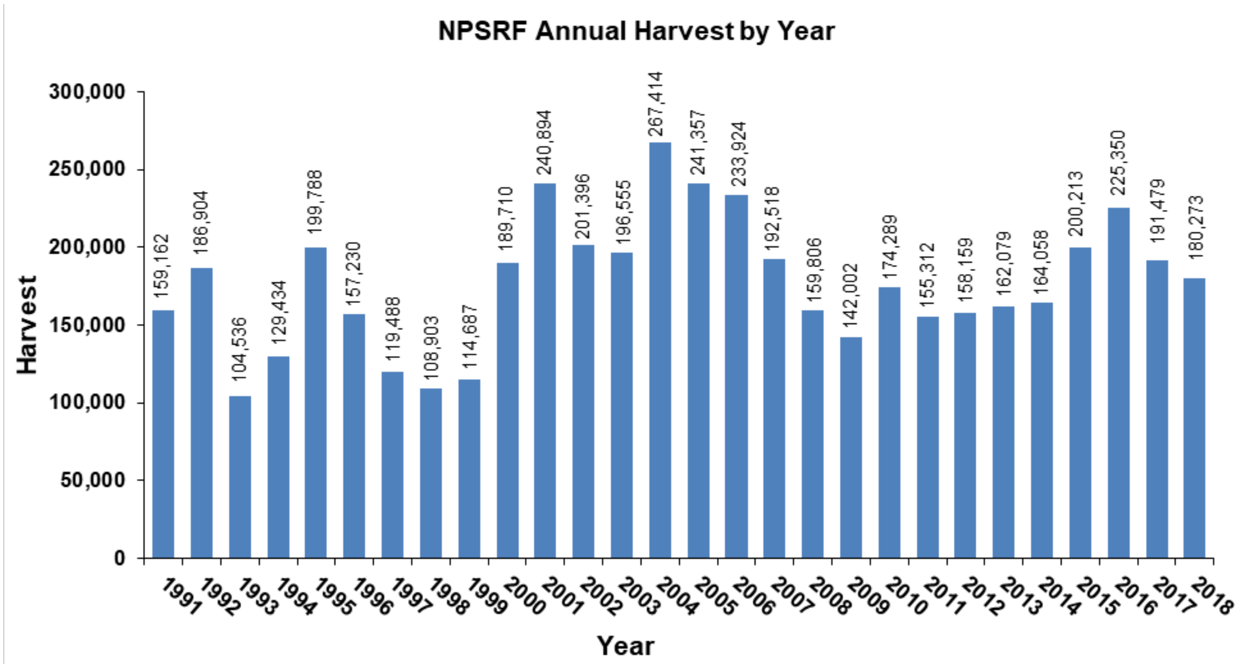


Figure 4. Annual Harvest Totals for the Northern Pikeminnow Sport-Reward Fishery

Harvest by Week

Peak weekly harvest was 10,954 Northern Pikeminnow and occurred in week 26 (Figure 5), one week later than in 2017 (Figure 6), and 3,600 fish less than in 2017 (14,554). Weekly harvest in 2018 was above 2017 weekly harvest for 7 weeks of the 22 week season, and mean weekly harvest was lower in 2018 (8,194) than in 2017 (8,704). Other than late in the season, water conditions were not as favorable during the first half of the 2018 NPSRF as they were in 2017 (Shirley et al. 2018). This resulted in weekly harvest totals under 10,000 fish per week during the first critical 6 weeks of the season and without that high early season harvest, total harvest was only slightly above average. Peak harvest occurred the same week as the NPSRF's historical 1991-2017 peak in week 26 (Fox et al. 2000) and was followed by a second late-season peak in week 35 (Figure 7).

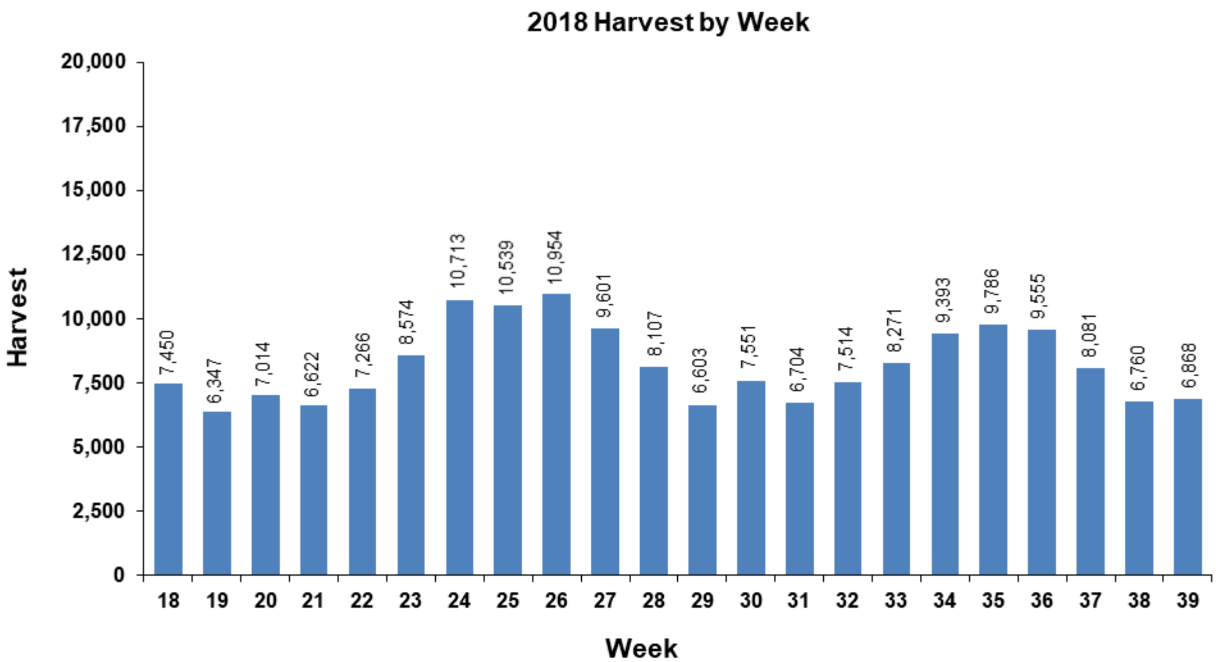


Figure 5. 2018 Weekly Northern Pikeminnow Sport-Reward Fishery Harvest

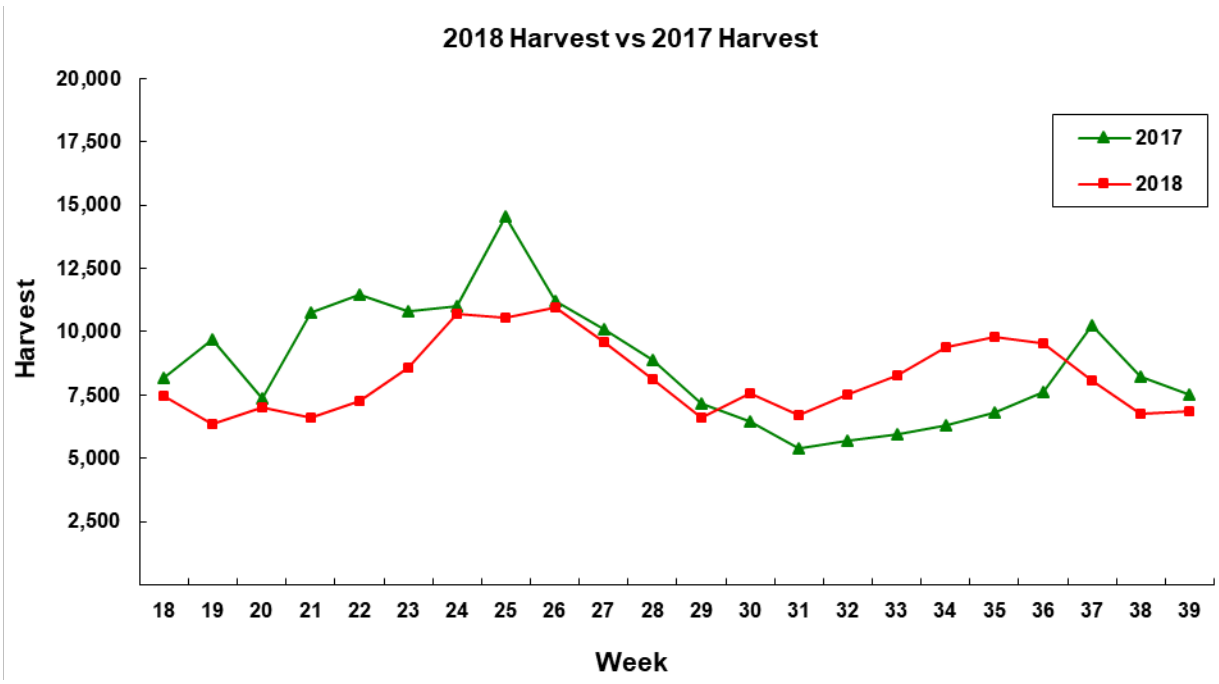


Figure 6. 2018 Weekly NPSRF Harvest vs 2017 Weekly Harvest

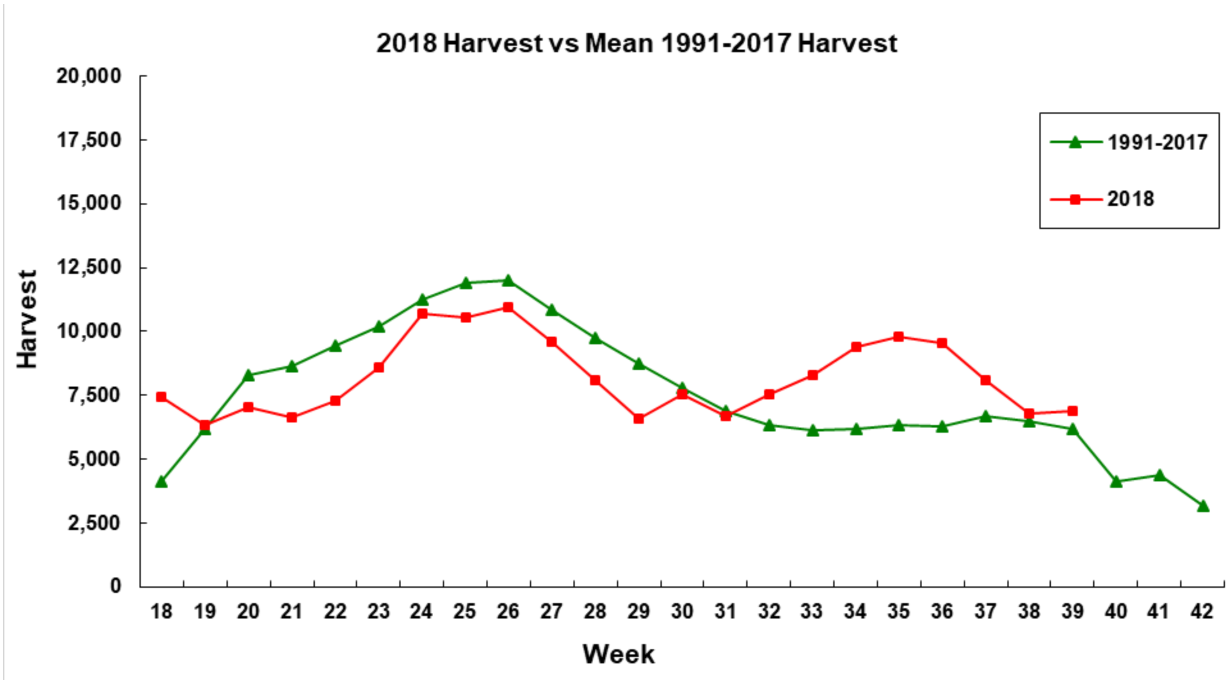


Figure 7. Comparison of 2018 NPSRF Weekly Harvest to 1991-2017 Mean Weekly Harvest

Harvest by Fishing Location

The mean harvest by fishing location for the 2018 NPSRF was 15,023 Northern Pikeminnow and ranged from 97,099 reward size Northern Pikeminnow in fishing location 01 (Below Bonneville Dam) to only 51 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 53.86% of total NPSRF harvest and was the highest producing location again in 2018 as it has been 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 17.37% of the total 2018 NPSRF harvest, while fishing location 10 (Little Goose Reservoir) accounted for 12.87% of the 2018 harvest.

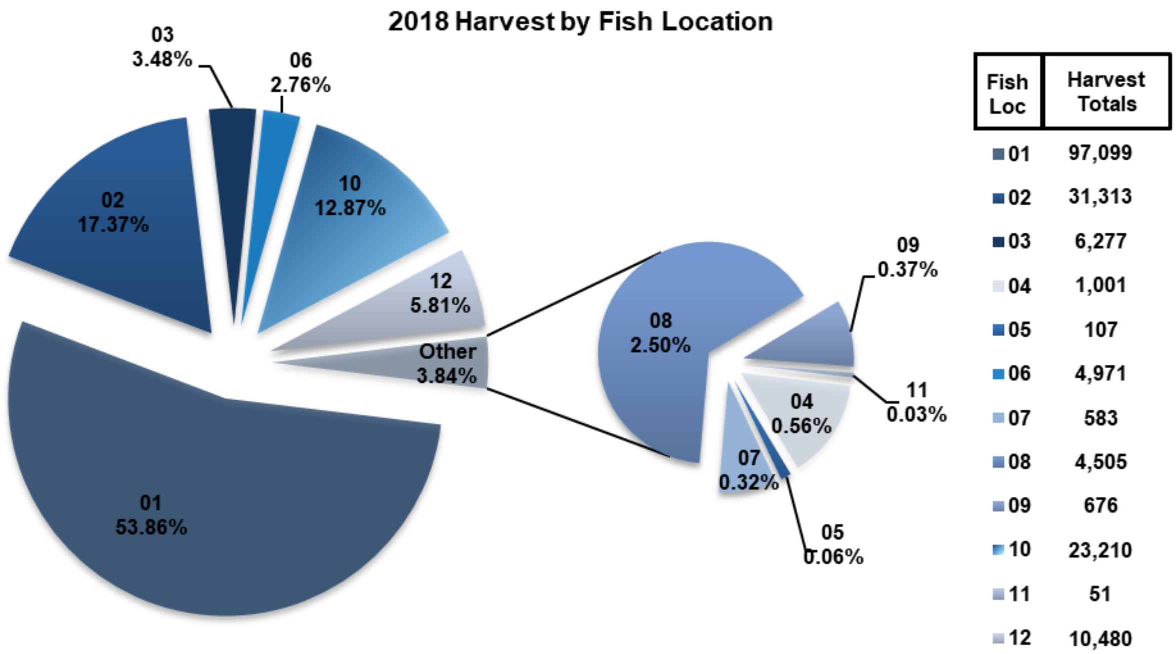


Figure 8. 2018 Northern Pikeminnow Sport-Reward Fishery Harvest by Fishing Location*
*Fishing Location Codes for **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth of the Snake River to Priest Rapids Dam. **Snake River;** 07 = Mouth of the Snake River to Ice Harbor Dam, 08 = Ice Harbor Reservoir, 09 = 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 Hells Canyon Dam.

Harvest by Registration Station

Harvest in 2018 was up from 2017 at 6 of the 19 registration stations, mostly in the lower river (Shirley et al. 2018). The Cathlamet registration station claimed the title of the NPSRF's top producing station for the first time in the 28 year history of the NPSRF, where anglers harvested 25,135 Northern Pikeminnow, equaling 13.9% of total 2018 NPSRF harvest (Figure 9). The Boyer Park registration station finished with the second highest total of 22,950 Northern Pikeminnow (12.7% of total) harvested in 2018. The Dalles station, which is typically one of the top two stations, fell to third place in 2018 with harvest of 22,464 fish. The average harvest per registration station was 9,488 reward size Northern Pikeminnow, down from 10,078 per station in 2017 (Shirley et al. 2018). The registration station with the smallest harvest was Vernita where anglers harvested only 722 Northern Pikeminnow during the 2018 season. The Cathlamet registration station also showed the largest increase in harvest during the 2018 NPSRF with 11,739 more reward size Northern Pikeminnow turned in than in 2017 (Shirley et al. 2018).

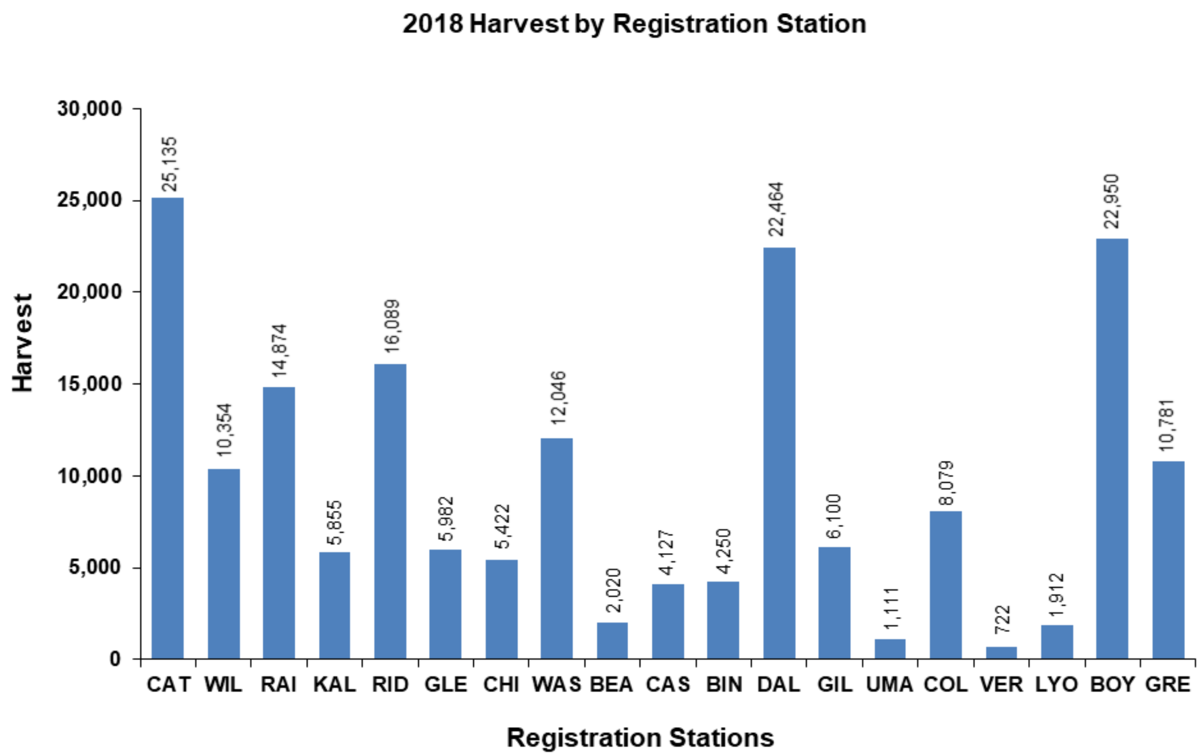


Figure 9. 2018 Northern Pikeminnow Sport-Reward Fishery Harvest by Registration Station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL- The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia 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 2018 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 2018.

Salmon

Species	Caught	Harvest	Harvest Percent
Trout (Unknown)	82	6	7.32%
Steelhead Juvenile (Hatchery)	80	0	0%
Steelhead Juvenile (Wild)	50	0	0%
Chinook (Juvenile)	45	0	0%
Steelhead Adult (Hatchery)	25	4	16%
Chinook (Adult)	24	6	25%
Steelhead Adult (Wild)	17	0	0%
Chinook (Jack)	12	1	8.33%
Cutthroat (Unknown)	8	0	0%
Coho (Adult)	5	0	0%

Anglers reported that all juvenile salmonids caught during the 2018 NPSRF were released. Per NPSRF protocol, technicians recorded all juvenile steelhead caught by NPSRF anglers (except those specifically reported as missing the adipose fin), as "wild". Harvested adult salmonids that were caught incidentally during the 2018 NPSRF were only retained during legal salmonid fisheries. NPSRF protocol is to report anglers illegally harvesting any salmonids (whether juvenile or adult) to the appropriate enforcement entity for action.

Other fish species incidentally caught by returning NPSRF anglers targeting Northern Pikeminnow in 2018 were most often Peamouth, Smallmouth Bass, and Yellow Perch (Table 2).

Table 2. Catch and Harvest of Non-Salmonids by Returning Anglers Targeting Northern Pikeminnow in 2018

Non-Salmonid Species	Caught	Harvest	Harvest Percent
Northern Pikeminnow >228mm	180,276	180,273	99.99%
Northern Pikeminnow <228mm	46,692	4,428	9.48%
Peamouth	30,446	12,402	40.73%
Smallmouth Bass	15,268	1,242	8.13%
Yellow Perch	10,699	2,511	23.47%
Sculpin (unknown)	7,361	4,183	56.82%
Channel Catfish	3,345	423	12.65%
White Sturgeon	3,237	3	.09%
Sucker (unknown)	1,935	238	12.30%
Walleye	1,337	687	51.38%
Catfish (unknown)	1,330	270	20.30%
Bullhead (unknown)	906	189	20.86%
Chiselmouth	415	34	8.19%
Carp	297	26	8.75%
Starry Flounder	219	27	12.33%
Bluegill	205	2	.98%
American Shad	174	53	30.46%
Crappie (unknown)	55	0	0%
Largemouth Bass	46	8	17.39%
Whitefish	7	0	0%
Pumpkinseed	4	0	0%
Warmouth	2	0	0%
Sandroller	1	0	0%

Non-Returning Anglers Catch and Harvest Estimates

As in past years, telephone interviews were conducted to randomly survey non-returning participants at each of the NPSRF's 19 stations in order to determine and record their catch and/or harvest of reward sized Northern Pikeminnow and other incidentally caught salmonid species. In 2018, there were 6,796 non-returning angler days recorded and a total of 1,633 calls were completed to non-returning anglers (24% of all non-returning anglers). 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 2018 NPSRF. A simple estimator was applied to the catch and harvest totals obtained from the surveyed anglers to obtain Total Catch and Total Harvest estimates for non-returning anglers participating in the 2018 NPSRF. Estimated totals are listed in columns 5 and 6 of Table 3.

Table 3. 2018 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	236	101	42.8%	982	420
Northern Pikeminnow ≥ 228 mm	39	36	92.3%	162	150
Chinook Salmon (juvenile)	9	0	0%	37	0
Chinook Salmon (Adult)	5	5	100%	21	21
Trout (Unknown)	5	0	0%	21	0
Steelhead Adult (Hatchery)	1	1	100%	4	4

N=6,796 n=1,633

Fork Length Data

The length frequency distribution for harvested Northern Pikeminnow (≥ 200 mm) from the 2018 NPSRF is presented in Figure 10. Fork length data from 119,205 Northern Pikeminnow ≥ 200 mm FL (59% of total harvest) were taken during the 2018 NPSRF. The mean fork length for all measured Northern Pikeminnow (≥ 200 mm) in 2018 was 272.6 mm (SD= 62.16 mm), down from 279.8 in 2017 (Shirley et al. 2018).

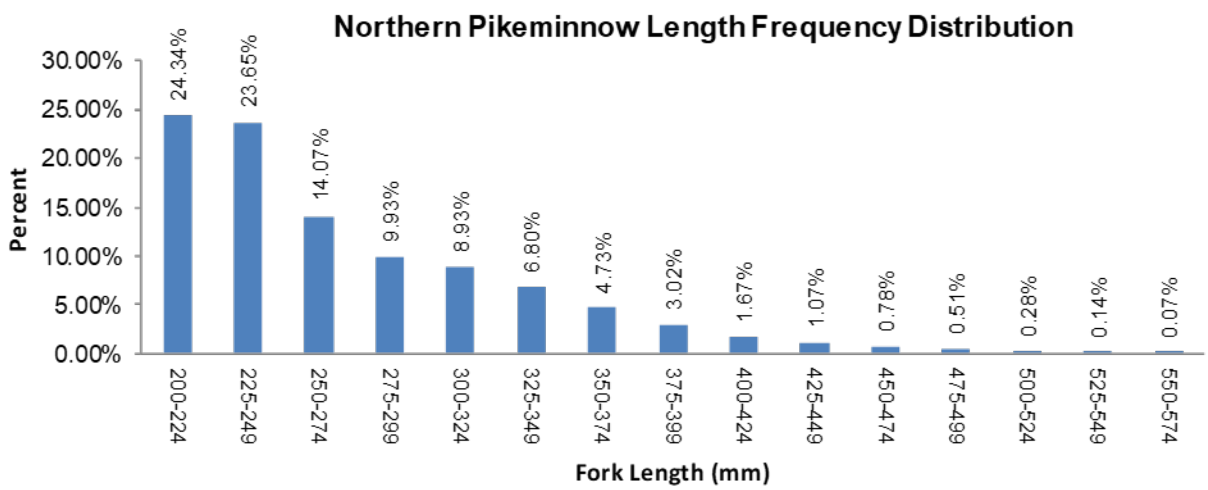


Figure 10. Length Frequency Distribution of Northern Pikeminnow ≥ 200 mm FL from 2018 NPSRF

Angler Effort

The 2018 NPSRF recorded total effort of 23,979 angler days spent during the season, a decrease of 1,984 angler days from 2017 (Shirley et al. 2018) (Figure 11). Despite the decrease in angler effort, 2018 total angler effort was still 1,514 days higher compared to mean 2010-2014 effort (prior to the change in reward tiers). When total effort is divided into returning and non-returning angler days, 17,183 angler days (71.7%) were recorded by returning anglers, and 6,796 angler days (28.3%) were spent by non-return anglers. The percentage of returning anglers in 2018 (71.7%) was higher than the 2017 (70.8%) season (Shirley et al. 2018). In addition, 60% of total effort, and 84% of returning angler effort (14,426 angler days), was attributed to successful anglers who harvested at least one Northern Pikeminnow in 2018.

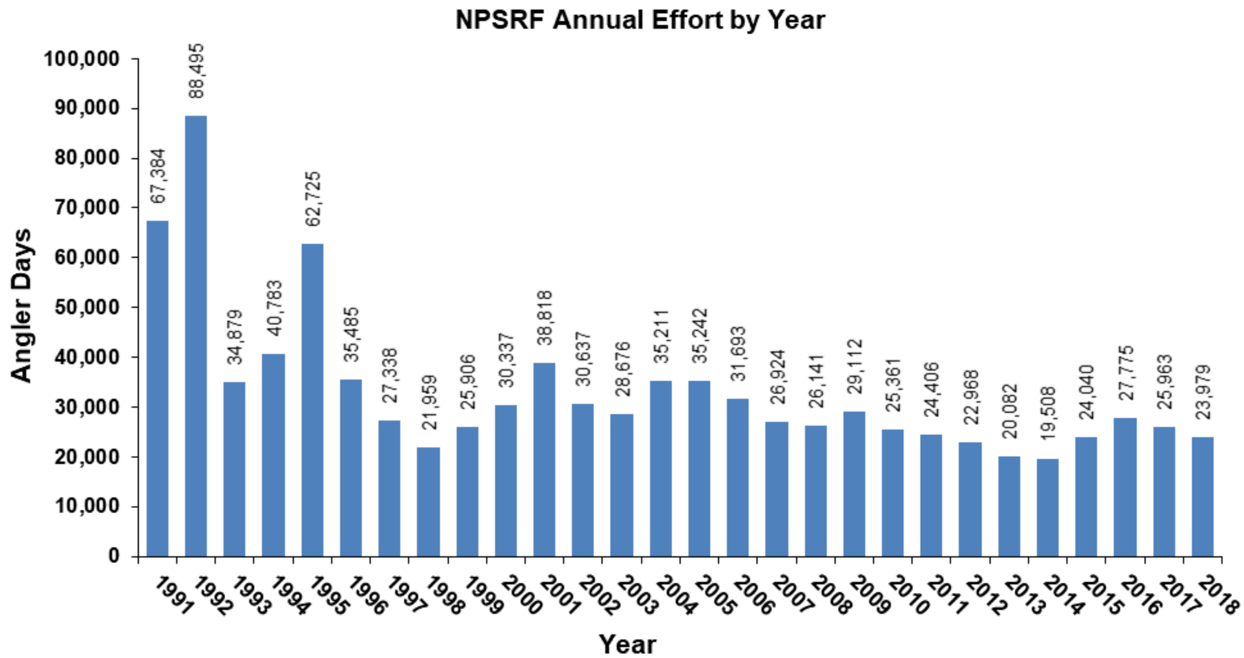


Figure 11. Annual Northern Pikeminnow Sport-Reward Fishery Effort

Effort by Week

Mean weekly effort for the 2018 NPSRF was 1,090 angler days during the season, with the peak occurring in week 18 during the first week of the season (Figure 12). When we compare weekly effort totals for 2018 with the 2017 season, weekly effort totals from 17 of the 22 weeks were down from those of 2017 (Shirley et al. 2018) (Figure 13). Peak weekly effort in 2018 occurred in week 18, eight weeks earlier than 2018 peak harvest (week 26) (Figure 5). Overall, mean weekly effort decreased from 1,180 in 2017 to 1,090 in 2018 (Shirley et al. 2018). Since the tier change in 2015, weekly effort totals have followed a pattern where peak effort occurs in the first full week of the season (Figure 14). This is different from historical 1991-2015 (Winther et al. 2016) pattern where peak effort typically occurred on the same week as peak harvest (Figure 14).

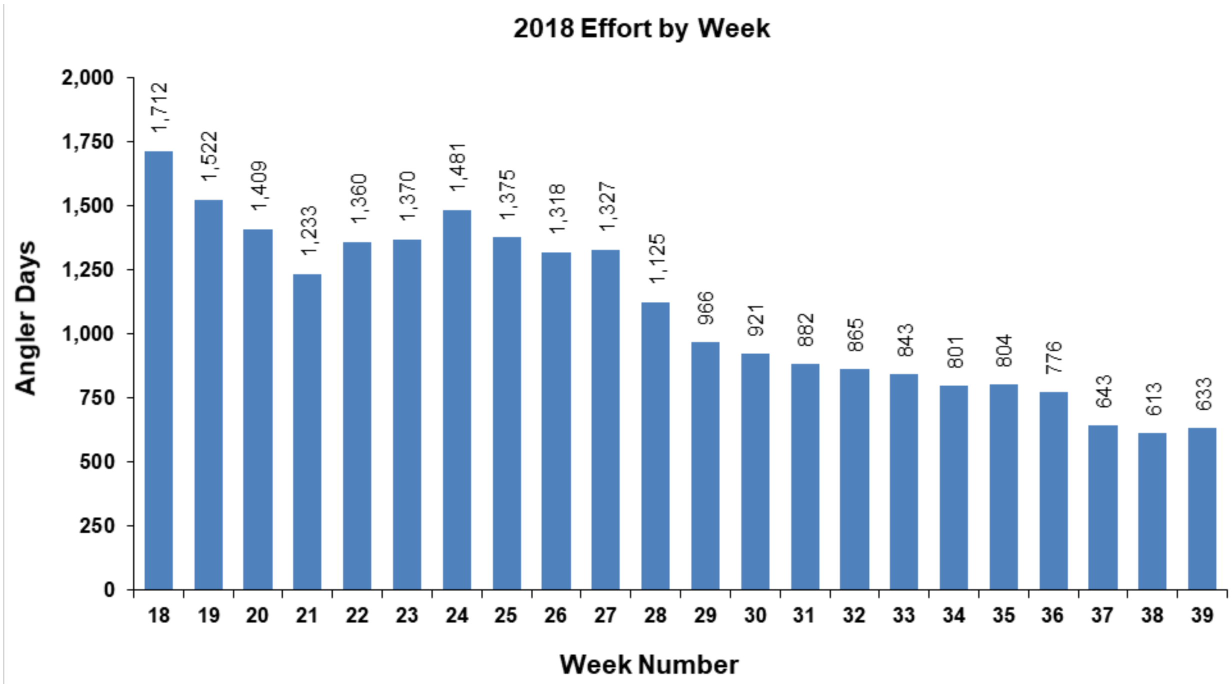


Figure 12. 2018 Weekly Northern Pikeminnow Sport-Reward Fishery Effort

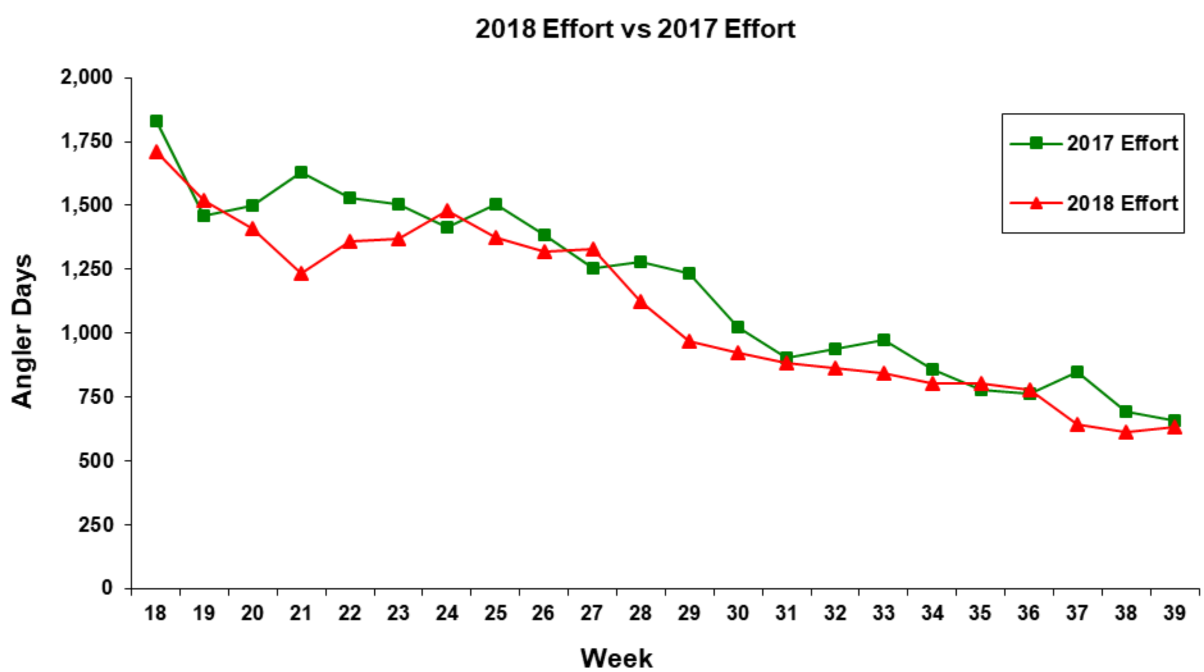


Figure 13. Effort 2018 Northern Pikeminnow Sport-Reward Fishery Effort vs 2017 Effort

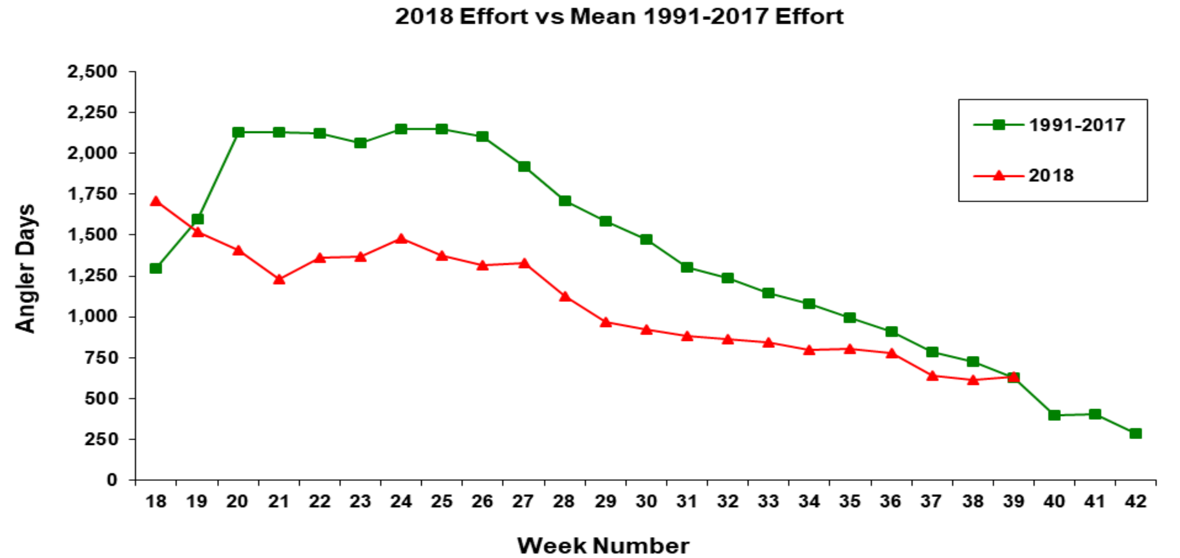


Figure 14. 2018 NPSRF Weekly Effort vs Mean 1991-2017 Effort

Effort by Fishing Location

Mean annual effort by fishing location for the 2018 NPSRF (returning anglers only) decreased from 1,531 angler days in 2017 (Shirley et al. 2018) to 1,432 angler days in 2018. Effort totals ranged from 7,934 angler days spent in fishing location 01 (below Bonneville dam) to only 39 angler days spent in fishing location 11 on the Snake River (Lower Granite Dam to the mouth of the Clearwater River) (Figure 15). While effort decreased in 8 of the 12 NPSRF fishing locations, we recorded a large increase in effort (+19.8%) below Bonneville Dam (fishing location 01) in 2018 (up from 6,625 angler days in 2017) (Shirley et al. 2018).

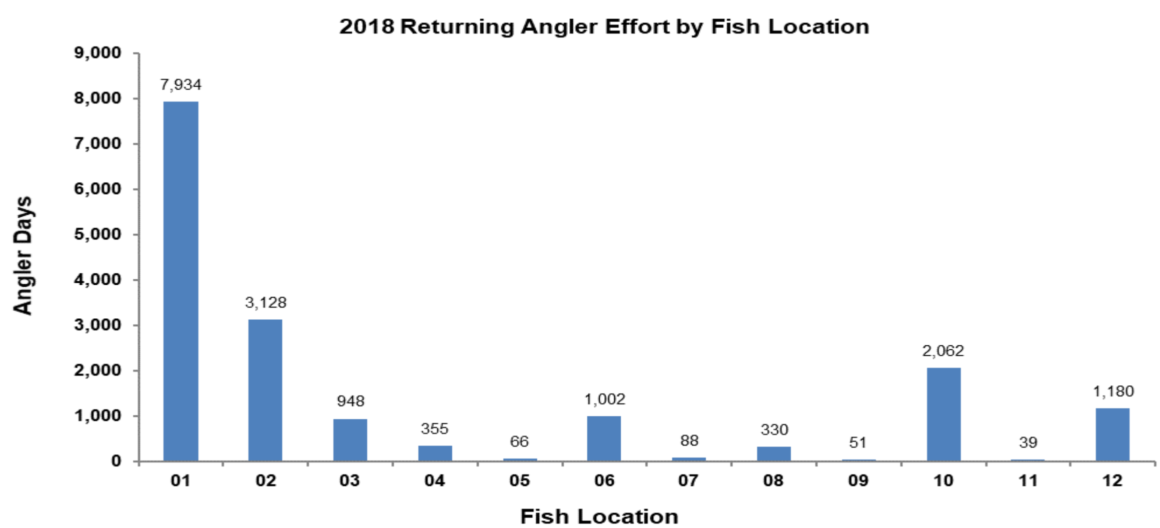


Figure 15. 2018 NPSRF Angler Effort by Fishing Location* (returning anglers only).
*Fishing Location Codes for **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth of the Snake River to Priest Rapids Dam. **Snake River;** 07 = Mouth of the Snake River to Ice Harbor Dam, 08 = Ice Harbor Reservoir, 09 = 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 Hells Canyon Dam.

Effort by Registration Station

Mean effort per registration station during the 2018 NPSRF was 1,262 angler days compared to 1,366 angler days in 2017. Effort totals ranged from a high of 3,505 angler days at The Dalles station (a decrease of 920 angler days from 2017) to a low of 171 angler days at the Vernita station (Figure 16). Effort during the 2018 NPSRF decreased at 10 of the 19 registration stations (from 2017), although the lower Columbia stations generally were the exceptions (Shirley et al. 2018).

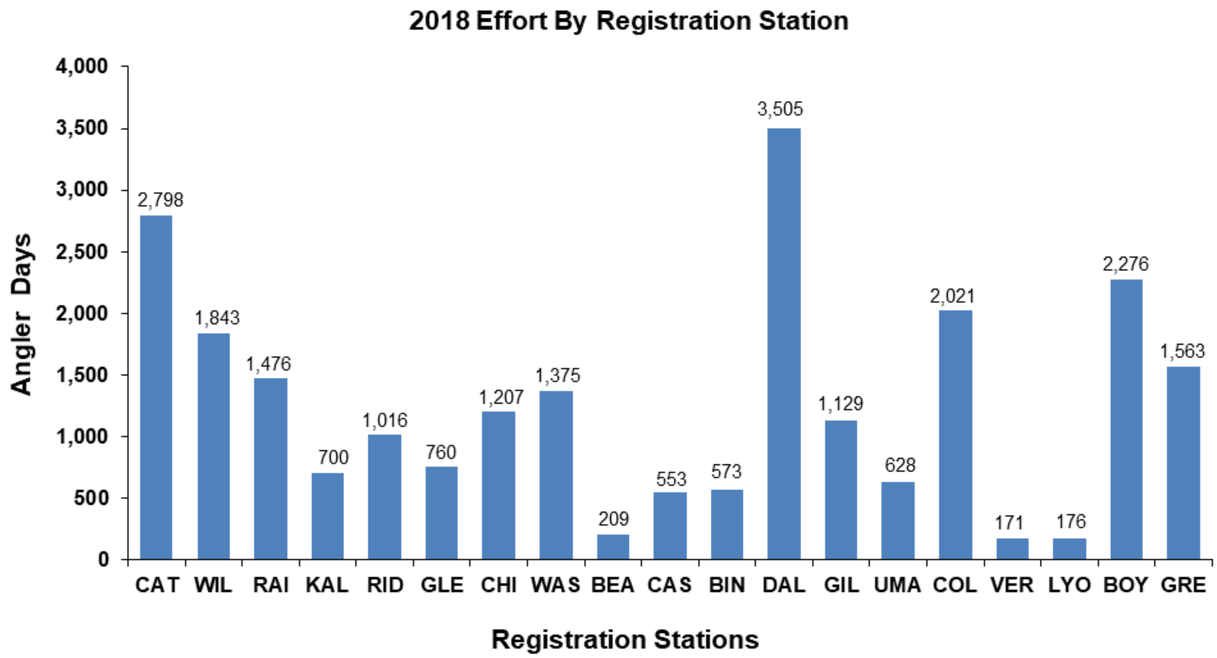


Figure 16. 2018 Northern Pikeminnow Sport-Reward Fishery Angler Effort by Registration Station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Catch Per Angler Day (CPUE)

The 2018 NPSRF recorded an overall (returning + non-returning anglers) catch per unit of effort (CPUE) of 7.52 Northern Pikeminnow harvested per angler day during the season. This catch rate was up from the 2017 overall CPUE of 7.38 (Figure 17). Angler CPUE has trended upwards throughout the NPSRF's 28-year history and has resumed climbing after falling for the past three seasons, likely due to the influx of new anglers attracted by the reward change in 2015 (Winther et al. 2015). Returning angler CPUE during the 2018 NPSRF was 10.49 Northern Pikeminnow per angler day, up slightly from the 2017 returning angler CPUE of 10.42 (Shirley et al. 2018). The estimated CPUE for non-returning anglers was 0.02 reward size Northern Pikeminnow per angler day based on 2018 NPSRF phone survey results.

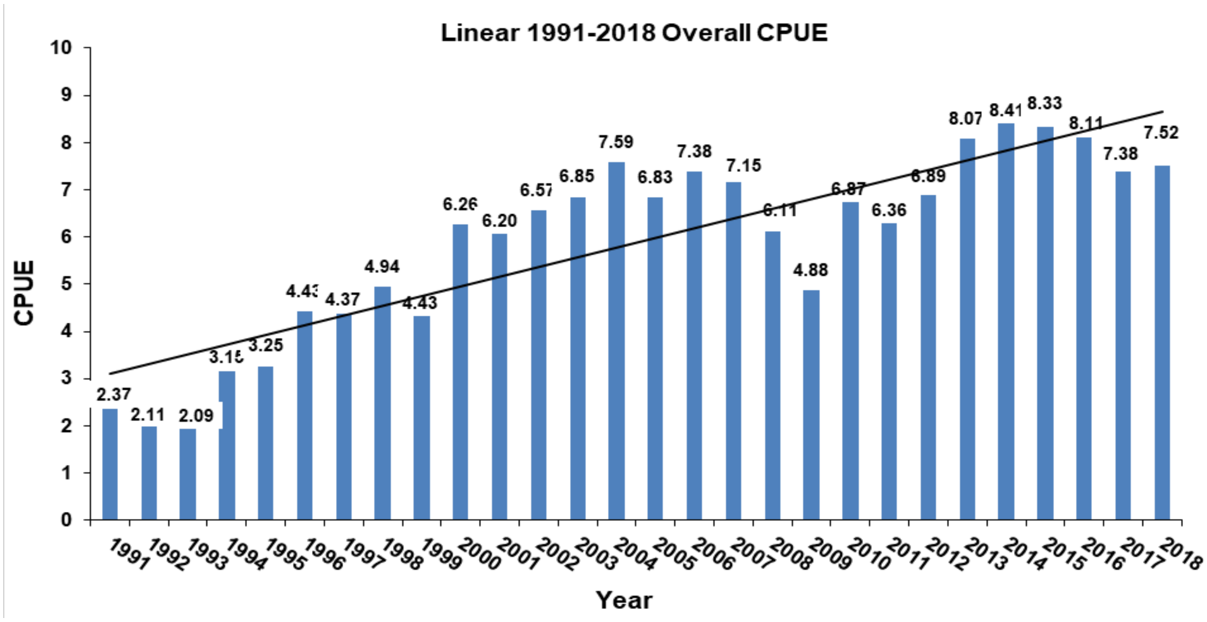


Figure 17. Annual NPSRF CPUE (Returning + Non-Returning Anglers) for the years 1991-2018

CPUE by Week

Mean angler CPUE by week for the 2018 NPSRF was 8.18 fish per angler day compared to 7.70 in 2017 (Shirley et al. 2018) and ranged from a low of 4.17 in week 19 (May 1-6) to a peak of 12.57 in week 37 (September 10-16) (Figure 18). Weekly CPUE for the 2018 NPSRF followed a typical two-peak pattern where the first peak happened in week 26 near the historical Northern Pikeminnow spawning peak and then again late in the season (week 37) when favorable water conditions were present in the lower Columbia and Snake rivers (Winther et al. 2011).

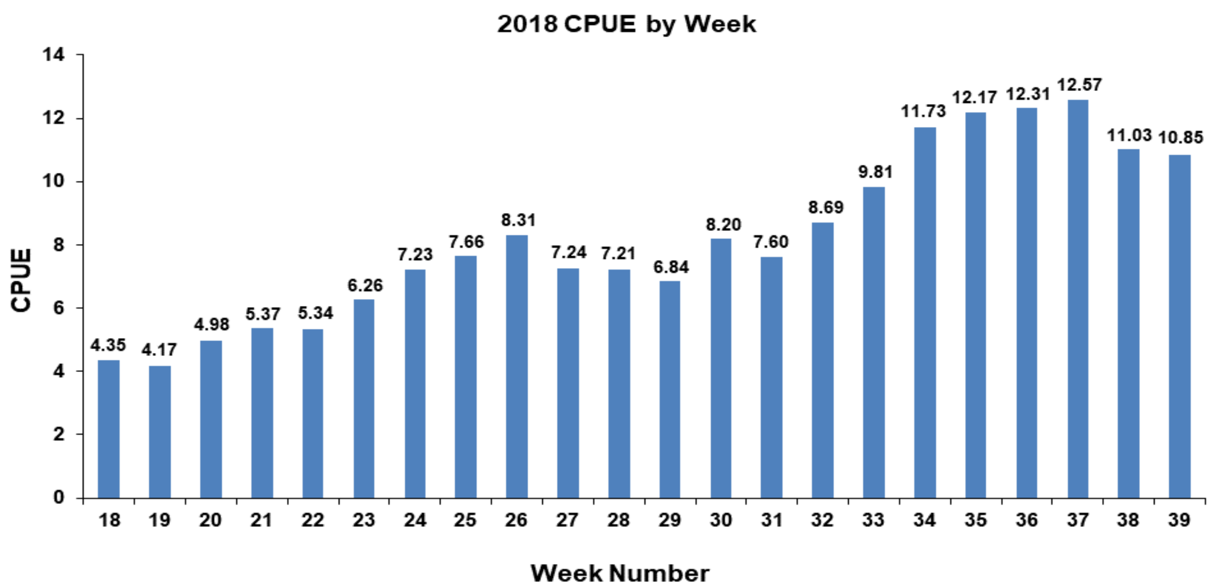


Figure 18. 2018 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Week

CPUE by Fishing Location

Angler success rates for the 2018 NPSRF (as indicated by CPUE), represent returning anglers only and varied by fishing location. Success rates ranged from a high of 13.65 Northern Pikeminnow per angler day in fishing location 08 (Ice Harbor Reservoir) to a low of 1.31 fish per angler per day in fishing location 11 (Lower Granite Reservoir to the Mouth of Clearwater River) (Figure 19). CPUE increased at eight of the 12 fishing locations in 2018. The average CPUE by fishing location was 7.77 Northern Pikeminnow per angler day in 2018 compared to 7.23 in 2017 (Shirley et al. 2018).

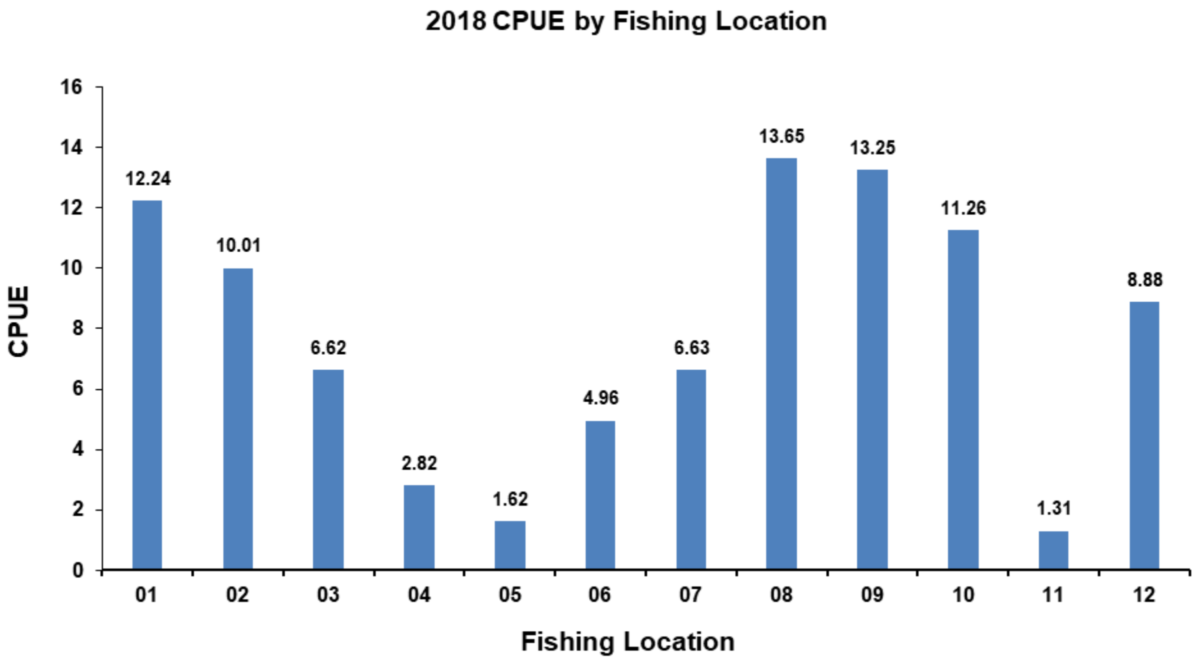


Figure 19. 2018 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Fishing Location.*
*Fishing Location Codes for **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth of the Snake River to Priest Rapids Dam. **Snake River**; 07 = Mouth of the Snake River to Ice Harbor Dam, 08 = Ice Harbor Reservoir, 09 = 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 Hells Canyon Dam.

CPUE by Registration Station

The registration station with the highest CPUE during the 2018 NPSRF was the Ridgefield station where anglers averaged 15.84 Northern Pikeminnow per angler day (Figure 20). The registration station with the lowest CPUE was the Umatilla station with a CPUE of 1.77 Northern Pikeminnow per angler day. The station average for angler CPUE was 8.18 in 2018, up from 7.13 in 2017 (Shirley et al. 2018). Angler CPUE by registration station increased at ten stations (5 of the 10 were between Cathlamet and Ridgefield) during the 2018 NPSRF season. The largest CPUE increase occurred at the Ridgefield station, where CPUE increased from 10.96 in 2017 (Shirley et al. 2018) to 15.84 in 2018.

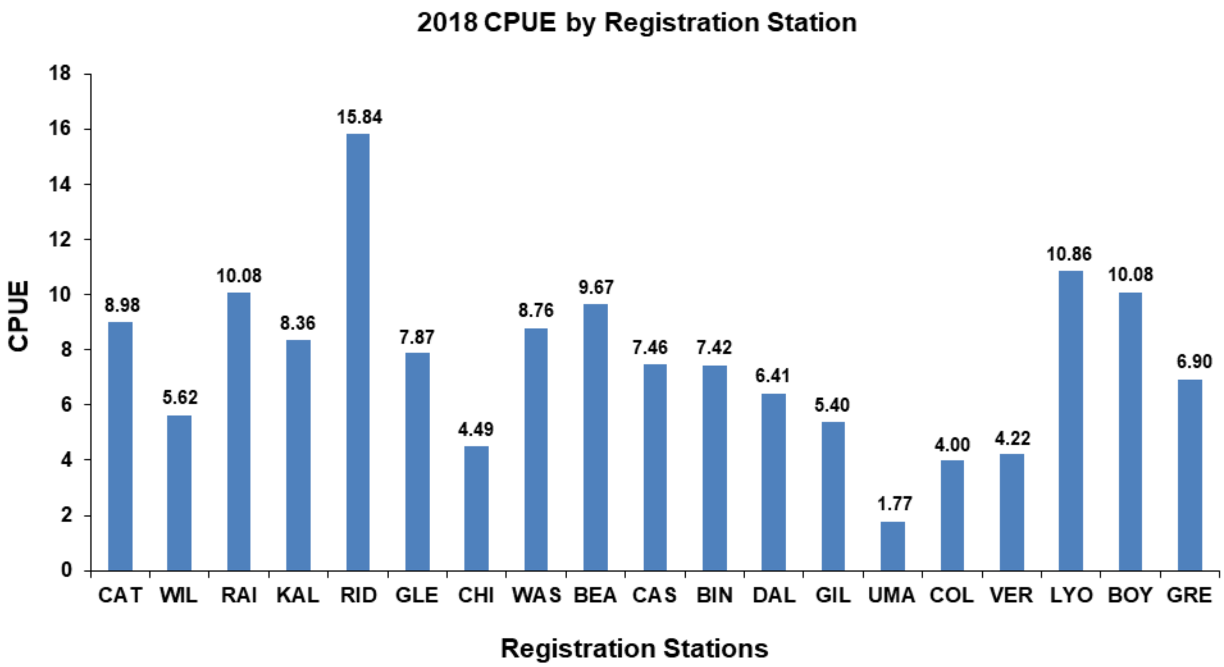


Figure 20. 2018 Northern Pikeminnow Sport-Reward Fishery Angler CPUE by Registration Station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Angler Totals

There were 3,048 separate anglers who participated in the 2018 NPSRF, a decrease of 414 participants from 2017 (Shirley et al. 2018). One thousand, three hundred one of these anglers (43.7% of total vs. 43.0% in 2017 (Shirley et al. 2018)) were classified as successful, harvesting at least one reward size Northern Pikeminnow (for which a voucher was issued) during the 2018 season. Of the successful anglers, 73% (951 anglers) sent in their vouchers to PSMFC for payment (PSMFC 12/13/18 Sport-Reward Payment Summary) while 350 anglers (27%) did not. The average successful angler harvested 137 Northern Pikeminnow during the 2018 NPSRF compared to 129 in 2017 (Shirley et al. 2018).

When we break down the 1,301 successful anglers by tier, 917 of these anglers (70.48%) harvested fewer than 25 Northern Pikeminnow and were classified as Tier 1 anglers (Figure 21). While this is down from the 1,048 individual Tier 1 anglers in 2017 (Shirley et al. 2018), the total number of Tier 1 anglers has remained relatively steady, with not changing much after the 2015 tier change (Table 4). The number of Tier 2 anglers declined to 226 in 2018 (down from 287 in 2017), although it is still more than double the mean number of Tier 2 anglers (101 anglers) recorded during the 2010-2014 NPSRF seasons prior to the tier change in 2015. The number of Tier 3 anglers (known as "highliners") increased from 155 anglers in 2017 (Shirley et al. 2018) to 158 anglers in 2018, which is 66% higher than the mean number of Tier 3 anglers recorded during the 2010-2014 NPSRF seasons (95 anglers) (Winther et al. 2016).

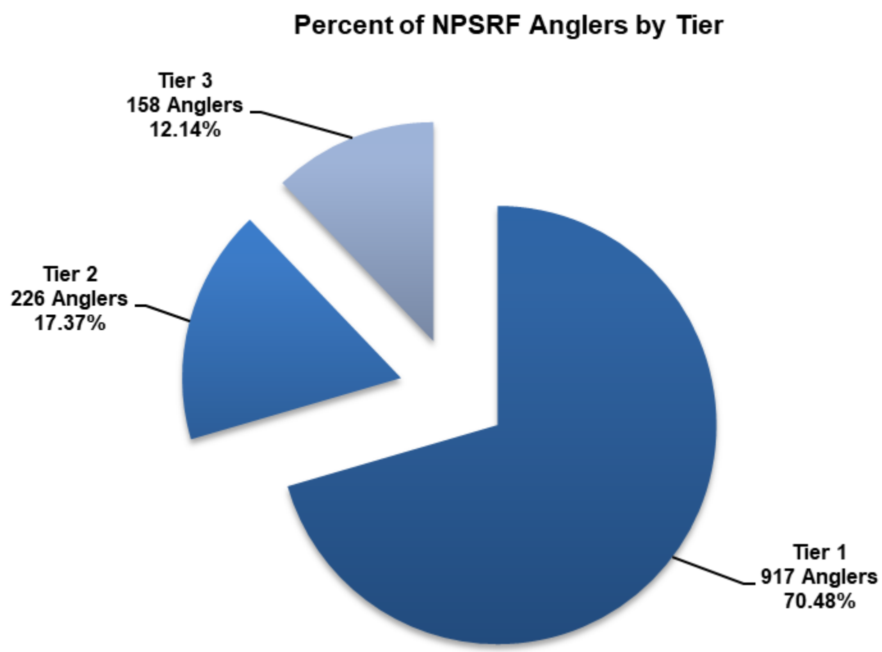


Figure 21. 2018 NPSRF Anglers by Tier (Returning Anglers) Based on Total Harvest

Table 4. Annual Comparison of NPSRF Successful Anglers by Tier (Before and After the 2015 Tier Change).

Year	Tier 1 Anglers	Tier 2 Anglers	Tier 3 Anglers	Successful Anglers	Separate Anglers	%Successful Anglers
2010	1,091	111	109	1,311	3,313	39.57
2011	1,226	113	87	1,426	3,624	39.35
2012	1,097	90	98	1,285	3,302	38.92
2013	941	97	92	1,130	2,618	43.16
2014	977	96	91	1,164	2,773	41.98
2010-2014 Mean	**1,066**	**101**	**95**	**1,263**	**3,126**	**40.41**
2015	986	239	163	1,388	3,210	43.24
2016	1,140	295	184	1,619	3,718	43.54
2017	1,048	287	155	1,490	3,462	43.04
2018	917	226	158	1,301	3,048	42.68
2015-2018 Mean	**1,023**	**262**	**165**	**1,450**	**3,360**	**43.15**

The larger number, and higher percentage of individual anglers at Tiers 2 and 3, (as a component of successful anglers) compared to mean 2010-2014 totals, is especially important to achieving NPSRF harvest and exploitation objectives since Tier 2 and Tier 3 anglers have a much higher CPUE than Tier 1 anglers (Hisata et al. 1996). Additionally, at the same time that the number and percentage of anglers at Tiers 2 and 3 was growing, the NPSRF was able to recruit and maintain a similar number of Tier 1 anglers (which make up the largest group of successful anglers) so the overall number of successful anglers is above 2010-14 levels.

While Tier 1 anglers made up 70.48% of all successful NPSRF participants in 2018, (well below the mean 2010-2014 level of 84.4%), they accounted for only 2.75% of total NPSRF harvest (4,951 Northern Pikeminnow) (Figure 22). Tier 2 anglers made up 17.37% of all successful anglers and harvested 9.69% of total NPSRF harvest (17,477 fish). Tier 3 anglers made up 5.2% of all participants (both returning and non-returning anglers), 12.14% of all successful anglers and accounted for 87.56% of total NPSRF harvest (157,845 fish).

Average annual harvest per angler was up for both Tier 1 and Tier 2 anglers. Tier 1 anglers annual average harvest was up slightly from 5.39 fish per year in 2017 to 5.40 fish per year in 2018. Tier 2 anglers harvested an annual average of 77.33 fish per year in 2018, up from 74.25 fish per year in 2017. Average annual harvest for Tier 3 anglers declined to 999.02 fish per angler, per year, compared to 1,061.44 fish per year in 2017 (Shirley et al. 2018).

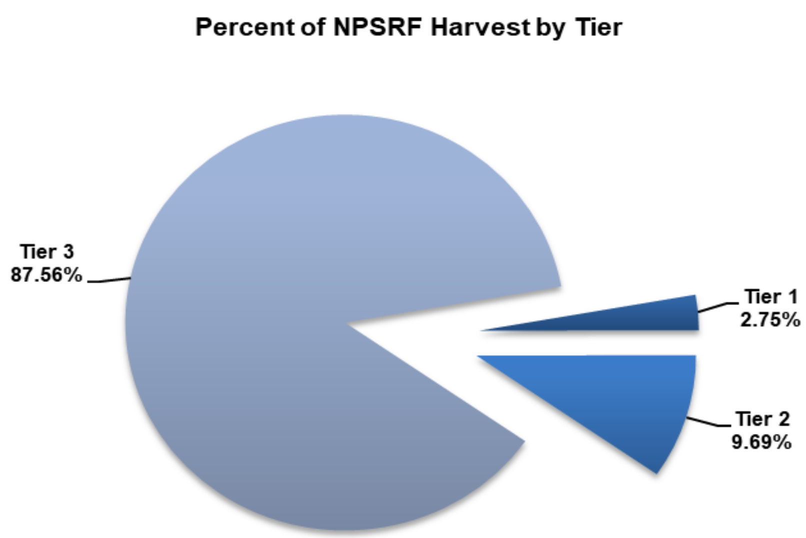


Figure 22. 2018 NPSRF Harvest by Angler Tier (Tier 1 = ≤25, Tier 2 =26-200, Tier 3 = > 200)

The overall average NPSRF participant (returning + non-returning anglers) expended more effort pursuing Northern Pikeminnow during the 2018 season than in 2017 (7.87 vs. 7.50 angling days of effort). When we look at successful anglers only, the average successful angler increased their average annual effort spent to 16.27 angler days during the 2018 NPSRF compared to 15.23 days in 2017. When we break down successful angler effort by tier, Tier 1 anglers spent an average of 5 days fishing in both 2017 and 2018 (Figure 23). Tier 2 anglers spent an average of 26 days fishing in 2018 versus 23 days fishing in 2017. Tier 3 anglers spent an average of 67 days fishing in 2018, down from 71days in 2017 (Shirley et al. 2018).

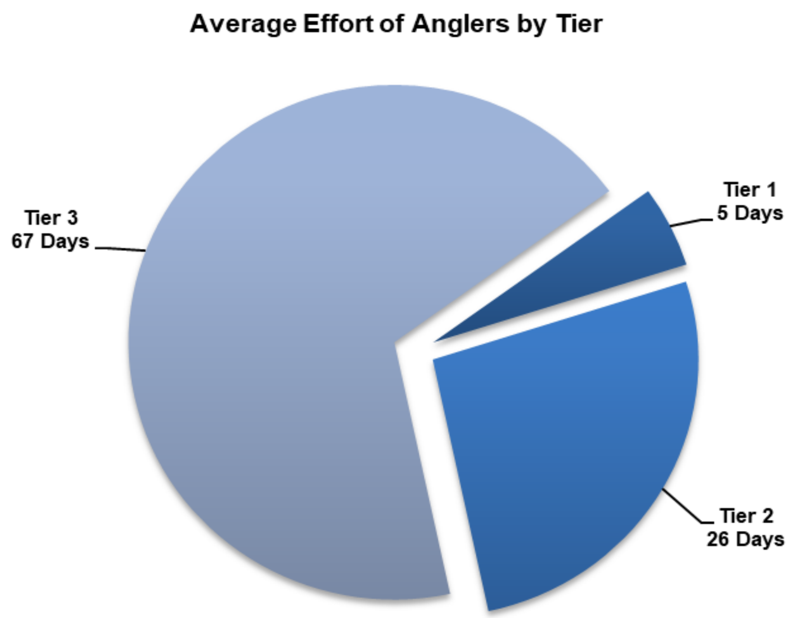


Figure 23. Average Effort of 2018 NPSRF Anglers by Tier (Tier 1 = < 25, Tier 2 = 26-200, Tier 3 = > 200)

When 2018 CPUE by tier is compared to 2017 there is a decrease in CPUE at Tier 1 and 2 while Tier 3 remained the same. CPUE for anglers at Tier 1 decreased from 1.09 fish per angler day in 2017 to 1.05 in 2018 (Figure 24). CPUE for Tier 2 anglers decreased from 3.27 fish per angler day in 2017 to 2.98 in 2018. CPUE for Tier 3 anglers in 2018 was the same as in 2017, 14.93 fish per angler day (Shirley et al. 2018).

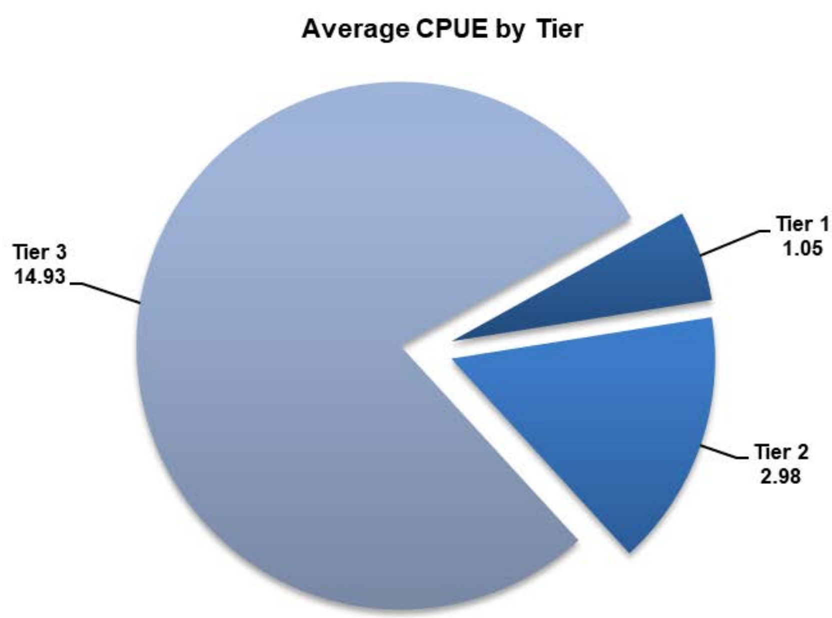


Figure 24. Average CPUE of 2018 NPSRF Anglers by Tier (Tier 1 = <25, Tier 2 =26-200, Tier 3 = > 200)

The top individual angler (based on number of fish caught) for the 2018 NPSRF harvested 8,686 Northern Pikeminnow, which also included 3 spaghetti tagged Northern Pikeminnow and 5 tag-loss Northern Pikeminnow worth a total earnings of $71,049 (PSMFC 12/13/2018 Sport-Reward Payment Summary). The 2018 top angler caught 1,591 less reward sized Northern Pikeminnow than he did as the top angler in 2017. The CPUE for this year's top angler (64.8 fish per angler day) was down from what he had as the top angler in 2017 (79.6 fish per angler day) reflecting that even the top angler had a more difficult time catching Northern Pikeminnow with the river conditions in effect during much of the 2018 NPSRF. The top angler for the 2018 season spent 5 more days of effort (134 days) than he did in 2017 (129 days) as the top angler (Shirley et al. 2018). By comparison, the top angler in terms of participation (rather than harvest) for the 2018 NPSRF fished 152 days of the 153 available days (99.3% of available days) and harvested 1,926 Northern Pikeminnow.

Tag Recovery

Northern Pikeminnow Tags

Returning anglers harvested 198 Northern Pikeminnow tagged by ODFW with external spaghetti tags during the 2018 NPSRF compared to 269 spaghetti tags harvested in 2017 (Shirley et al., 2018). Tag recoveries peaked during week 26, the same as peak 2018 NPSRF harvest (Figure 25), and was five weeks later than peak tag recovery in 2017 (Shirley et al. 2018). All of the 198 spaghetti tagged Northern Pikeminnow recovered in the 2018 NPSRF, retained PIT tags added by ODFW as a secondary mark. WDFW technicians also recovered an additional 126 Northern Pikeminnow, which had retained ODFW PIT tags, but had "lost" the ODFW spaghetti tag (e.g. tag-loss). The recovered spaghetti and PIT tags from tag-loss data were estimated by ODFW to equal a 16.8% exploitation rate for the 2018 NPSRF (Carpenter et al. 2019).

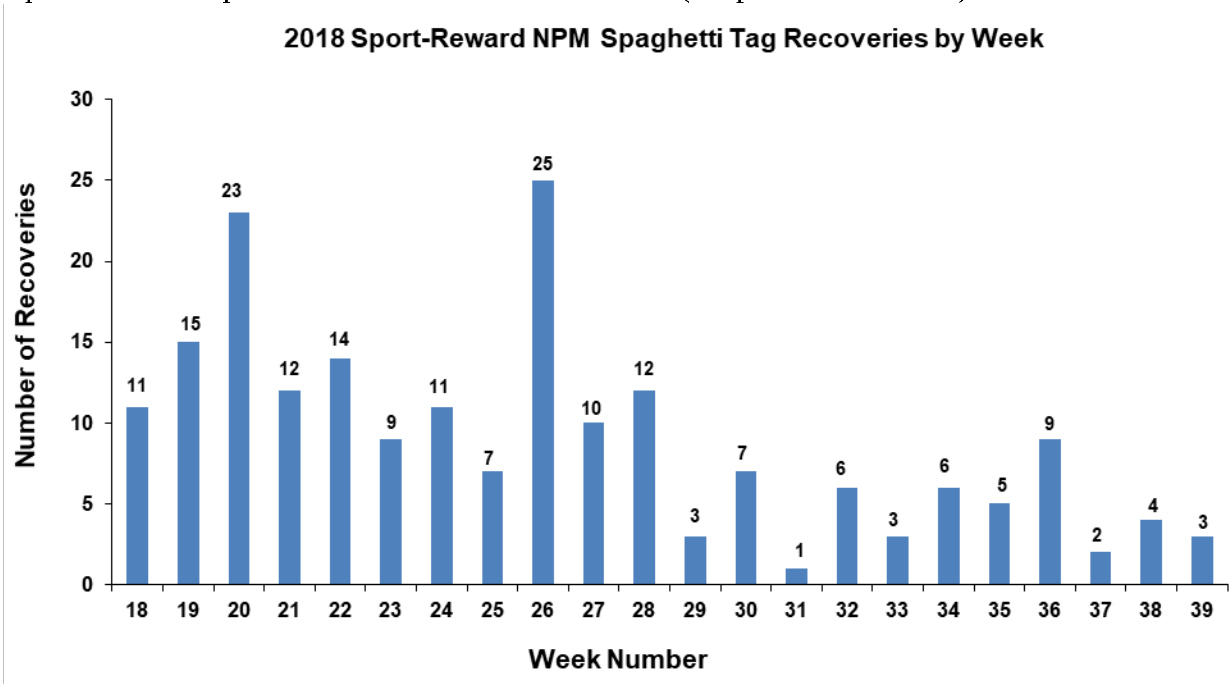


Figure 25. 2018 NPSRF Spaghetti Tag Recoveries by Week

Ingested PIT Tags

A total of 180,273 Northern Pikeminnow were individually scanned for the presence of PIT tags in 2018. This represents 100% of the total harvest of reward-size fish for the 2018 NPSRF (Northern Pikeminnow not qualifying for rewards were also scanned whenever possible). Technicians recovered a total of 26 PIT tags from consumed smolts that had been ingested by Northern Pikeminnow harvested during the 2018 NPSRF, an overall occurrence ratio of 1:6,934 compared to 1:7,659 in 2017. Total ingested PIT tag recoveries in 2018 was one recovery higher than the previous year. While total harvest was lower in 2018 than in 2017, the rate of occurrence for ingested PIT tags increased from 1:7,659 in 2017 to 1:6,934 in 2018. PIT tag recoveries of salmonid smolts ingested by Northern Pikeminnow had peaks on two different occasions one during week 18 and another during week 25 of the 2018 season (compared to week 19, 22, and 27 in 2017) (Shirley et al. 2018). Our last ingested PIT tag recovery occurred during week 30 (July 23rd – July 29th) (Figure 26).

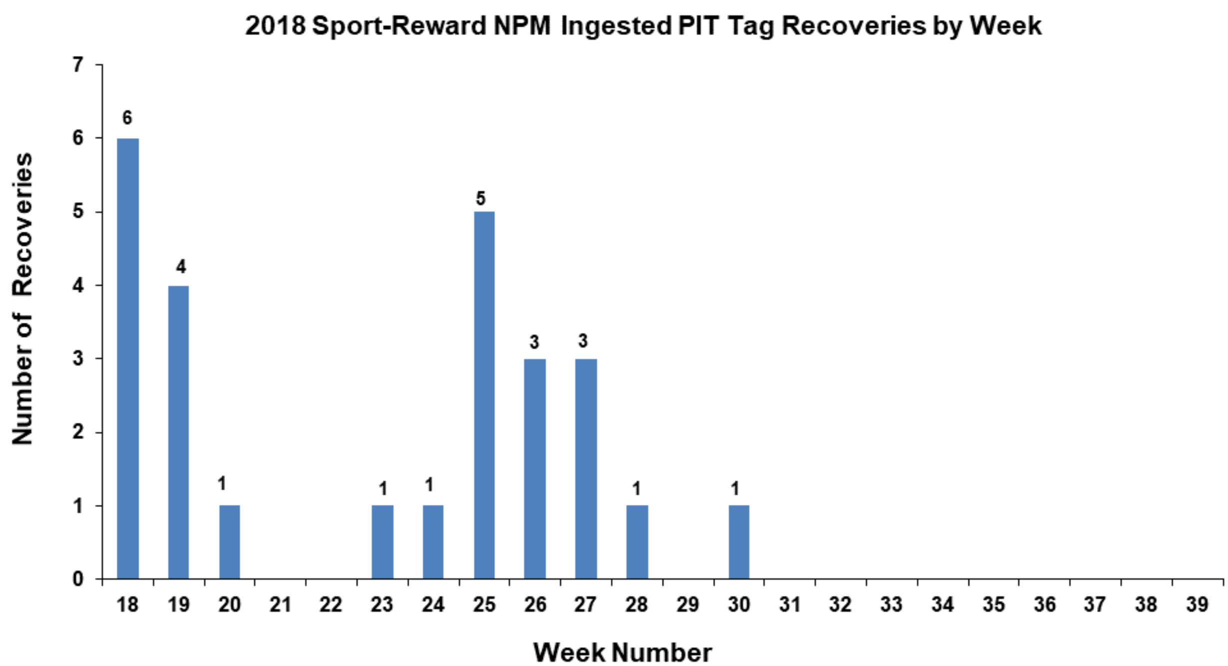


Figure 26. 2018 NPSRF Ingested PIT Tag Recoveries by Week

Ingested PIT tag recoveries by fishing location during the 2018 NPSRF showed that Northern Pikeminnow harvested from fishing location 08 (Ice Harbor Reservoir) and fishing location 10 (Little Goose Reservoir) had ingested the largest number of salmonid smolts containing PIT tags (Figure 27).

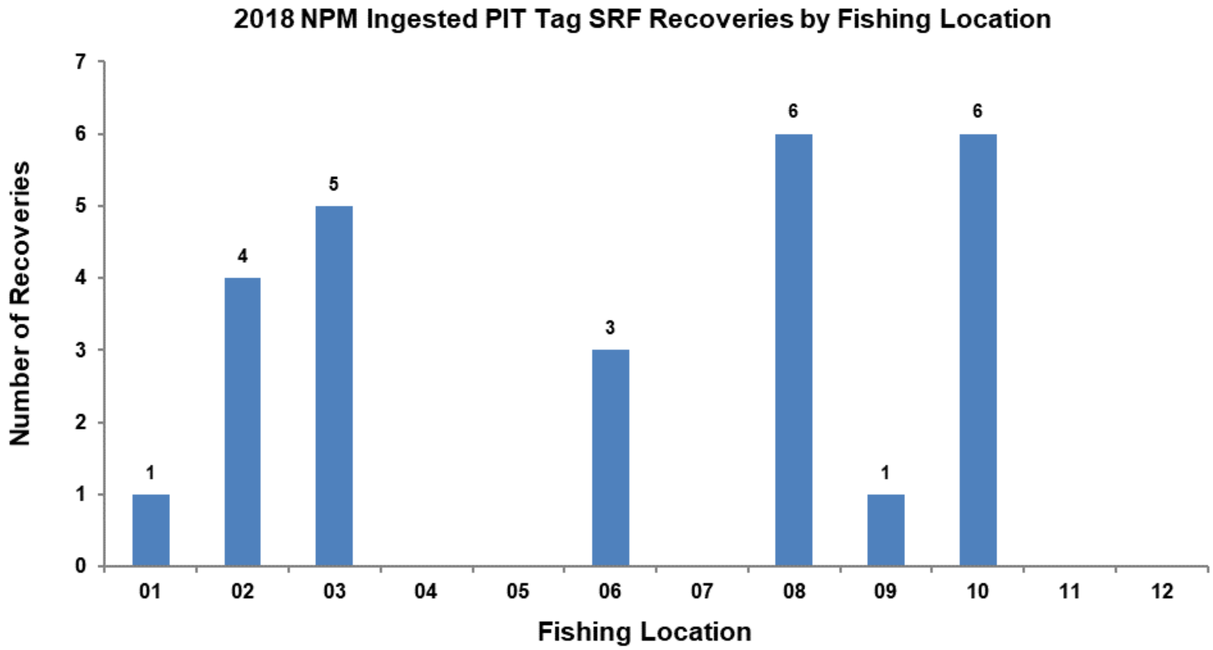


Figure 27. 2018 NPSRF ingested PIT Tag Recoveries by Fishing Location*
*Fishing Location Codes – **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth of the Snake River to Priest Rapids Dam. **Snake River**; 07 = Mouth of the Snake River to Ice Harbor Dam, 08 = Ice Harbor Reservoir, 09 = 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 Hells Canyon Dam.

Species composition of PIT tagged smolts ingested by Northern Pikeminnow harvested in the 2018 NPSRF was obtained from PTAGIS and indicated that 25 of the 26 ingested PIT tag recoveries (96.2%) were from Chinook smolts (Figure 27). In addition, all (100.0%) of the Chinook PIT tags were of hatchery origin. PTAGIS queries revealed that these PIT tag recoveries consisted of 15 Fall Chinook, 8 Spring Chinook, 1 Summer Chinook, and 1 unknown hatchery origin Chinook. The one non-chinook PIT tag recovery was from a Hatchery Summer Steelhead.

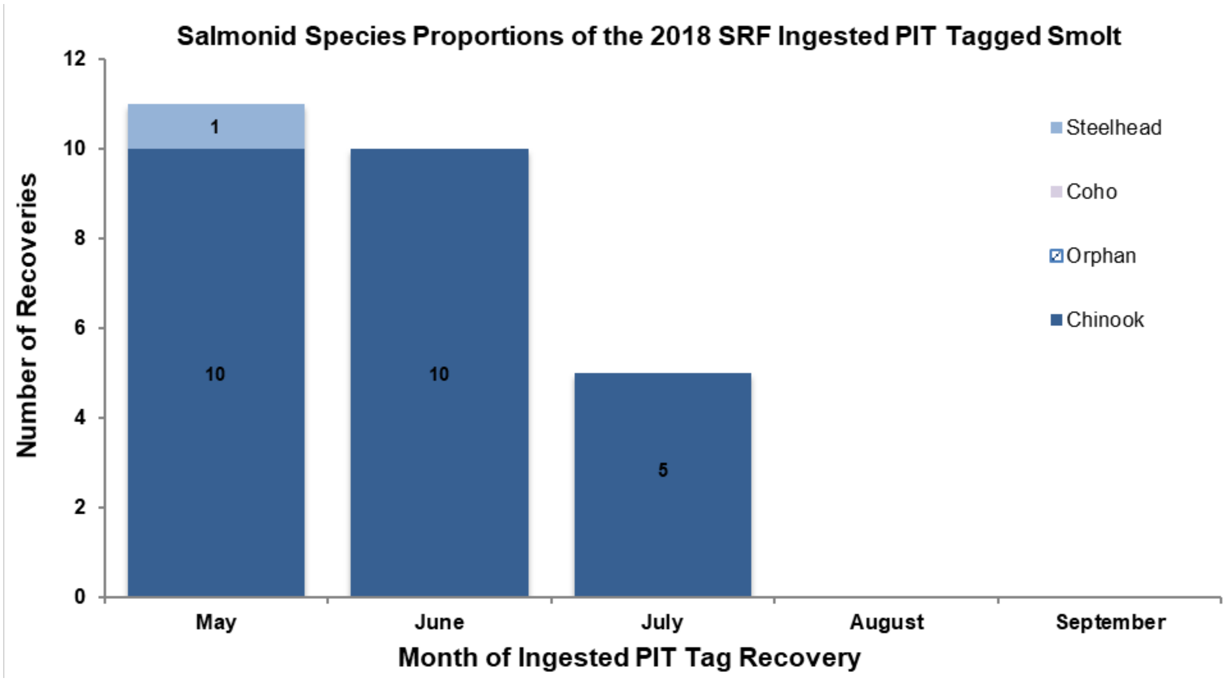


Figure 28. Recoveries of Ingested Salmonid PIT Tags From the 2018 NPSRF

Analysis of PIT tag recovery data from the 2018 NPSRF continues to document actual Northern Pikeminnow predation on downstream migrating juvenile salmonids and possible predation "hotspots". 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 2018 NPSRF succeeded in reaching the NPMP's 10-20% exploitation goal for the twenty-first consecutive year, achieving an estimated exploitation rate of 16.8%. NPSRF harvest in 2018 was 11,206 fish lower than 2017 harvest, but well above mean 1991-2017 annual harvest of 176,913. Annual angler effort in 2018 decreased by 1,984 angler days (7.7%) from 2017, but was still 4,471 angler days more than in 2014, prior to the tier modification. The number of individual anglers decreased by 414 anglers in 2018 (12%) from 2017, but is still 275 anglers higher than 2014, prior to the tier modification designed to boost effort. Despite higher water conditions early in the season (which is less favorable for angling), CPUE increased from 7.38 in 2017 to 7.52 in 2018 (Shirley et al. 2018). Peak weekly harvest occurred during the historical peak in week 26. Peak weekly effort occurred during the first week of the 2018 season (May 1-6), continuing a trend that began in 2015 with the first year of the tier modification. The Cathlamet registration station was the NPSRF's top station for harvest in 2018 (44,607 fish) for the first time in the 28 year history of the NPSRF. The Dalles registration station once again accounted for the most effort with 4,425 angler days of effort spent. We recovered 198 Northern Pikeminnow that were spaghetti tagged by ODFW, and an additional 126 Northern Pikeminnow which were missing spaghetti tags but retained ODFW PIT tags (tag-loss). Mean fork length for Northern Pikeminnow harvested in the 2018 NPSRF was 272.6 mm, down from 279.82 mm in 2017 (Shirley et al. 2018). Incidental catch consisted primarily of Peamouth, Smallmouth Bass, and Yellow Perch (mostly released), and reflected similar catch patterns to previous NPSRF seasons.

For the 2018 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) where angler CPUE was 13.65 Northern Pikeminnow per angler day. The station with the highest CPUE in 2018 was Ridgefield (15.84). Early in the 2018 NPSRF, The Dalles station experienced a major downturn in CPUE going from 10.08 in 2017 to 6.41 in 2018 (Shirley et al. 2018). As a result of these lower catch rates, angler effort also declined at The Dalles and some anglers fished other locations. Many of the anglers who would have normally fished near The Dalles station found better fishing (as indicated by much higher CPUE) in the lower Columbia area near the Cathlamet through Ridgefield stations. Higher catch rates found in the lower river during 2018 also led to angler effort well above recent levels at those stations. The top angler harvested 8,686 fish (worth $71, 049) during the 2018 NPSRF compared to 10,277 fish in 2017 ($83,877) (Shirley et al. 2018).

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 of ingested salmonids declined 1:6,934 in 2018 versus 1:7659 in 2017 (Shirley et al. 2018). Species composition of the 26 ingested PIT tags that we recovered from harvested Northern Pikeminnow showed that they were almost exclusively from Chinook smolt of hatchery origin. We also recovered PIT tags from one ingested Hatchery Steelhead according to PTAGIS.

RECOMMENDATIONS

1) Continue to use standardized season dates (May 1st-Sept 30th) for implementation of the 2019 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 $5 base reward level used in 2018 as an incentive designed to recruit new anglers to the 2019 NPSRF. Continue to utilize the Tier levels used in 2018 designed to incentivize current, proficient anglers to expend additional effort participating in the 2019 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) Continue to 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) 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.

5) Investigate the feasibility of using PIT tag scanners that can communicate with Ipad-type devices for PIT tag data collection.

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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PSMFC 2018 SPORT-REWARD PAYMENT SUMMARY - December 13, 2018

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REPORT B

Northern Pikeminnow Sport-Reward Payments

2018 Annual Report

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March 2019

ABSTRACT

Northern Pikeminnow Sport-Reward Program Payments: *PSMFC to 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.*

For 2018, the rewards paid to anglers were the same as in the 2017 season. Anglers were paid $5, $6, and $8 per fish for the three payment tiers (1-25 fish, 26-200 fish and 201 and up) during the season. The rewards for a tagged fish were $500 per fish. One hundred seventy-eight thousand ninenty-four 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, tagged fish and tag-loss bonus payments) was $1,307,442.

A total of 198 tagged fish (having an external spaghetti tag) were paid at $500 each. The season total paid for tag rewards was $99,000. A total of 126 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 $12,600.

A total of 795 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 $7,950.

A total of 3,048 separate anglers registered to fish, of which 951 (31%) caught one or more fish and received payments during the season. The total value for all 178,292 Northern Pikeminnow submitted for payment in 2018 (including all coupons, tagged fish and tag-loss *bonus* payments) was $1,426,992.

INTRODUCTION

The **Northern Pikeminnow Sport Reward Program** was administered by PSMFC in 2018. 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.

THE 2018 SEASON

The 2018 season ran from May 1, 2018 through September 30, 2018.

PSMFC maintained an accounting system during the season to determine the appropriate reward amount due each angler for particular fish. Rewards were paid at $5 for the first 25 fish caught during the season, $6 for fish in the 26-200 range, and $8 for all fish caught by an angler above 200 fish.

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 (2013 – 2017) and to those who signed up for our mailing list at the various sportsmen's shows. The 2018 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 795 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 $7,950.

PARTICIPATION AND PAYMENT

A total of 1,301 anglers who registered were successful in catching one or more fish in 2018. Of those anglers; 951 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 2018 a total of 180,273 fish were harvested in the sport-reward fishery. Of this total, 178,292 fish were submitted for payment and paid prior to the 2018 payment deadline (To obtain payment, vouchers must have been received no later than November 15, 2018). In addition, any *received* vouchers with issues preventing payment (missing information, voiding of voucher for program violations, etc.) not resolved by November 15, 2018 became null and void.

TAGGED FISH AND PAYMENTS

Registered anglers caught and submitted a total of 198 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 $99,000.

TAG-LOSS BONUS PAYMENT

All tagged Northern Pikeminnow initially have both a spaghetti tag and a PIT (Passive Integrated Transponder) 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 126 tag-loss fish qualified for and were paid the *bonus* reward of $100. The season total paid for tag-loss *bonus* was $12,600.

TOTAL ACCOUNTING

Total payments for the season of regular vouchers, *$10 bonus coupons*, tag vouchers and *tag-loss bonus* payments was $1,426,992.

All IRS Form 1099-MISC Statements were sent to the qualifying anglers for tax purposes in the fifth week of January 2019. Appropriate reports and copies were provided to the IRS by the end of February 2019.

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

2018 SPORT REWARD PAYMENTS SUMMARY

The following is a summary of all vouchers received and paid as of December 13, 2018

	Fish	Incentives	Reward
Fish paid @ tier 1 ($5 each):	13,130	-	$65,650
Fish paid @ tier 2 ($6 each):	38,960	-	$233,760
Fish paid @ tier 3 ($8 each):	126,004	-	$1,008,032
Tags paid (@ $500 each):	198	-	$99,000
Coupons issued (@ $10 each):	-	795	$7,950
Tag-loss issued (@ $100 each):	-	126	$12,600
Total:	178,292		$1,426,992

Anglers @ tier 1	*573*
Anglers @ tier 2	*220*
Anglers @ tier 3	*158*
Number of separate anglers	*951*
Anglers with 10 fish or less:	*444*
Anglers with 2 fish or less:	*198*

	Total Fish	$500 Tags	Tag Loss Tags	Coup.	Total Reward Paid
1.	8,686	3	$ 500	$ 10	$ 71,049
2.	6,438	4	$ 400	$ 10	$ 53,457
3.	6,317	5	$ 300	$ 10	$ 52,881
4.	6,358	2	$ -	$ 10	$ 51,433
5.	3,902	11	$ 100	$ 10	$ 36,313
6.	3,051	6	$ 400	$ 10	$ 27,345
7.	3,078	4	$ 200	$ 10	$ 26,377
8.	3,061	1	$ 200	$ -	$ 24,755
9.	2,903	1	$ 100	$ 10	$ 23,401
10.	2,765	2	$ 100	$ 10	$ 22,789
11.	2,539	5	$ 200	$ 10	$ 22,563
12.	2,498	3	$ 200	$ 10	$ 21,245
13.	2,339	4	$ 300	$ 10	$ 20,565
14.	2,543	0	$ -	$ 10	$ 19,929
15.	2,024	3	$ 400	$ 10	$ 17,655
16.	2,185	1	$ -	$ 10	$ 17,557
17.	2,052	1	$ 100	$ 10	$ 16,593
18.	1,829	4	$ 100	$ 10	$ 16,297
19.	1,885	2	$ 500	$ 10	$ 16,149
20.	1,868	3	$ 100	$ 10	$ 16,105
	68,321	65	$4,200	$ 190	$ 574,458

NORTHERN PIKEMINNOW SPORT-REWARD FISHERY VOUCHER

2018 STANDARD

TO ENSURE PROMPT PAYMENT:
1) Verify voucher is complete.
2) Fill out, detach and keep receipt.

MAIL TO: NORTHERN PIKEMINNOW SPORT-REWARD FISHERY
PO Box 82128
Portland, OR 97282-0128

LAST NAME

FIRST NAME

MI

ADDRESS

CITY

STATE

ZIP CODE

ANGLER TELEPHONE NUMBER

– –

VOUCHER #

EMAIL (OPTIONAL)

@

MONTH DAY 2 0 1 8

DOCUMENT #

STATION

TOTAL # OF QUALIFYING NORTHERN PIKEMINNOW CLAIMED (EXCLUDING TAGGED FISH)

(NUMBER)

X

(WRITTEN TOTAL)

LAST 4 DIGITS SS#: -

I hereby swear under the penalty of perjury that the above information is true and correct and that I caught all fish claimed on this voucher in accordance with all Sport-Reward Fishery Rules and Regulations printed on the back of this voucher.

X

TECHNICIAN SIGNATURE

X

ANGLER SIGNATURE (Must be signed in the presence of Technician)

DATE

STATION

Fishing Date: ____________________

Station: ____________________

Voucher #: ____________________

Document Number: ____________________

Number of fish: ____________________

*** * * DETACH & KEEP THIS STUB FOR YOUR RECORDS * * ***

REWARD VOUCHER INFORMATION

1-800-769-9362 (Toll Free)

E-MAIL: vouchers@pikeminnow.org

*****TO OBTAIN PAYMENT, THIS VOUCHER MUST BE RECEIVED BY PSMFC NO LATER THAN 11/15/18.*****

[ANY ISSUES PREVENTING PAYMENT (missing information, voiding of vouchers for sport-reward fishery rule violations ect.) MUST BE RESOLVED PRIOR TO THIS DATE OR THE VOUCHER BECOMES NULL AND VOID]

NORTHERN PIKEMINNOW SPORT-REWARD FISHERY VOUCHER

2018 TAG

LAST NAME | FIRST NAME | MI

ADDRESS

CITY | STATE | ZIP CODE

ANGLER TELEPHONE NUMBER — —

TAG VOUCHER #

EMAIL (OPTIONAL) @

MONTH | DAY | 2 0 1 8 | DOCUMENT # | STATION | LOC FISHED

SPAGHETTI TAG # | PIT TAG # | TAG COLOR

LAST 4 DIGITS SS#: -

X

TECHNICIAN SIGNATURE

I hereby swear under the penalty of perjury that the above information is true and correct and that I caught all fish claimed on this voucher in accordance with all Sport-Reward Fishery Rules and Regulations printed on the back of this voucher.

X

ANGLER SIGNATURE (Must be signed in the presence of Technician) | **DATE** | **STATION**

STAPLE TAG ENVELOPE HERE
(Write Fork Length on Tag Envelope)

X

ODFW TAG VERIFICATION SIGNATURE

TO ENSURE PROMPT PAYMENT:
1) Verify voucher is complete.
2) Fill out, detach and keep receipt.

MAIL TO:
ODFW
NORTHERN PIKEMINNOW PROGRAM
PO Box 2290
Clackamas, OR 97015

Fishing Date: ______
Station: ______
Voucher #: ______
Document Number: ______
Tag Number: ______

*** * * DETACH & KEEP THIS STUB FOR YOUR RECORDS * * ***
REWARD VOUCHER INFORMATION
1-800-769-9362 (Toll Free)
E-MAIL: vouchers@pikeminnow.org

*****TO OBTAIN PAYMENT, THIS VOUCHER MUST BE RECEIVED BY PSMFC NO LATER THAN 11/15/18.*****

[ANY ISSUES PREVENTING PAYMENT (missing information, voiding of vouchers for sport-reward fishery rule violations ect.) MUST BE RESOLVED PRIOR TO THIS DATE OR THE VOUCHER BECOMES NULL AND VOID]

Report C

System-wide Predator Control Program: Fisheries and Biological Evaluation

Prepared by

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Division of Fish and Wildlife
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ABSTRACT

Since 1990, the Northern Pikeminnow Management Program (NPMP) has applied targeted removal fisheries in the Columbia and Snake rivers to restructure populations of Northern Pikeminnow *Ptychocheilus oregonensis* in an effort to suppress predation on out-migrating juvenile Pacific salmon and steelhead *Oncorhynchus* spp. During 2018, the Oregon Department of Fish and Wildlife evaluated the continued efficacy of the Northern Pikeminnow removal program and assessed potential outcomes of the fisheries through a combination of field and laboratory activities and data analyses. This report augments historical information with current data and seeks to 1) estimate rates of exploitation of Northern Pikeminnow; 2) quantify the potential reduction in predation of juvenile salmonids 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 2018, we used standardized boat electrofishing to tag and release Northern Pikeminnow throughout the lower Columbia and Snake rivers. Tags recovered in the NPMP Sport Reward Fishery were used to calculate exploitation rates for Northern Pikeminnow in the area covered by program implementation. Analyses of recaptures indicated that system-wide exploitation of Northern Pikeminnow greater than or equal to 250-mm fork length in the Sport Reward Fishery during 2018 was 16.8% (95% confidence interval, 12.1–21.5%). This value was within the NPMP targeted range of 10-20%. Based on this level of exploitation, we estimate 2019 predation levels will be 29% (range: 13–41%) 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 and gradually decrease through 2022. Predation behavior by Northern Pikeminnow caught in the Dam Angling Fishery in Bonneville and The Dalles reservoirs was similar to previous years with the highest presence of juvenile salmonids, lamprey (family Petromyzontidae), and American Shad *Alosa sapidissima* in the diet coinciding with their respective outmigration peaks. Abundance index estimates for 2018 in most areas of The Dalles and John Day reservoirs indicate a decrease since the early 1990s in Northern Pikeminnow greater than or equal to 250-mm fork length. Overall, highly variable abundance, consumption, and predation index values for the predators monitored in our study provide no obvious indication of a long-term compensatory response to the targeted removal of Northern Pikeminnow. However, increases in Smallmouth Bass and Walleye abundance observed in The Dalles and John Day reservoirs could reduce the benefit of removing Northern Pikeminnow as these fish also prey on juvenile salmon and steelhead. Proportional size distribution of Northern Pikeminnow collected during Sport Reward Fishery evaluation indicates a significant decrease since the early 1990s in The Dalles, John Day, McNary, and Lower Granite reservoirs. 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 system-wide effects.

INTRODUCTION

The Columbia and Snake rivers historically 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 investigate predator impacts on juvenile salmonids given that: (1) the reservoir was known to be an important area for rearing of subyearling Chinook Salmon *Oncorhynchus tshawytscha*; (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 dominant predator on juvenile salmon, accounting for 78% of the predation-related mortality 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 explain these questions, indices were developed to allow rapid assessment of the extent of predation by Northern Pikeminnow throughout the system. From 1991 through 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 the issue of predation on juvenile salmonids 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 objective, the Oregon Department of Fish and Wildlife (ODFW) has sampled standardized areas since the early 1990s in the Columbia and Snake rivers to evaluate the efficacy of targeted removals to reduce predation and 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 2018 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 Columbia and lower Snake rivers.

METHODS

Sampling during 2018 was conducted using Smith-Root™ 18-EH model electrofishing boats equipped with a 5.0 or 7.5 generator powered pulsator electrofisher powered by either a Kohler Power Systems™ or Briggs and Stratton™ gas generator. When engaged, the electrofishing unit applies pulsed direct current (DC) at a rate of 60 pulses/s; 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 and each supports a single array composed of six electrodes. Electrodes hanging from the boat hull function as the cathodes. Electrofishing controls are set according to federal guidelines where peak output does not exceed 800 V at water conductivity 100 to 300 µS/cm (NMFS 2000). The targeted average current during all electrofishing events was 3–4 A. All controls were standardized across boats with minor adjustments to the duty cycle to achieve the targeted output. Program electrofishing protocols were developed to minimize fish exposure to electric current to induce electrotaxis (uncontrolled convulsion which causes a fish to swim toward the anode) while avoiding tetany (when a fish becomes stiff). Additionally, protocols to limit interactions with species listed under the U.S. Endangered Species Act guide sampling efforts.

Sport Reward Fishery Evaluation and Predation Reduction Estimates

Field Procedures

To address our first objective, we tagged Northern Pikeminnow and estimated exploitation rates with tag recovery data from the Sport Reward Fishery (SRF). 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 16 (Ice Harbor Dam) to rkm 66 (Lower Monumental Dam) and rkm 113 (Little Goose Dam) to rkm 251 upstream of Lower Granite Dam (Figure 1). Four sampling events consisting of 900 seconds (s) of boat electrofishing effort were conducted within each 1.61 river kilometer (1 river mile). The efficacy of boat electrofishing tends to be limited to a maximum depth of approximately 3 m; thus, sampling was conducted primarily along shallow shoreline areas. Sampling occurred from 3 April to 28 June 2018 between 1800 and 0500 hours, except in the Hanford Reach of the Columbia River (rkm 561– 637) and near Asotin, WA on the Snake River (rkm 230–251), where safe river navigation necessitated daytime sampling. A total of 42 rkm in the Columbia River and two rkm in the Snake River were not sampled due to equipment malfunction or 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 The Dalles Dam (rkm 307) were tagged prior to the start of the fisheries (1 May 2018). Upstream of The Dalles Dam, Northern Pikeminnow were tagged concurrent with the fisheries.

We tagged, and subsequently released Northern Pikeminnow ≥ 200 mm 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 passive integrated transponder (PIT) tag inserted into the dorsal sinus. Additionally in 2018, Walleye were opportunistically captured, measured for fork length, and weighed throughout the Columbia and lower Snake rivers in an attempt to gain some understanding of the populations in these areas and supplement data collected during biological evaluation activities (see below).

Working with the Washington Department of Fish and Wildlife (WDFW), tag recovery information was obtained from the Sport Reward and Dam Angling fisheries. The Sport Reward Fishery occurred daily from 1 May to 30 September 2018 (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 TL corresponds approximately to the minimum FL (200 mm) of Northern Pikeminnow marked during tagging operations. The reward payment schedule consisted of three tiers (see Report B for details). Further, anglers were eligible for a $500 reward for each external loop tagged fish returned to a check station and a $100 reward for each "tag-loss" fish (i.e., those fish for which an external tag had been lost in the environment, but a functioning PIT tag remained present). Given this, we assumed 100% of the Northern Pikeminnow marked with an external and/or an internal PIT tag removed from the fishery were submitted to a check station for reward payment during the season.

In addition to the Sport Reward Fishery, an NPMP-administered Dam Angling Fishery (see Report D for details) was conducted from 1 May to 3 October 2018 in the powerhouse tailrace areas of The Dalles (sampling Bonneville Reservoir) and John Day (sampling The Dalles Reservoir) dams. A team of anglers used hook-and-line gear to remove Northern Pikeminnow; all fish were examined for presence of external loop and internal 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 both 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 in TL (≥ 278 mm TL; ≥ 250 mm FL) to 9 in 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 tagged fish), 2) 200–249 mm FL, and 3) ≥ 250 mm FL. The subset of fish ≥ 250 mm FL was used for long-term temporal comparisons.

To account for 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 = the number of tagged fish recaptured during the season in area j, and
M_j = the number of fish tagged in area j.

Beginning in 2014, the NPMP incentivized the return of tag-loss Northern Pikeminnow. Thus, a correction for tag retention was not necessary to estimate 2018 exploitation rates.

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

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

where

z = a multiplier from the standard normal distribution,
R_j = as described above, and
M_j = as described above.

When tagging and fishing efforts occurred concurrently, 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} = the number of tagged fish recaptured in area j during the i^{th} week, and
M_{ij} = the number of marked fish at large in area j at the beginning of the i^{th} week of the Sport Reward Fishery.

To account for positive bias associated with insufficient mixing, we excluded the few fish that were recaptured during the same week they were tagged from the analysis.

The magnitude of negative bias associated with exploitation rates calculated using the Petersen estimator can be uncertain 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

n_j = the number of weeks in the season in area j,
R_{ij} = as described above, and
M_{ij} = as described above.

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

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

where

t = a multiplier from the Student's *t*-distribution for $k - 1$ degrees of freedom,
s_j = the standard deviation of the weekly exploitation estimates for area j, and
n_j = as described 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 pre-program 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 2019 based on observed exploitation rates from 2018 and predict three future predation rates (maximum, median, and minimum) using the mean level of exploitation observed during contemporary program rules (2001; 2004–2018). Additional model documentation is described in Friesen and Ward (1999).

Biological Evaluation

Field Procedures

We used standardized boat electrofishing techniques (Ward et al. 1995; Zimmerman and Ward 1999) to evaluate Northern Pikeminnow, Smallmouth Bass, and Walleye population parameters in The Dalles and John Day reservoirs during 2018. Early morning (0200–1200 hours) sampling was conducted during spring (8–25 May 2018) and summer (19 June–3 July 2018) 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 900-second boat electrofishing period with continuous output of approximately 4 A.

We recorded catch and biological data for all Northern Pikeminnow, Smallmouth Bass, and Walleye collected. Fork length (nearest mm) and mass (nearest 10 g) were measured for all fish collected. Scale samples were removed from 25 fish per 25-mm FL increments for all three species in both areas. All untagged Northern Pikeminnow greater than or equal to 200 mm FL were sacrificed and digestive tracts were collected for subsequent analyses. Tagged Northern Pikeminnow captured during biological evaluation are measured, weighed, and returned to the river. Digestive tracts were removed by securing both ends with hemostats and pulling free of 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 processed in the laboratory.

Using the protocol described above, we also collected digestive tracts from Northern Pikeminnow captured during the 2018 Dam Angling Fishery of the NPMP. Digestive tracts were collected from a representative subsample of catches at each dam weekly from 22 May–23 August 2018, generally three days per week. In addition, morphometric measurements (FL and mass), sex, and maturity data were collected for each fish sampled. Starting in 2018, Walleye that were caught during these activities were also opportunistically sampled using non-lethal gastric lavage following the protocols used above during biological evaluation.

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 and Walleye collected during the Dam Angling Fishery to quantify relative consumption of juvenile salmon. Due to the large number of Smallmouth Bass diet samples collected during the biological evaluation, a random subsample of 34 diet samples per day were processed in the laboratory. Additional samples were selected from another representative day if 34 samples were not collected on a given day. All Northern Pikeminnow and Walleye gut contents collected in the field during 2018 were processed in the laboratory.

Frozen field samples were thawed in the laboratory and the contents sorted into general prey categories (i.e., fish, crayfish, other crustaceans, insects and other invertebrates, and miscellaneous). Parasitic invertebrates (e.g., tapeworms) found in the gut contents were noted in the comments, but not weighed or categorized as prey items. Gut 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), tissue, or other possible fish remnants were then returned to the original sample bags for chemical digestion to allow for further determination of prey fish taxa. To ensure complete recovery of diagnostic structures from Northern Pikeminnow diet samples, entire gastrointestinal tracts were digested along with fish parts. To digest soft tissues, a 20-ml solution of pancreatin and sodium sulfide nonahydrate (Na_2O_9S)—mixed at 20 g/L and 10 g/L with tap water, respectively—was added to each sample. Sample bags were then placed in a desiccating oven at approximately 48°C for 24 h. After removal from the oven, a 20-ml solution of sodium hydroxide (lye, NaOH)—mixed at 30g/L with 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. In some cases, the presence of fish was noted during the initial sorting and weighing, but no diagnostic bones, otoliths, or fish hard parts were found post-cook. When this occurred, it was assumed that those hard parts were lost during the cooking process, and an unidentified fish was counted for diet analysis. Stomach samples of fishes that did not contain diet items (empty) were included in all analyses.

Hard parts remaining after chemical digestion were examined to identify prey to the lowest possible taxon (usually family) under stereoscopic 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 minimum counts of a given prey taxon in a diet sample; however, only presence/absence could be evaluated for certain prey items. 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 because of differential digestion, we assumed one American Shad 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. In 2018, we discovered notochord structures remained post chemical digestion when lamprey tissues were noted before chemical digestion. 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 comparing 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 accuracy among analysts throughout examination, a minimum of 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 calculating the mean catch per 900 s boat electrofishing by season and area, then multiplying by the surface area (ha) of specific sampling locations in each river area and dividing by 1,000 for scale. 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}) using the formulas:

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

and

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

where

T = mean water temperature per season-area stratum ($^{\circ}$C),
W = mean predator mass (g),
S = mean number of juvenile salmon per predator, and
GW = mean gut mass (g) per predator.

Although these consumption indices do not provide direct estimates of the number of juvenile salmon eaten per day by an average predator; the 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 therefore provide a means to characterize relative predation impacts. Consumption index values were calculated only when sample sizes exceeded five fish for a given species, season, and sampling area. 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 size distribution (PSD; Anderson 1980; Guy et al. 2007) to characterize variation in size structure for Northern Pikeminnow sampled both in the Dam Angling Fishery and during biological evaluation of the Sport Reward Fishery, and Smallmouth Bass and Walleye populations sampled during biological evaluation of the Sport Reward Fishery using the formula:

$$PSD_i = 100 \times \frac{FQ_i}{FS_i}, \tag{8}$$

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 proportional size distribution of preferred-length fish (PSD-P) for Smallmouth Bass and Walleye (Gabelhouse 1984; Guy et al. 2007) sampled during biological evaluation using the equation:

$$PSD\ P_i = 100 \times \frac{FP_i}{FS_i}, \tag{9}$$

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). Anderson (1980) and Gabelhouse (1984) define stock, quality, and preferred minimum length categories for Smallmouth Bass as 180, 280, and 350 mm total length (TL), respectively. This stock-length is smaller than our target size (200 mm FL) for Smallmouth Bass. To remove any bias in our data from variation in sampling procedures that affect the lower observed FL of Smallmouth Bass among years, we chose to use our target size (FL > 199 mm) as minimum stock-length for PSD and PSD-P analyses of those fish. Because we only measure FL, quality and preferred minimum values were converted from TL to FL using species-specific models ($FL_{SMB} = TL_{SMB} /1.040$). Thus, stock, quality, and preferred minimum FL categories for Smallmouth Bass were 200, 269, and 337 mm, respectively. Similarly, previously defined categories for Walleye are: stock 250, quality 380, and preferred 510 mm TL (Anderson 1980; Gabelhouse 1984). These values were also converted to FL values of stock 236, quality 358, and preferred 481 mm using the species-specific model for Walleye ($FL_{WAL}= TL_{WAL}/1.060$). Annual PSD and PSD-P values were calculated only when sample sizes exceeded 19 stock-length fish in an area. To characterize uncertainty surrounding PSD and PSD-P 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) to calculate 95% confidence intervals.

Similar to shifts in size-structure, changes in body condition may indicate a compensatory response by remaining predators to the sustained exploitation of Northern Pikeminnow. We used relative weight (W_r; Wege and Anderson 1978) to compare the condition of Northern Pikeminnow, Smallmouth Bass, and Walleye in 2018 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 W_r according to the equation:

$$W_r = 100 \times \frac{W}{W_s}, \tag{10}$$

where

W = the mass of an individual fish, and

W_s = predicted standard weight.

To account for 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 between sexes when calculating W_r for these species. For these calculations, we only used fishes that met minimum target sizes (250 mm FL for Northern Pikeminnow and 200 mm FL for Smallmouth Bass and Walleye). As for PSD and PSD-P, we estimated 95% confidence intervals for median W_r values using a non-parametric bootstrap approach (Fox and Weisberg 2011; R Core Team 2013).

Temporal monotonic trends in PSD and median W_r for Northern Pikeminnow, Smallmouth Bass, and Walleye were assessed by applying a non-parametric Mann-Kendall test (Mann 1945). Similarly, PSD-P was also analyzed with this method for Smallmouth Bass and Walleye. To diagnose potential serial dependence among these data, we reviewed autocorrelation functions (acf) and partial autocorrelation functions (pacf) applied to time series objects (R Core Team 2013). 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' or 'tsboot' (Fox and Weisberg 2011) packages. All tests were considered significant at $\alpha < 0.05$.

RESULTS

Sport Reward Fishery Evaluation and Predation Reduction Estimates

We tagged and released 1,000 Northern Pikeminnow greater than 199 mm FL throughout the lower Columbia and Snake rivers during 2018 (Table 1). ODFW also recaptured 38 Northern Pikeminnow greater than 199 mm FL that were tagged in previous seasons. These previously marked fish are accounted for in the current annual exploitation calculation and are therefore considered “tagged” fish for 2018 (Table 1). Within the two size classes, 375 were from 200 to 249 mm and 663 were 250 mm FL and greater. Sport Reward Fishery anglers recaptured 104 of those during 2018 and two fish were recaptured in the Dam Angling Fishery. Six fish tagged in McNary Reservoir and one fish each in The Dalles and Lower Granite reservoirs were recaptured within the same week they were tagged and therefore not included in our calculations of exploitation to avoid violating mark recapture assumptions (i.e., incomplete mixing). Fish tagged in 2018 and subsequently recaptured in the Sport Reward Fishery were at large from 6 to 159 d (mean = 62 d; SE = 6). Sport Reward Fishery recaptures greater than or equal to 250 mm FL accounted for 88% of all recoveries of fish tagged during 2018.

System-wide exploitation of Northern Pikeminnow greater than or equal to 200 mm FL during the Sport Reward Fishery in 2018 was 12.6%, similar to the 12.7% average since 2000 when the minimum FL eligible for reward was reduced from 250 to 200 mm (Table 2). Tag returns were sufficient ($n \geq 4$) to calculate area-specific exploitation estimates for all sampling areas with the exception of The Dalles, John Day, and Ice Harbor pools. Tagged fish were released in Ice Harbor reservoir for the second time since 1992, but few fish were tagged in 2018 and no tags were returned. For areas where exploitation rates could be calculated, values varied from 5.5 to 18.3%. Within the 200–249 mm FL size class, exploitation was estimated to be 3.5% downstream of Bonneville Dam and 10.6% in McNary Reservoir (Table 3). Too few tags were returned to calculate exploitation rates in the other six reservoirs. The 2018 system-wide exploitation rate for Northern Pikeminnow greater than or equal to 250 mm FL exceeded those of the other size classes at 16.8% (confidence interval 12.1–21.5%) and was above the program average of 13.8% since 1991 (Figure 2). Area-specific exploitation rates of fish greater than or equal to 250 mm FL were 13.8% for the Columbia River below Bonneville Dam, 18.3% for Bonneville Reservoir, 18.1% for McNary Reservoir, and 16.9% 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. In 2018, we found an error in the calculation of predation reduction which slightly altered calculations from prior years and presented in previous reports. The model-estimated median reduction in predation on juvenile salmonids relative to pre-program levels for 2018 was 29% (range: 12–41%) and for 2019 will remain 29% (range: 12–42%; 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 at relatively stable suppressed levels and gradually decrease through 2022.

From data collected during fishery evaluation (i.e. tagging activities), we were able to calculate PSD for Northern Pikeminnow for 2018 and across our time series (Table 5). Similar to our 2017 results, below Bonneville Dam and McNary Reservoir had higher PSD values for 2018 than other reservoirs surveyed. Northern Pikeminnow PSD decreases, increases, and then decreases again for the majority of the reaches (Figure 4). Sample sizes of Northern Pikeminnow ≥ 250 mm FL in John Day Reservoir were often too low to calculate PSD for prior years. Significant monotonic decreases in PSD were observed in The Dalles (Mann-Kendall τ = -0.38, P = 0.03), John Day (Mann-Kendall τ = -0.71, P = 0.04), McNary (Mann-Kendall τ = -0.31, P = 0.03), and Lower Granite reservoirs (Mann-Kendall τ = -0.40, $P < 0.01$).

The distribution of fork lengths for Walleye collected during Northern Pikeminnow tagging operations, suggests successful reproduction occurred in the three years before 2018 (Figure 5), given that 3-year-old fish are typically less than 500 mm FL. Upstream of Bonneville Reservoir, size distribution is similar across reservoirs in the Columbia River. Size distribution in Ice Harbor Reservoir suggests successful year classes of reproduction also within the previous three years. In Little Goose and Lower Granite Reservoirs, few Walleye have been observed during past index sampling events and none were observed during 2018 opportunistic sampling associated with tagging activities.

Through our opportunistic sampling of Walleye during 2018 Northern Pikeminnow tagging operations, we were able to calculate PSD and PSD-P values for five of the eight areas sampled (Table 6). Data from Little Goose and Lower Granite Reservoir were not included in the table as sample sizes have never been great enough to calculate PSD or PSD-P. From Bonneville Reservoir to McNary Reservoir, all Walleye PSD values in 2018 were higher than 2017 values. The lowest value in 2017 was 24% in John Day Reservoir compared to the lowest value for 2018 at 81% in Ice Harbor Reservoir. Similar to 2018, Bonneville Reservoir had the highest PSD at 88%. McNary had the highest PSD-P at 40%. Estimates of PSD in all reservoirs were greater than values suggested for balanced populations (PSD 30–60%; Anderson and Weithman 1978). Larger size classes of Walleye were captured during 2018 compared to 2017, however fewer Walleye were collected overall. The Dalles, John Day and McNary reservoirs all had decreasing trends in PSD across the entire time series, however only the decreasing monotonic trend in McNary Reservoir was significant (Figure 6, Mann-Kendall τ = -0.44, P = 0.04). Distribution of the preferred size category of Walleye also decreased overtime in these reservoirs. The Dalles Reservoir had a non-significant decreasing trend in PSD-P (Mann-Kendall τ = -0.30, P = 0.19) and trends in John Day (Mann-Kendall τ = -0.44, P = 0.02) and McNary reservoirs (Mann-Kendall τ = -0.51, P = 0.01) decreased significantly (Figure 7).

Biological Evaluation

We conducted 324 electrofishing runs during 2018 in the forebay, mid-reservoir, and tailrace sampling areas of The Dalles and John Day reservoirs to collect fish for biological evaluation (Table 7). In prior years, sampling was conducted in boat-restricted zones of the forebay and tailraces of many of the areas we sampled. However, we have not surveyed these areas in recent years and have left past years' data out of this report. Spring sampling in John Day Reservoir coincided with the peak of yearling salmon and the end of steelhead outmigration (Figure 8). For The Dalles Reservoir, spring sampling occurred near the end of yearling salmon and steelhead outmigration. Summer sampling occurred during the subyearling outmigration in both reservoirs as evidenced by smolt passage through John Day and McNary dams.

Across all sample sites, spring 2018 mean CPUE ranged from 0.03 to 0.19 fish/900 s for Northern Pikeminnow, 3.84 to 9.97 fish/900 s for Smallmouth Bass, and 0.00 to 5.20 fish/900 s for Walleye (Table 8). Across all sites during summer 2018, mean CPUE ranged from 0.00 to 0.14 fish/900 s for Northern Pikeminnow, 3.55 to 9.05 fish/900 s for Smallmouth Bass, and 0.00 to 1.10 fish/900 s for Walleye. The highest catch rates of Northern Pikeminnow were observed in the John Day tailrace during spring and in The Dalles mid-reservoir area during summer. Overall, CPUE continued to be much lower for Northern Pikeminnow in both The Dalles and John Day reservoirs compared to the observations from earlier years when the larger individuals began to be systematically removed in the sport reward fisheries. 2018 Smallmouth Bass CPUE is the highest for the period of record seasonally in both reservoirs. In 2018, Smallmouth Bass were caught at the highest rate of any target species except Walleye caught in John Day tailrace during spring. Compared to previous years, Walleye were relatively abundant in both The Dalles and John Day reservoirs during spring sampling. Few were encountered during the summer sampling in 2018.

When CPUE is scaled across unsurveyed areas in the two reservoirs, the abundance index is lower than average for Northern Pikeminnow and two to three times higher for Smallmouth Bass and Walleye based on observations during 1990 – 2018 (Tables 9, 10, and 11). Spring abundance index values for Northern Pikeminnow (≥250 mm FL) in 2018 ranged from 0.03 to 0.60 in The Dalles Reservoir and 0.07 to 0.81 in John Day Reservoir (Table 9). Abundance index values during the summer were lower than the spring in all areas sampled. The highest abundance of Northern Pikeminnow occurred in the mid-reservoir of The Dalles in both seasons at 0.60 during spring and 0.55 during summer. When compared to the mean values for each season over the time series, 2018 values were below the mean in all areas.

The Smallmouth Bass abundance index across areas and seasons sampled in 2018 ranged widely from 3.76 to 185.53 (Table 10). The abundance index values of The Dalles mid-reservoir was an order of magnitude less than John Day Reservoir because of the greater size of John Day Reservoir (19,781 ha; Ward et al. 1999). With the exception of John Day forebay area, abundance index values calculated for 2018 were the highest observed since 1990.

The greatest Walleye abundance indices were observed in the tailrace and mid-reservoir of John Day Reservoir during spring (Table 11). The spring tailrace value was the highest recorded for Walleye to date. Area-specific abundance index estimates for Walleye were greater than the mean of the time series.

We examined the contents of the digestive tracts collected from Northern Pikeminnow captured in The Dalles (n = 18) and John Day (n = 13) reservoirs to characterize their diet habits (Table 12). Across areas and seasons, four Northern Pikeminnow gut content samples did not contain food items. For both spring and summer, fish were the second most frequent diet item observed per fish (spring $\hat{p}$ = 0.32; summer $\hat{p}$ = 0.17) after crayfish (spring $\hat{p}$ = 0.37; summer $\hat{p}$ = 0.42). Salmonids were encountered more frequently in diet samples of Northern Pikeminnow captured in John Day Reservoir ($\hat{p}$ = 0.08) than Northern Pikeminnow captured in The Dalles Reservoir ($\hat{p}$ = 0.00). Lampreys were found most frequently in diets of Northern Pikeminnow captured in The Dalles Reservoir ($\hat{p}$ = 0.17) and none were observed in samples from John Day Reservoir (Table 13).

Of the 845 Smallmouth Bass diet samples collected in 2018, large proportions contained prey items (spring $\hat{p}$ = 0.96; summer $\hat{p}$ = 0.98) across both reservoirs and seasons. In the spring, fish ($\hat{p}$ = 0.29) were the third most frequently encountered diet item in Smallmouth Bass behind crustaceans excluding crayfish ($\hat{p}$ = 0.43) and crayfish (0.38). In the summer, fish ($\hat{p}$ = 0.15) were the fourth most frequently encountered diet item in Smallmouth Bass behind crayfish ($\hat{p}$ = 0.76), other crustaceans ($\hat{p}$ = 0.35), and insects ($\hat{p}$ = 0.35). Across both reservoirs, salmonids were identified in 0.05 and 0.03 of the diet samples collected during spring and summer. Across both seasons, diets of Smallmouth Bass captured in The Dalles Reservoir included salmonids ($\hat{p}$ = 0.02) less frequently than diets of fish captured in John Day Reservoir ($\hat{p}$ = 0.07; Table 13). Sculpins (Cottidae) were the most represented taxon in Smallmouth Bass diets for both reservoirs (The Dalles $\hat{p}$ = 0.07; John Day $\hat{p}$ = 0.08).

We collected 75 Walleye diet samples in The Dalles Reservoir and 170 in John Day Reservoir (Table 12). A majority of Walleye diet samples contained prey items (spring $\hat{p}$ = 0.94; summer $\hat{p}$ = 0.96) across reservoirs and seasons. From both areas, fish were the most common diet item and were found in proportions of 0.47 in spring and 0.42 in summer. Proportions of all diet samples containing salmonids were 0.16 in The Dalles Reservoir and 0.27 in John Day Reservoir (Table 13). In Walleye diet samples collected in The Dalles Reservoir, lampreys were the next most frequently encountered fish taxa ($\hat{p}$ = 0.09) and unidentified fishes were the next most frequently encountered fish in John Day Reservoir ($\hat{p}$ = 0.07). One Walleye diet sampled in the spring in John Day Reservoir contained a PIT tag belonging to a wild summer steelhead originally tagged near Lower Granite Dam in the Snake River.

The average juvenile salmonid consumption rate index for Northern Pikeminnow remains an order of magnitude more than the consumption indices of Smallmouth Bass (Tables 14 and 16). We were unable to calculate a consumption index for Northern Pikeminnow for 2018 because too few fish have been encountered during recent annual boat index electrofishing sampling events. The consumption index for Smallmouth Bass during spring and summer sampling events in 2018 was higher in the forebays of The Dalles and John Day reservoirs than the consumption indices for middle sections and tailraces during spring. In summer, it was also higher in the forebay of The Dalles Dam.

Change in predatory impact can result from the abundance of predators and their prey consumption rates. The predation indices could not be calculated for Northern Pikeminnow during 2018 because too few fish were observed. Predation indices for previous years are presented in Table 15. For Smallmouth Bass, the predation indices were highest in the middle sections of both reservoirs and seasons (Table 17). In the middle section of John Day Reservoir, the Smallmouth Bass predation index is the highest observed since 1990. Smallmouth Bass consumption of juvenile salmonids by individuals does not appear to be appreciably greater, but the apparent increase in numbers of individuals results in an overall increase in the numbers of juvenile salmon prey consumed by Smallmouth Bass during 2018.

A consumption index has not been developed for Walleye in the Columbia River Basin. The apparent abundance during 2018 is high compared to previous years (Table 11). Frequency of occurrence of salmon prey in the diet samples of Walleye since 2004 is generally less than Northern Pikeminnow and higher than the frequency of occurrence in diet samples of Smallmouth Bass (Table 12; Williams et al. 2016; Gardner et al. 2013; Weaver et al. 2010; Takata et al. 2007;

and Jones et al. 2005). The frequency of occurrence has averaged about one third and not exceeded one-half of the samples observed. While Walleye individuals' predation of juvenile salmon does not appear to be higher, when the population abundance increases, the net effect is that the removal of the Northern Pikeminnow predators could be less effective to reduce losses of the out-migrating juvenile salmon.

In 2018, we did not catch enough Northern Pikeminnow greater than or equal to 250 mm FL to calculate PSD for either reservoir, as has been the case since 2009 ($n \leq 19$; Table 18). Smallmouth Bass PSD decreased in both reservoirs since our last visit in 2015 (The Dalles 47%; John Day 33%). PSD-P was also lower in 2018 in The Dalles (14%) and John Day (4%) reservoirs than previous years. Monotonic trends of Smallmouth Bass PSD and PSD-P over time did not change (The Dalles Mann-Kendall $\tau = 0.16$, $P = 0.52$; John Day Mann-Kendall $\tau = 0.21$, $P = 0.32$; Figures 9 and 10).

Walleye PSD in 2018 increased in The Dalles (81%) and John Day (82%) reservoirs relative to the last prior observation (Table 18). For both areas, there was a small decrease in PSD-P since last calculation (The Dalles 24%; John Day 23%). For both reservoirs few data points exist over the time series making the detection of trends over time difficult. As expected, there was no significant monotonic trend over time for The Dalles (Mann-Kendall $\tau = -0.40$, $P = 0.46$) or John Day reservoir (Mann-Kendall $\tau = -0.28$, $P = 0.35$) PSD or PSD-P (The Dalles Mann-Kendall $\tau = -0.40$, $P = 0.46$; John Day Mann-Kendall $\tau = -0.17$, $P = 0.60$).

Median W_r for female Northern Pikeminnow in The Dalles Reservoir (113%) was similar to recent years (Figure 11). Trend analyses show an increasing monotonic trend for females in The Dalles Reservoir (Mann-Kendall $\tau = 0.58$, $P = 0.01$). Median W_r of male Northern Pikeminnow slightly declined during recent years to 90% and no significant W_r trend was evident (Mann-Kendall $\tau = 0.21$, $P = 0.37$). Similar to results in The Dalles, John Day Reservoir female median W_r (112%) was higher than last observed in 2012 and male median W_r slightly decreased (93%; Figure 12). Both male and female W_r appear to exhibit decreasing trends although neither were statistically significant (female Mann-Kendall $\tau = -0.51$, $P = 0.85$; male Mann-Kendall $\tau = -0.33$, $P = 0.13$).

The 2018 median W_r value for Smallmouth Bass was the same for The Dalles and John Day reservoirs (93%; Figure 13). Little variation of annual median W_r values in The Dalles Reservoir has been observed (Mann-Kendall $\tau = 0.13$, $P = 0.64$). Smallmouth Bass median W_r in John Day Reservoir has exhibited no significant trend change (Mann-Kendall $\tau = -0.17$, $P = 0.44$).

Median W_r of Walleye was relatively similar in The Dalles (86%) and John Day reservoirs (90%; Figure 14). Neither area displays a monotonic trend of condition factor over the time series (The Dalles Mann-Kendall $\tau = 0.06$, $P = 0.83$; John Day Mann-Kendall $\tau = 0.01$, $P = 1.00$), similar to what we observed for Smallmouth Bass.

In 2018, we collected 819 Northern Pikeminnow digestive tracts from fish harvested in the Dam Angling Fishery from the angler accessible areas in the powerhouse tailraces of The Dalles (fishing in Bonneville Reservoir) and John Day (fishing in The Dalles Reservoir) dams. These fish ranged in size from 268 to 544 mm FL in Bonneville Reservoir (mean = 354 mm; SE 2.7) and from 272 to 545 mm FL in The Dalles reservoir (mean = 371 mm; SE 2.5). In both reservoirs, large proportions of the digestive tracts of Northern Pikeminnow examined contained food (Bonneville

$\hat{p}$ = 0.72; The Dalles $\hat{p}$ = 0.75; Table 19). Invertebrates that were not identified as crayfish (Other Invertebrates; $\hat{p}$ = 0.57) were observed in larger proportions of diet samples in The Dalles Reservoir than all of the other prey types, including fish ($\hat{p}$ = 0.30). We found that a large proportion of the "Other Invertebrates" weight category consisted of prawns and amphipods, although we did not weigh them separately from the other invertebrates (i.e., insects, and mollusks). Fish were the most abundant diet item in Bonneville Reservoir ($\hat{p}$ = 0.46) and second most abundant in The Dalles Reservoir ($\hat{p}$ = 0.30). In Bonneville Reservoir, the proportion of lamprey found in 2018 Dam Angling gut samples ($\hat{p}$ = 0.05) was less than in 2017 ($\hat{p}$ = 0.18) and less than a fifth of the average proportion for 2006—2017 ($\hat{p}$ = 0.27). In The Dalles Reservoir, the proportion of lamprey found in 2018 Dam Angling gut samples ($\hat{p}$ = 0.09), while greater than 2017 ($\hat{p}$ = 0.07), was less than half the average proportion for 2006—2017 ($\hat{p}$ = 0.20).

Lamprey were encountered in the greatest proportion of Northern Pikeminnow diet samples during May ($\hat{p}$ = 0.41) and in the second greatest proportion during June ($\hat{p}$ = 0.10; Table 20). Salmon and steelhead were encountered in the greatest proportion of Northern Pikeminnow diet samples in June ($\hat{p}$ = 0.13) and July ($\hat{p}$ = 0.15). Juvenile salmon and steelhead were observed infrequently during May ($\hat{p}$ = 0.05) and August ($\hat{p}$ = 0.02). American Shad were encountered at relatively low rates until August, when it was the most frequent taxon observed in diet samples ($\hat{p}$ = 0.62). Diversity of prey fish families consumed by Northern Pikeminnow was greatest during August and included five native and three non-native taxa, along with unidentified fishes.

The weekly consumption index for the Northern Pikeminnow that were removed from the powerhouse tailraces of The Dalles and John Day dams in 2018 was seasonally highest during the second week of July similar to five years beginning 2014 (Figure 15; Tinus et al. 2015; Barr et al. 2016; Carpenter et al. 2017; Carpenter et al. 2018). The highest consumption index value generally coincides with the peak SMP index downstream migration passage value for subyearling Chinook Salmon at John Day Dam. During 2018, the seasonal relation between consumption and smolt passage indices was more variable than previous years. The consumption index was greater than nine in 2014 and less than four in 2018. The 2018 rate coincides with high spring discharge of snow melt and reservoir storage that was beyond the hydraulic capacity of the Federal Columbia River Power System (FCRPS) dams.

In 2018, ODFW initiated a pilot study to examine diets of Walleye incidentally captured in the Northern Pikeminnow Dam Angling fishery at John Day Dam (fishing in The Dalles Reservoir). All of the 14 Walleye sampled contained food items in their stomach ($\hat{p}$ = 1.00). Invertebrates that were not identified as crayfish were encountered in the greatest proportion of Walleye stomach samples ($\hat{p}$ = 0.86). Six of the 14 Walleye sampled contained at least one fish prey item ($\hat{p}$ = 0.43), three contained at least one salmonid prey item ($\hat{p}$ = 0.21), and one contained at least one lamprey prey item ($\hat{p}$ = 0.07) in the stomach samples.

Although statistical significance of trends in PSD values calculated based on the FL of Northern Pikeminnow subsampled from the Dam Angling Fishery for diet analyses was not tested directly, estimates since the inception of the NPMP for each dam appear to exhibit a long-term decrease (cf., 1990–1995 and 2006–2018; Figure 16). Results determined monotonic decreasing trends in both reservoirs were significant (Bonneville Mann-Kendall τ = -0.61, P < 0.001; The Dalles Mann-Kendall τ = -0.52, P < 0.01). In 2018, PSD estimate for Bonneville Reservoir was 23% and 37% for The Dalles Reservoir, which was an increase over 2017 values.

DISCUSSION

In the 28th year since Northern Pikeminnow removal fisheries were implemented, the 2018 exploitation rate of Northern Pikeminnow ≥ 250 mm FL (16.8%) was well within the management goal of 10-20%, potentially exceeding 20% within the 95% confidence bounds of 12.1 to 21.5%. The 2018 system-wide exploitation rate is higher than the average since 1991 (13.8%). Where area-specific tag recoveries were sufficient, exploitation rate was highest in Bonneville Reservoir followed by McNary Reservoir. This pattern may result from the proximity to the Portland/Vancouver metropolitan and Tri-Cities (Washington) areas. Area-specific estimates of exploitation rates rely on numbers of Northern Pikeminnow tagged per year, and removals (recaptures) of tagged-fish that year. In McNary Reservoir, 6 recaptured fish occurred during the same week that fish were tagged and could not be used in the reservoir-specific exploitation rate calculation. This also happened frequently in McNary Reservoir in 2017 and is likely the result of both when the tagging activities occur (during the SRF fishery) and the close proximity to the populous Tri-Cities area. Over the last 10 years, too few tags were recovered in The Dalles, John Day, and Little Goose reservoirs to regularly calculate annual exploitation rates there. This occurred again in 2018. We tagged Northern Pikeminnow in Ice Harbor Reservoir for the second time since 1993 but captured and tagged very few fish (10) and no fish were recaptured. Continued tagging in this reservoir and financial incentive to catch tagged fish could serve to encourage additional participation in the SRF in the lower Snake River, but if too few tags are recovered, an exploitation rate cannot be calculated.

Removal fisheries led by WDFW-managed angling crews from the tailrace decks at the powerhouses of The Dalles and John Day dams continue to remove substantial numbers of predatory size Northern Pikeminnow from Bonneville and The Dalles reservoirs in concert with the Sport Reward Fishery in those two reservoirs. Angling from The Dalles and John Day dams, accessible only by authorized fish and wildlife management agencies, continues to successfully remove Northern Pikeminnow that are generally larger than individuals in the catch in the Sport Reward Fishery. Our observations from analyses of diet samples from the dam angling fisheries since 2006 show consistent annual predatory impacts to juvenile salmon and steelhead. Importantly, the predators at these locations prey consistently on lamprey juveniles, also a regional taxon of conservation concern. We explored a pilot initiative to sample incidental catch of Walleye to evaluate diet characteristics but sampled at low rates (14 Walleye).

Median modelled potential reductions in NPM predation rates have generally remained around 30% with some variability since 1997. Projected levels of reduced predation relative to preprogram levels suggest a very modest increase (reduced predation) during future years, if exploitation rates continue at average levels and natural mortality is constant. Ongoing implementation of this long-term and mature mitigation effort to meet target exploitation rates is successful with continued annual promotion and occasional changes to incentives for participating sport reward anglers.

To evaluate the success of the ongoing removal efforts since inception of the NPMP to suppress predation by Northern Pikeminnow requires ongoing monitoring of the catch from the SRF system-wide and the localized catch in the tailraces of The Dalles and John Day dams. From the biological evaluation, the primary indicator is whether the level of predation changes within Northern Pikeminnow populations and what the level is for other fish predators of salmon and steelhead, particularly Smallmouth Bass and Walleye. Changes in the predation index are influenced by either changes in the abundance of the predatory populations, their rates of consumption of juvenile salmon and steelhead, or both. If changes are observed, potential explanatory mechanisms could be described by indicators of variations in recruitment to reproductive or predatory size, condition factor of individuals, and changes in diet including proportional changes in diet capacity (proportion full stomachs, distribution of vertebrates and invertebrates, and vegetation).

Through our fisheries evaluation data, we observed a significant decrease in PSD for Northern Pikeminnow in The Dalles, John Day, McNary, and Lower Granite reservoirs. This indicates that the Sport Reward Fishery is successful in restructuring the size distribution of the population of Northern Pikeminnow by reducing the number of larger, more predatory fish. Simultaneously, we observed a significant decrease in PSD for Walleye in McNary reservoir and significant decrease in PSD-P in John Day and McNary reservoirs. These trends could indicate there is no compensatory response by Walleye to Pikeminnow removals in terms of size structure. Alternatively, recent successful years of reproduction are skewing data towards smaller sized fish (which would lower PSD and PSD-P) or other factors affecting population size distribution of Walleye have a greater influence. The intermittent sampling combined with low sample sizes of Northern Pikeminnow by site make calculation and comparison of these values difficult and restrict our ability to assess trends over time. At present, we do not have substantial evidence to indicate compensation by Northern Pikeminnow, Smallmouth Bass, or Walleye, however, we have indications that each of these reservoirs have unique characteristics (e.g., species composition, environment, fishing pressure), which may have individual responses to our metrics, as significant trends were not consistent within species or among metrics. These mixed and sometimes conflicting signals inhibit our ability to make conclusions, but indicate continued monitoring to add to the time series is essential. Beamesderfer et al. (1996) predicted that as a result of the low exploitation rate the NPMP exerts on Northern Pikeminnow, it simply restructures the population, as opposed to depleting it, and thus removals may never reach a level to cause a compensatory response.

The density index (CPUE) for biological evaluation data continues to be much lower for Northern Pikeminnow in both The Dalles and John Day reservoirs compared to the observations in earlier years of the program when the larger individuals began to be systematically removed in the sport reward fisheries. In contrast, both Smallmouth Bass and Walleye in John Day Reservoir display significant increasing trends in CPUE over time. CPUE in 2018 was the highest for the period of record across seasons and in both reservoirs for Smallmouth Bass. The 2018 encounter rate for Walleye is also the highest ever in John Day reservoir and among the highest observed in The Dalles Reservoir. We observed a great number of Walleye during fisheries evaluation in 2017 and it appears that those fish have likely remained and thrived within these reservoirs. We frequently encountered reproductive male and female Walleye this spring in John Day Reservoir, which was not the case during our biological evaluation in 2015. These data may be evidence of some compensatory responses in John Day Reservoir, however condition factor (relative weight) for Smallmouth Bass and Walleye has not changed significantly over the time series. In The Dalles reservoir, female Northern Pikeminnow relative weight has significantly increased over time, though it was the only observed significant trend with respect to body condition. This is in contrast to results from Barr et al. (2016) that indicated significant increasing trends for both sexes in The Dalles reservoir and female Northern Pikeminnow in John Day reservoir. Unlike the fisheries evaluation data, there were no significant trends in PSD for any species, nor PSP-P for Smallmouth Bass or Walleye. Unfortunately, we still do not catch enough stock size Northern Pikeminnow (≥ 250 mm FL) to be able to reliably calculate PSD and have not been able to estimate it since 1999 in John Day and 2006 in The Dalles reservoirs. No statistically significant temporal trends in relative weight were identified for Smallmouth Bass or Walleye. During our 2015 biological evaluation, however, we detected significant increasing monotonic relative weight trends for Smallmouth Bass in The Dalles Reservoir and Walleye in John Day Reservoir (Barr et al. 2016). Estimates of relative weight since 2006 for Smallmouth Bass in The Dalles Reservoir appear cyclical when adding data from 2018 which could explain the difference in results from Barr et al. (2016).

When CPUE is scaled across unsurveyed areas in the two reservoirs, the abundance index is lower than average for Northern Pikeminnow and two to three times higher for Smallmouth Bass and Walleye based on observations during 1990 – 2018. The spatial distribution of abundance of Northern Pikeminnow within reservoirs during 2018 is similar to previous years where abundance indices are highest in the middle areas of the reservoirs with the exception being zero during 2018 in the forebay and middle survey areas of John Day Reservoir. Smallmouth Bass are most abundant in the middle sections of both reservoirs. Walleye are most common in the sampling areas of the tailraces of John Day and The Dalles dams (The Dalles and Bonneville reservoirs) compared to the downstream reservoir areas. They are less abundant in the middle section sampling area and uncommon in the forebays of both reservoirs. Noteworthy, Walleye were encountered in 2018 in the forebay of The Dalles Dam at the highest rate for the period of record during spring.

The average juvenile salmonid consumption rate index for Northern Pikeminnow remains an order of magnitude more than the consumption indices of Smallmouth Bass. We were unable to calculate a consumption index for Northern Pikeminnow for 2018 because too few fish have been encountered during recent annual boat index electrofishing sampling events. The consumption index for Smallmouth Bass during spring and summer sampling events in 2018 was higher in the forebays of The Dalles and John Day reservoirs than the consumption indices for middle sections and tailraces during spring. In summer, it was also higher in the forebay of The Dalles Dam.

In the middle section of John Day Reservoir, the combined abundance and consumption indices for Smallmouth Bass are the highest observed since 1990. Smallmouth Bass consumption of juvenile salmonids by individuals does not appear to be appreciably greater, but the apparent increase in numbers of individuals results in an overall increase in the numbers of juvenile salmon prey consumed by Smallmouth Bass during 2018.

A consumption index has not been developed for Walleye in the Columbia River Basin. The apparent abundance during 2018 is high compared to previous years and frequency of occurrence of salmon prey in the diet samples of Walleye since 2004 is generally less than Northern Pikeminnow and higher than the frequency of occurrence in diet samples of Smallmouth Bass. The frequency of occurrence has averaged about one third of the samples observed. While Walleye individuals' predation of juvenile salmon does not appear to have systematically increased, when the population abundance increases, the net effect is that the removal of the Northern Pikeminnow predators could be less successful to reduce losses of the out-migrating juvenile salmon.

In 2018, the presence of salmonids in diet samples was higher in John Day Reservoir than in The Dalles Reservoir for Northern Pikeminnow (8% in John Day Reservoir; 0% in The Dalles Reservoir) and Smallmouth Bass (7% in John Day Reservoir; 2% in The Dalles Reservoir). This may be a reflection of greater abundance of juvenile salmon or greater exposure of individuals to predation in John Day Reservoir. For Walleye, the presence of salmonids in diet samples was also higher in John Day Reservoir than in The Dalles Reservoir, but was much higher in both reservoirs (27% John Day Reservoir; 16% in The Dalles Reservoir) than Northern Pikeminnow and Smallmouth Bass. Regardless of season, lamprey (Petromyzontidae; 17%) was the prey family that was observed most frequently in Northern Pikeminnow diets in The Dalles Reservoir. In John Day Reservoir, salmonids (Salmonidae; 8%) were present in the second greatest proportion of Northern Pikeminnow diets, following unidentified fishes (15%). Regardless of season, salmonids were observed most frequently in Walleye stomach contents in both The Dalles (16%) and John Day (27%) reservoirs. Smallmouth Bass diets most frequently contained sculpin (Cottidae) prey items (7% The Dalles Reservoir; 8% John Day Reservoir).

Sources of variability in the values of metrics collected annually, seasonally, and by location used for biological evaluation are uncertain. They can result from the sample design and varying predator and prey behavior coinciding with changing environmental conditions, changes to operation and configuration of the FCRPS, hatchery production practices, changes in lower Snake River smolt collection and transportation practices, other factors – and the sustained removal of larger Northern Pikeminnow. To infer a cause and effect relationship of interactions within and between fish predator populations and their behavior and to quantify a compensation response due to the NPMP is equivocal. However, if predation by other fish predators increases concurrent to removing Northern Pikeminnow, the success to suppress the predation rate by Northern Pikeminnow could be diminished.

Sampling via boat electrofishing is conducted each year during spring and again during summer in fixed index areas within one of three system-wide reaches (lower Columbia River downstream of Bonneville Dam, The Dalles and John Day reservoirs, and the lower Snake River). The biological evaluation relies on the assumption that observed predator-prey interactions are similar outside the index sampling areas and do not change during the two years when sampling in index areas is not conducted. Seasonal sampling was originally intended to coincide with peak juvenile salmon outmigration timing in spring (primarily yearling salmon and steelhead) and summer (primarily sub-yearling Chinook Salmon). Annual seasonal sampling is now consistently scheduled administratively (calendar date and standard business weeks). If outmigration timing were the same each year, the sampling period in the lower Columbia River could be expected to coincide with an earlier portion of the outmigration for upper Columbia and Snake River populations, while the sampling period in the lower Snake River could be expected to coincide with a later portion of the outmigration of those populations. However, outmigration timing does vary across years and if prey density and abundance influence consumption rates and localized predator abundance, timing of sample events could affect the results of biological evaluations.

Our diet analyses to enumerate minimum average juvenile salmon and steelhead prey presence in the stomach content samples of the three predator species do not distinguish individual salmonid prey fish by species, ESU/DPS, or rearing origin (hatchery or wild). Biological evaluation samples collected within The Dalles and John Day reservoirs could be expected to potentially include U.S.

ESA-listed species of upper Columbia and Snake River steelhead and stream-type Chinook Salmon; Mid-Columbia steelhead; and Snake River Sockeye Salmon and fall run Chinook Salmon. Unlisted species could include upper Columbia Sockeye Salmon and summer and fall run Chinook Salmon; Mid-Columbia spring and fall run Chinook Salmon. Unlisted species could also include reintroduction attempts for Coho Salmon, Sockeye Salmon, fall run Chinook Salmon, and steelhead. Juvenile salmon and steelhead in the lower Snake River collected in dam bypasses and put into barges or trucks for transport and release downstream of Bonneville Dam presumably would not be subject to predation in The Dalles and John Day reservoirs. Thus, outmigration timing, hatchery release schedules, and the biological sampling schedule would influence the prey composition in diet samples.

The fisheries and biological evaluation of the potential predatory impact by Northern Pikeminnow and success to suppress its predation on juvenile salmon and steelhead through the removal fisheries is limited in scope. Ongoing monitoring does not allow evaluation of any lower trophic interactions between younger age fish and systemic changes to their environment. With the exception of lower catches of Northern Pikeminnow, the results of the periodic biological evaluations in The Dalles and John Day reservoirs generally show no consistent changes. However, increases in density of other fish predators can decrease the success of reducing predation by removing Northern Pikeminnow. Resolution of temporal and spatial system-wide inferences are constrained by the sampling routine that began in 2004, whereby reach sampling was changed to a three-year rotation. With no empirical observations existing within reaches until every third year, knowledge of demographic changes within un-sampled years for predator populations is unavailable. We have renewed attempts to observe length frequency, or a minimum of presence/absence, of Walleye during Northern Pikeminnow tagging to inform fluctuations in potential predation impact that may be dependent or independent of the NPMP. Tagging Northern Pikeminnow in preparation for the annual SRF is the priority, and consistent enumeration of other predator species could be infeasible. Nonetheless, this effort could help to monitor potential predatory impact by Walleye relative to NPMP objectives.

As information on exploitation rates and demographic phenomena continue to accrue, the potential to refine future NPMP analyses grows. For example, tagged fish at large are as old as eleven years. Including recaptured fish tagged and caught in years previous could help to estimate exploitation rates in reservoirs where few tags are recovered, and increase precision of estimates. Scrutiny of the tag recoveries could help refine knowledge of natural mortality to affirm assumptions about catch rates as they relate to suppressing predation by Northern Pikeminnow. We routinely collect and archive age samples from Smallmouth Bass and Walleye. As future resources allow, age information could inform variability in year class strength and growth rates of individual predators.

Oregon and Washington sport fisheries regulations have changed to have no number or size restrictions on the harvest of Smallmouth Bass and Walleye. Treaty Indian fisheries have been permitted to harvest and sell Smallmouth Bass and Walleye (and other non-native species) during seasonal fisheries upstream of Bonneville Dam. Whether these changes have an impact on overall fish predation on out-migrating juvenile salmon and steelhead is beyond the scope of the NPMP evaluations. Whether out-migrating juvenile salmon and steelhead that survive being eaten by Northern Pikeminnow survive to adult-hood is dependent on survival of salmon and steelhead at later life stages and is not monitored by the NPMP. Continued regional evaluation of combined predatory impacts from fish, colonial fish eating birds, and marine mammals in the ocean and

Columbia River estuary will be important to adaptively manage the negative impacts to depressed populations of Columbia Basin salmon and steelhead. Coordination through the Northwest Power and Conservation Council Fish and Wildlife amendment process with input from the Independent Scientific Advisory Board will be important as the NPMP continues.

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TABLES

Table 1. Numbers of Northern Pikeminnow tagged and recaptured[a] in the Sport Reward Fishery during 2018 by location and size class.

	200–249 mm FL		≥ 250 mm FL		Combined	
Reach/Reservoir	Tagged	Recaptured	Tagged	Recaptured	Tagged	Recaptured
Below Bonneville	143	5	261	36	404	41
Bonneville	9	0	104	19	113	19
The Dalles	1	0	22	2	23	2
John Day	12	0	10	0	22	0
McNary	81	0	218	28	299	28
Ice Harbor	3	0	7	0	10	0
Little Goose	59	3	15	1	74	4
Lower Granite	67	1	26	3	93	4
Combined	375	9	663	89	1,038	98

[a] Fish that were recaptured the same week in which they were tagged are not included in this table or in calculations of exploitation to avoid violating mark-recapture assumptions (i.e., incomplete mixing). They comprise one each in The Dalles and Lower Granite reservoirs and six in McNary reservoir.

Table 2. Time series of annual exploitation rates (%) of Northern Pikeminnow (≥ 200 mm) in the Sport Reward Fishery by location. Mean and SE were calculated for each location across the time series.

Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	Ice Harbor	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
2016	9.2	5.4	*a*	*a*	2.3	—	8.0	5.1	7.5
2017	15.1	13.8	*a*	*a*	20.3	5.7	13.6	*a*	15.0
2018	10.1	16.8	*a*	*a*	18.3	*a*	5.5	5.5	12.6
mean (SE)	13.8 (1.0)	10.4 (0.7)	14.2 (3.5)	*b*	11.6 (1.4)	*b*	13.2 (2.8)	13.7 (4.7)	12.7 (0.7)

Note: *a* = no exploitation calculated ($n \leq 3$), dashes (—) = no sampling conducted, *b* = no mean exploitation calculated ($n \leq 2$). Sport Reward Fishery regulations changed in 2000 to allow angler retention of Northern Pikeminnow ≥ 200 mm FL. During prior years (1991–1999), 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. Mean SE were calculated for each location across the time series.

Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	Ice Harbor	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
2016	1.6	3.8	*a*	*a*	*a*	—	4.8	2.8	2.8
2017	*a*	10.4	*a*	*a*	7.3	*a*	10.6	*a*	8.7
2018	3.5	*a*	*a*	*a*	10.6	*a*	*a*	*a*	4.5
mean (SE)	6.8 (1.5)	7.5 (1.2)	*b*	*b*	7.5 (1.2)	*b*	9.0 (2.0)	4.9 (2.9)	6.6 (0.7)

Note: *a* = no exploitation calculated ($n \leq 3$), dashes (—) = no sampling conducted, *b* = no mean exploitation calculated ($n \leq 2$). Sport Reward Fishery regulations changed in 2000 to allow angler retention of Northern Pikeminnow ≥ 200 mm FL. During prior years (1991–1999), 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. Mean and SE were calculated for each location across the time series.

Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	Ice Harbor	Little Goose	Lower Granite	All areas
1991	7.6	10.9	23.6	2.8	5.3	6.9	2.4	20.0	8.5
1992	11.4	4.0	6.2	3.4	5.6	*a*	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
2016	11.6	8.9	*a*	*a*	4.6	—	24.8	14.4	12.1
2017	16.3	14.8	*a*	*a*	28.1	8.4	*a*	*a*	17.4
2018	13.8	18.3	*a*	*a*	18.1	*a*	*a*	16.9	16.8
mean (SE)	13.8 (0.9)	10.2 (0.8)	14.2 (1.8)	3.1 (0.2)	14.8 (1.3)	*b*	13.4 (3.2)	13.7 (1.2)	13.8 (0.7)

Note: *a* = no exploitation calculated ($n \leq 3$), dashes (—) = no sampling conducted, *b* = no mean exploitation calculated ($n \leq 2$).

Table 5. Number of stock-length (n_s) Northern Pikeminnow collected by boat electrofishing and proportional size distribution (PSD, %) as part of fishery evaluation by location. Mean and SE were calculated for each location across the time series.

	Below Bonneville		Bonneville		The Dalles		John Day		McNary		Ice Harbor		Little Goose		Lower Granite	
Year	n_s	PSD	n_s	PSD	n_s	PSD	n_s	PSD	n_s	PSD	n_s	PSD	n_s	PSD	n_s	PSD
1991	0	*a*	238	63	0	*a*	3	*a*	0	*a*	0	*a*	3	*a*	8	*a*
1992	750	39	390	50	121	58	255	65	85	55	3	*a*	442	29	108	14
1993	418	37	44	49	47	70	74	61	186	51	—	—	36	27	86	50
1994	367	34	55	74	52	43	96	85	195	75	—	—	61	46	0	*a*
1995	106	41	34	6	15	*a*	2	*a*	49	64	—	—	0	*a*	3	*a*
1996	246	32	57	35	19	*a*	9	*a*	19	*a*	—	—	9	*a*	39	21
1997	307	18	113	23	78	36	44	23	108	55	—	—	18	*a*	46	36
1998	248	27	108	27	43	23	14	*a*	296	61	—	—	18	*a*	94	35
1999	156	26	64	23	25	12	19	*a*	131	61	—	—	17	*a*	85	31
2000	361	29	138	25	26	31	6	*a*	172	57	—	—	9	*a*	41	20
2001	373	49	81	30	18	*a*	3	*a*	133	53	—	—	—	—	29	21
2002	524	35	26	48	24	21	13	*a*	87	70	—	—	—	—	97	10
2003	489	42	50	54	12	*a*	16	*a*	116	76	—	—	—	—	40	20
2004	254	54	48	40	10	*a*	5	*a*	57	60	—	—	—	—	28	11
2005	359	47	179	21	25	48	14	*a*	95	41	—	—	—	—	33	15
2006	387	38	272	19	43	36	22	42	100	73	—	—	37	3	19	*a*
2007	189	65	95	44	26	56	13	*a*	102	77	—	—	3	*a*	39	38
2008	265	54	77	47	26	31	16	*a*	185	75	—	—	30	13	47	19
2009	712	24	103	65	28	54	11	*a*	168	64	—	—	41	17	48	20
2010	440	41	56	58	11	*a*	6	*a*	91	56	—	—	9	*a*	27	36
2011	185	39	109	52	16	*a*	5	*a*	90	32	—	—	9	*a*	37	3
2012	327	31	105	32	108	8	8	*a*	213	50	—	—	5	*a*	42	2
2013	277	34	171	19	27	14	10	*a*	187	49	—	—	8	*a*	37	18
2014	436	31	73	31	33	24	13	*a*	276	55	—	—	9	*a*	37	8
2015	437	35	126	32	11	*a*	23	17	87	34	—	—	18	*a*	87	3
2016	773	26	183	19	30	7	18	*a*	119	23	—	—	22	5	44	9
2017	252	41	341	24	70	4	23	4	240	38	49	16	13	*a*	39	15
2018	254	42	100	30	20	41	10	*a*	194	47	7	*a*	14	*a*	26	11
mean (SE)	353 (34)	37 (2)	123 (17)	37 (3)	34 (5)	32 (4)	27 (9)	43 (11)	135 (14)	56 (3)	15 (12)	*b*	36 (19)	20 (6)	45 (5)	19 (3)

Note: *a* = no PSD value calculated ($n_s \leq 19$), dashes (—) = no sampling conducted, *b* = no mean calculated ($n \leq 2$).

Table 6. Number of stock-length (n_s) Walleye opportunistically sampled by boat electrofishing, proportional size distribution (PSD, %), and proportional size distribution of preferred-length fish (PSD-P, %) as part of fishery evaluation by location. Mean and SE were calculated for each location across the time series.

	Below Bonneville			Bonneville			The Dalles			John Day			McNary			Ice Harbor		
Year	n_s	PSD	PSD-P	n_s	PSD	PSD-P	n_s	PSD	PSD-P	n_s	PSD	PSD-P	n_s	PSD	PSD-P	n_s	PSD	PSD-P
1992	0	*a*	*a*	0	*a*	*a*	0	*a*	*a*	0	*a*	*a*	0	*a*	*a*	0	*a*	*a*
1993	3	*a*	*a*	1	*a*	*a*	14	*a*	*a*	4	*a*	*a*	0	*a*	*a*	—	—	—
1994	1	*a*	*a*	9	*a*	*a*	4	*a*	*a*	11	*a*	*a*	2	*a*	*a*	—	—	—
1995	9	*a*	*a*	17	*a*	*a*	14	*a*	*a*	12	*a*	*a*	11	*a*	*a*	—	—	—
1996	28	62	36	0	*a*	*a*	18	*a*	*a*	26	97	85	17	*a*	*a*	—	—	—
1997	17	*a*	*a*	6	*a*	*a*	93	63	10	23	97	39	15	*a*	*a*	—	—	—
1998	4	*a*	*a*	8	*a*	*a*	23	78	30	18	*a*	*a*	43	96	79	—	—	—
1999	3	*a*	*a*	2	*a*	*a*	16	*a*	*a*	33	68	52	14	*a*	*a*	—	—	—
2000	9	*a*	*a*	1	*a*	*a*	18	*a*	*a*	15	*a*	*a*	24	100	71	—	—	—
2001	13	*a*	*a*	4	*a*	*a*	15	*a*	*a*	19	*a*	*a*	17	*a*	*a*	—	—	—
2002	15	*a*	*a*	2	*a*	*a*	45	90	31	45	60	36	19	*a*	*a*	—	—	—
2003	18	*a*	*a*	2	*a*	*a*	31	73	19	129	73	16	36	84	58	—	—	—
2004	6	*a*	*a*	3	*a*	*a*	2	*a*	*a*	22	70	41	33	100	91	—	—	—
2005	2	*a*	*a*	0	*a*	*a*	30	83	30	52	40	12	10	*a*	*a*	—	—	—
2006	3	*a*	*a*	5	*a*	*a*	51	94	39	97	69	12	56	100	96	—	—	—
2007	0	*a*	*a*	1	*a*	*a*	22	64	45	50	82	32	33	100	88	—	—	—
2008	10	*a*	*a*	2	*a*	*a*	29	69	17	49	58	20	73	59	52	—	—	—
2009	6	*a*	*a*	11	*a*	*a*	11	*a*	*a*	48	52	23	20	95	50	—	—	—
2010	20	75	0	2	*a*	*a*	15	*a*	*a*	37	32	5	68	71	47	—	—	—
2011	14	*a*	*a*	29	83	17	68	57	6	171	51	6	90	83	50	—	—	—
2012	6	*a*	*a*	21	100	24	47	49	9	53	81	9	98	66	55	—	—	—
2013	2	*a*	*a*	1	*a*	*a*	9	*a*	*a*	85	55	29	101	75	59	—	—	—
2014	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2015	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2016	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2017	4	*a*	*a*	131	79	2	276	45	3	214	24	10	243	66	32	31	52	16
2018	11	*a*	*a*	59	88	29	121	85	13	164	85	26	343	83	40	74	81	12
mean (SE)	9 (1)	*b*	*b*	13 (6)	88 (5)	18 (6)	41 (12)	71 (5)	21 (4)	57 (12)	64 (5)	27 (5)	57 (16)	84 (4)	62 (5)	35 (21)	*b*	*b*

Note: *a* = no PSD value calculated ($n_s \leq 19$), dashes (—) = no sampling for Walleye conducted, *b* = no mean calculated ($n \leq 2$).

Table 7. Number of 900-s boat electrofishing runs by sampling year and location conducted during biological evaluation in The Dalles and John Day reservoirs, 1990–2018. FB = forebay, Mid = mid-reservoir, TR = tailrace, and Rkm = river kilometer.

	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
1990	47	34	45	38	60	38
1991	—	—	—	44	58	44
1992	—	—	—	50	62	47
1993	33	38	21	36	43	37
1994	80	—	40	75	43	60
1995	62	—	27	59	94	80
1996	58	—	28	52	52	71
1999	—	—	71	52	—	62
2004	—	—	18	25	17	68
2006	76	95	74	70	80	76
2009	72	60	78	60	95	70
2012	64	80	70	67	66	77
2015	35	48	40	40	44	37
2018	56	55	54	58	46	55

Note: dashes (—) = no sampling conducted.

Table 8. Mean catch per 900-s boat electrofishing (CPUE; and SE) of Northern Pikeminnow (≥ 250 mm FL), Smallmouth Bass (≥ 200 mm FL), and Walleye (≥ 200 mm FL) that were captured during biological evaluation in The Dalles and John Day reservoirs during spring and summer 2018. FB = forebay, Mid = mid-reservoir, and Rkm = river kilometer.

Species,	The Dalles Reservoir			John Day Reservoir		
Season	FB	Mid	TR	FB	Mid	TR
Northern Pikeminnow,						
Spring	0.15 (0.07)	0.15 (0.09)	0.04 (0.04)	0.03 (0.03)	0.04 (0.04)	0.19 (0.10)
Summer	0.10 (0.06)	0.14 (0.14)	0.04 (0.04)	0.00 (0.00)	0.00 (0.00)	0.07 (0.05)
Smallmouth Bass,						
Spring	9.97 (1.23)	8.70 (1.19)	3.84 (0.54)	4.12 (0.65)	9.46 (1.44)	3.94 (1.02)
Summer	4.88 (0.62)	6.90 (0.85)	5.83 (0.96)	4.70 (0.76)	9.05 (1.29)	3.55 (0.57)
Walleye,						
Spring	0.42 (0.20)	0.50 (0.21)	1.35 (0.32)	0.00 (0.00)	0.12 (0.09)	5.20 (1.22)
Summer	0.03 (0.03)	0.10 (0.08)	0.34 (0.12)	0.00 (0.00)	0.00 (0.00)	1.10 (0.34)

Table 9. Spring and summer abundance index values (mean catch per 900-s boat electrofishing per surface area [ha] divided by 1,000; and SE) for Northern Pikeminnow (≥ 250 mm FL) in The Dalles and John Day reservoirs, 1990–2018. FB = forebay, Mid = mid-reservoir, TR = tailrace, and Rkm = river kilometer.

Season,	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
Spring,						
1990	1.41 (0.33)	1.80 (0.82)	2.94 (0.88)	0.56 (0.32)	3.50 (1.76)	2.84 (0.95)
1991	—	—	—	0.59 (0.29)	5.06 (2.22)	2.25 (0.84)
1992	—	—	—	0.49 (0.32)	3.27 (2.20)	0.76 (0.42)
1993	1.30 (0.37)	2.79 (1.17)	0.60 (0.26)	1.63 (0.67)	1.78 (1.78)	1.55 (0.66)
1994	0.46 (0.13)	—	—	0.39 (0.16)	2.56 (1.41)	0.68 (0.22)
1995	1.03 (0.37)	—	—	0.41 (0.17)	0.41 (0.41)	0.61 (0.27)
1996	0.59 (0.17)	—	—	0.39 (0.23)	2.67 (2.67)	0.92 (0.26)
1999	—	—	0.18 (0.07)	0.57 (0.30)	—	0.34 (0.14)
2004	—	—	*a*	0.00 (0.00)	0.00 (0.00)	0.33 (0.15)
2006	0.38 (0.21)	1.26 (0.38)	0.05 (0.04)	0.11 (0.07)	1.15 (0.80)	0.32 (0.12)
2009	0.14 (0.07)	0.66 (0.39)	0.00 (0.00)	0.05 (0.05)	0.41 (0.41)	0.20 (0.12)
2012	0.14 (0.08)	0.34 (0.17)	0.08 (0.05)	0.07 (0.07)	1.84 (1.03)	0.00 (0.00)
2015	0.04 (0.04)	0.08 (0.08)	0.15 (0.10)	0.00 (0.00)	0.00 (0.00)	0.05 (0.05)
2018	0.20 (0.09)	0.60 (0.36)	0.03 (0.03)	0.07 (0.07)	0.81 (0.81)	0.36 (0.18)
mean (SE)	0.57 (0.16)	1.08 (0.36)	0.72 (0.38)	0.38 (0.11)	1.80 (0.43)	0.80 (0.23)
Summer,						
1990	1.98 (0.61)	5.00 (1.23)	1.82 (0.61)	0.65 (0.30)	7.96 (3.03)	1.20 (0.39)
1991	—	—	—	0.33 (0.15)	4.30 (1.58)	0.66 (0.58)
1992	—	—	—	0.97 (0.28)	7.45 (1.85)	0.05 (0.05)
1993	2.14 (0.94)	1.51 (0.51)	0.86 (0.43)	1.06 (0.41)	3.68 (1.63)	0.47 (0.17)
1994	0.91 (0.25)	—	0.64 (0.17)	1.12 (0.31)	1.96 (1.35)	0.18 (0.12)
1995	0.55 (0.16)	—	1.52 (0.47)	0.62 (0.22)	1.70 (0.82)	0.61 (0.21)
1996	0.48 (0.25)	—	3.61 (0.91)	0.80 (0.30)	0.00 (0.00)	0.90 (0.21)
1999	—	—	1.28 (0.27)	0.07 (0.07)	—	0.58 (0.22)
2004	—	—	0.35 (0.29)	0.14 (0.14)	—	0.31 (0.17)
2006	0.10 (0.06)	0.25 (0.14)	0.33 (0.17)	0.00 (0.00)	0.00 (0.00)	0.09 (0.07)
2009	0.04 (0.04)	0.11 (0.11)	0.05 (0.03)	0.00 (0.00)	0.42 (0.42)	0.00 (0.00)
2012	0.00 (0.00)	0.23 (0.16)	0.06 (0.04)	0.15 (0.11)	0.00 (0.00)	0.20 (0.10)
2015	—	—	—	—	—	—
2018	0.13 (0.07)	0.55 (0.55)	0.04 (0.04)	0.00 (0.00)	0.00 (0.00)	0.13 (0.09)
mean (SE)	0.70 (0.27)	1.27 (0.77)	0.96 (0.32)	0.45 (0.12)	2.50 (0.90)	0.41 (0.10)

Note: dashes (—) = no sampling conducted, *a* = no mean CPUE calculated ($n \leq 2$).

Table 10. Spring and summer abundance index values (mean catch per 900-s boat electrofishing per surface area [ha] divided by 1,000; and SE) for Smallmouth Bass (≥ 200 mm FL) in The Dalles and John Day reservoirs, 1990–2018. FB = forebay, Mid = mid-reservoir, TR = tailrace, and Rkm = river kilometer.

Season,	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
Spring,						
1990	0.98 (0.30)	2.16 (1.12)	0.90 (0.45)	3.08 (1.17)	46.90 (11.51)	0.00 (0.00)
1991	—	—	—	3.43 (1.01)	62.60 (11.15)	0.45 (0.18)
1992	—	—	—	6.36 (2.61)	9.80 (4.51)	0.00 (0.00)
1993	3.77 (0.81)	17.89 (4.59)	2.11 (0.54)	5.72 (1.61)	60.52 (22.36)	0.82 (0.31)
1994	2.02 (0.36)	—	—	3.32 (0.70)	38.35 (10.99)	1.16 (0.29)
1995	5.28 (0.82)	—	—	5.06 (1.25)	51.86 (10.23)	0.52 (0.30)
1996	3.94 (0.85)	—	—	2.35 (0.60)	71.28 (12.93)	0.31 (0.13)
1999	—	—	0.95 (0.22)	1.14 (0.35)	—	0.24 (0.10)
2004	—	—	*a*	22.97 (3.90)	59.04 (9.71)	0.99 (0.41)
2006	6.32 (0.80)	20.59 (2.30)	2.72 (0.61)	4.65 (0.94)	120.26 (19.12)	3.10 (0.55)
2009	1.99 (0.40)	5.27 (1.21)	1.23 (0.31)	3.03 (0.67)	84.91 (12.64)	0.55 (0.19)
2012	6.71 (0.83)	19.99 (3.30)	2.08 (0.36)	7.00 (1.17)	104.19 (15.78)	0.85 (0.32)
2015	3.67 (0.66)	15.87 (2.03)	1.12 (0.29)	4.44 (0.70)	48.44 (8.60)	0.66 (0.25)
2018	12.98 (1.61)	34.50 (4.72)	3.76 (0.53)	8.06 (1.27)	185.53 (28.26)	7.45 (1.93)
mean (SE)	4.76 (1.09)	16.61 (4.04)	1.65 (0.38)	5.76 (1.42)	72.59 (12.25)	1.22 (0.52)
Summer,						
1990	0.62 (0.20)	1.90 (0.74)	0.51 (0.21)	3.83 (0.87)	12.86 (4.09)	0.76 (0.42)
1991	—	—	—	2.86 (0.55)	23.23 (6.19)	1.56 (0.51)
1992	—	—	—	4.37 (0.99)	28.23 (4.59)	1.59 (0.75)
1993	3.25 (0.49)	8.68 (2.28)	1.23 (0.52)	3.41 (0.75)	50.84 (8.11)	1.50 (0.56)
1994	1.85 (0.36)	—	1.10 (0.27)	6.43 (1.09)	24.50 (8.64)	1.26 (0.46)
1995	3.12 (0.69)	—	0.73 (0.23)	4.38 (0.67)	77.29 (7.83)	1.09 (0.36)
1996	1.06 (0.28)	—	1.12 (0.31)	2.26 (0.47)	44.34 (9.36)	0.43 (0.14)
1999	—	—	1.97 (0.33)	3.56 (0.73)	—	0.82 (0.31)
2004	—	—	0.00 (0.00)	17.72 (2.57)	—	5.34 (1.32)
2006	4.00 (0.63)	12.14 (2.35)	4.66 (0.69)	5.46 (1.08)	133.21 (17.90)	4.77 (0.91)
2009	1.19 (0.30)	8.81 (2.05)	0.93 (0.21)	8.81 (2.09)	60.81 (8.34)	1.59 (0.44)
2012	1.65 (0.54)	14.84 (3.07)	1.96 (0.46)	8.89 (1.25)	143.71 (15.70)	2.70 (0.68)
2015	—	—	—	—	—	—
2018	6.35 (0.80)	27.37 (3.37)	5.71 (0.94)	9.20 (1.49)	177.36 (25.28)	6.71 (1.08)
mean (SE)	2.56 (0.61)	12.29 (3.50)	1.81 (0.54)	6.24 (1.16)	70.58 (16.89)	2.32 (0.55)

Note: dashes (—) = no sampling conducted, *a* = no mean CPUE calculated ($n \leq 2$).

Table 11. Spring and summer abundance index values (mean catch per 900-s boat electrofishing per surface area [ha] divided by 1,000; and SE) for Walleye (≥ 200 mm FL) in The Dalles and John Day reservoirs, 1990–2018. FB = forebay, Mid = mid-reservoir, TR = tailrace, and Rkm = river kilometer.

Season,	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
Spring,						
1990	0.00 (0.00)	0.36 (0.36)	0.45 (0.17)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
1991	—	—	—	0.00 (0.00)	1.26 (1.26)	1.08 (0.50)
1992	—	—	—	0.00 (0.00)	0.00 (0.00)	0.95 (0.42)
1993	0.48 (0.23)	2.75 (1.73)	1.58 (1.12)	0.00 (0.00)	1.78 (1.78)	1.04 (0.42)
1994	0.00 (0.00)	—	—	0.00 (0.00)	0.00 (0.00)	2.13 (0.75)
1995	0.11 (0.07)	—	—	0.08 (0.08)	0.00 (0.00)	1.18 (0.39)
1996	0.17 (0.17)	—	—	0.00 (0.00)	0.00 (0.00)	1.71 (0.49)
1999	—	—	0.56 (0.20)	0.00 (0.00)	—	0.92 (0.28)
2004	—	—	*a*	0.00 (0.00)	5.73 (4.02)	1.49 (0.35)
2006	0.07 (0.05)	0.42 (0.22)	0.53 (0.16)	0.00 (0.00)	0.00 (0.00)	3.84 (1.36)
2009	0.18 (0.09)	0.66 (0.39)	0.43 (0.17)	0.00 (0.00)	2.04 (2.04)	1.10 (0.33)
2012	0.03 (0.03)	0.17 (0.17)	0.28 (0.11)	0.00 (0.00)	2.45 (1.70)	2.26 (0.44)
2015	0.04 (0.04)	0.58 (0.35)	0.22 (0.10)	0.00 (0.00)	0.00 (0.00)	0.81 (0.26)
2018	0.55 (0.26)	1.98 (0.83)	1.32 (0.31)	0.00 (0.00)	2.44 (1.78)	9.84 (2.31)
mean (SE)	0.16 (0.06)	0.99 (0.37)	0.60 (0.17)	0.01 (0.01)	1.21 (0.47)	2.03 (0.65)
Summer,						
1990	0.00 (0.00)	0.17 (0.17)	0.23 (0.19)	0.00 (0.00)	0.00 (0.00)	0.69 (0.33)
1991	—	—	—	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
1992	—	—	—	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
1993	0.00 (0.00)	0.19 (0.19)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.32 (0.19)
1994	0.10 (0.05)	—	0.17 (0.08)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
1995	0.07 (0.05)	—	0.04 (0.04)	0.00 (0.00)	2.13 (1.75)	0.99 (0.38)
1996	0.10 (0.07)	—	0.65 (0.25)	0.00 (0.00)	1.31 (1.31)	1.37 (0.46)
1999	—	—	0.28 (0.12)	0.00 (0.00)	—	0.65 (0.23)
2004	—	—	0.12 (0.08)	0.14 (0.14)	—	1.68 (0.35)
2006	0.00 (0.00)	0.08 (0.08)	0.18 (0.09)	0.00 (0.00)	1.28 (0.94)	2.03 (0.44)
2009	0.04 (0.04)	0.11 (0.11)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.77 (0.34)
2012	0.00 (0.00)	0.12 (0.12)	0.14 (0.08)	0.00 (0.00)	1.15 (1.15)	1.99 (0.62)
2015	—	—	—	—	—	—
2018	0.04 (0.04)	0.41 (0.30)	0.34 (0.12)	0.00 (0.00)	0.00 (0.00)	2.09 (0.64)
mean (SE)	0.04 (0.01)	0.18 (0.05)	0.19 (0.06)	0.01 (0.01)	0.53 (0.24)	0.97 (0.22)

Note: dashes (—) = no sampling conducted, *a* = no mean CPUE calculated ($n \leq 2$).

Table 12. Number (n) of Northern Pikeminnow, Smallmouth Bass, and Walleye (≥ 200 mm FL) digestive tracts examined during biological evaluation in The Dalles and John Day reservoirs during spring and summer 2018 and proportion of samples containing food, fish, crayfish (cray), other crustacea (crust), insects, salmonids (sal), and lamprey (lam). Stomach samples of fishes that did not contain diet items (empty) were included in all analyses.

Season,	Northern Pikeminnow								Smallmouth Bass								Walleye							
Area	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{crust}$	$\hat{p}_{insect}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{crust}$	$\hat{p}_{insect}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{crust}$	$\hat{p}_{insect}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$
Spring																								
The Dalles Reservoir	9	0.89	0.44	0.44	0.00	0.00	0.00	0.33	214	0.94	0.28	0.38	0.24	0.16	0.02	0.03	62	0.94	0.45	0.02	0.29	0.19	0.19	0.11
John Day Reservoir	10	1.00	0.20	0.30	0.10	0.40	0.10	0.00	209	0.97	0.30	0.37	0.63	0.40	0.09	0.00	138	0.93	0.47	0.03	0.39	0.20	0.27	0.01
All	19	0.95	0.32	0.37	0.05	0.21	0.05	0.16	423	0.96	0.29	0.38	0.43	0.28	0.05	0.01	200	0.94	0.47	0.03	0.36	0.20	0.25	0.05
Summer																								
The Dalles Reservoir	9	0.67	0.11	0.44	0.00	0.00	0.00	0.00	204	0.97	0.10	0.78	0.19	0.20	0.01	0.00	13	1.00	0.31	0.15	0.31	0.08	0.00	0.00
John Day Reservoir	3	1.00	0.33	0.33	0.00	0.33	0.00	0.00	210	1.00	0.19	0.74	0.50	0.50	0.04	0.00	32	0.94	0.47	0.19	0.22	0.41	0.28	0.03
All	12	0.75	0.17	0.42	0.00	0.08	0.00	0.00	414	0.98	0.15	0.76	0.35	0.35	0.03	0.00	45	0.96	0.42	0.18	0.24	0.31	0.20	0.02

Table 13. Proportion of diet samples containing specific prey fish families collected from Northern Pikeminnow, Smallmouth Bass, and Walleye during spring and summer biological evaluation in The Dalles and John Day reservoirs, 2018.

	Northern Pikeminnow		Smallmouth Bass		Walleye	
Common name (Family)	The Dalles Reservoir (*n* = 18)	John Day Reservoir (*n* = 13)	The Dalles Reservoir (*n* = 425)	John Day Reservoir (*n* = 420)	The Dalles Reservoir (*n* = 75)	John Day Reservoir (*n* = 170)
lampreys (Petromyzontidae)	0.17	0.00	0.01	0.00	0.09	0.02
minnows (Cyprinidae)	0.00	0.00	<0.01	0.00	0.07	0.03
catfish (Ictaluridae)	0.00	0.00	<0.01	0.01	0.00	0.01
salmon and trout (Salmonidae)	0.00	0.08	0.02	0.07	0.16	0.27
sunfishes (Centrarchidae)	0.06	0.00	0.02	0.04	0.04	0.01
perches (Percidae)	0.00	0.00	0.00	0.01	0.01	0.00
Threespine Stickleback (Gasterosteidae)	0.00	0.00	<0.01	0.00	0.00	0.00
sculpins (Cottidae)	0.06	0.00	0.07	0.08	0.07	0.03
unidentified	0.06	0.15	0.04	0.04	0.04	0.07

Note: Multiple families may be represented in the gut contents of some individual fish. Sample sizes (*n*) listed below each reservoir.

Table 14. Annual consumption index values for Northern Pikeminnow (≥ 250 mm FL) captured during biological evaluation in The Dalles and John Day reservoirs by season, 1990–2018. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, TR = tailrace, and Rkm = river kilometer.

Season,	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
Spring,						
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	*a*	*a*	*a*
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*
2018	*a*	*a*	*a*	*a*	*a*	*a*
mean (SE)	0.18 (0.13)	0.25 (0.16)	1.04 (0.63)	1.67 (0.16)	0.00 (0.00)	0.91 (0.27)
Summer,						
1990	1.01	0.15	3.86	2.41	0.88	6.16
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	1.38	0.00	6.02
1993	0.00	0.00	0.12	0.00	*a*	0.16
1994	0.00	—	1.15	0.65	*a*	1.88
1995	0.00	—	0.66	2.08	*a*	1.35
1996	0.00	—	0.77	0.44	*a*	0.34
1999	—	—	0.00	*a*	—	0.00
2004	—	—	5.52	*a*	—	
2006	*a*	*a*	5.74	*a*	*a*	*a*
2009	*a*	*a*	*a*	*a*	*a*	*a*
2012	*a*	*a*	*a*	*a*	*a*	*a*
2015	—	—	—	—	—	—
2018	*a*	*a*	*a*	*a*	*a*	*a*
mean (SE)	0.20 (0.20)	0.07 (0.07)	2.23 (0.86)	1.16 (0.39)	0.44 (0.44)	2.27 (1.02)

Note: *a* = no consumption index calculated ($n \leq 5$), dashes (—) = no sampling conducted, *b* = no mean calculated ($n \leq 2$).

Table 15. Annual predation index values for Northern Pikeminnow (≥ 250 mm FL) captured during biological evaluation in The Dalles and John Day reservoirs, 1990–2018. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, TR = tailrace, and Rkm = river kilometer.

Season,	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
Spring,						
1990	1.01	0.00	2.91	0.71	0.00	6.77
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	1.11	0.00	0.73
1993	0.11	0.57	0.00	*a*	*a*	*a*
1994	0.09	—	—	0.68	*a*	0.34
1995	0.00	—	—	0.61	*a*	0.65
1996	0.00	—	—	*a*	*a*	0.46
1999	—	—	0.08	0.77	—	0.57
2004	—	—	*a*	*a*	*a*	0.00
2006	0.00	0.69	*a*	*a*	*a*	0.10
2009	*a*	*a*	*a*	*a*	*a*	*a*
2012	*a*	*a*	*a*	*a*	*a*	*a*
2015	*a*	*a*	0.43	*a*	*a*	*a*
2018	*a*	*a*	*a*	*a*	*a*	*a*
mean (SE)	0.20 (0.16)	0.42 (0.21)	0.86 (0.69)	0.78 (0.09)	0.00 (0.00)	1.20 (0.80)
Summer,						
1990	1.97	0.71	6.87	1.57	6.26	6.71
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	1.34	0.00	0.30
1993	0.00	0.00	0.10	0.00	*a*	0.07
1994	0.00	—	0.74	0.73	*a*	0.34
1995	0.00	—	1.01	1.29	*a*	0.83
1996	0.00	—	2.79	0.35	*a*	0.31
1999	—	—	0.00	*a*	—	0.00
2004	—	—	1.93	*a*	—	*a*
2006	*a*	*a*	1.89	*a*	*a*	*a*
2009	*a*	*a*	*a*	*a*	*a*	*a*
2012	*a*	*a*	*a*	*a*	*a*	*a*
2015	—	—	—	—	—	—
2018	*a*	*a*	*a*	*a*	*a*	*a*
mean (SE)	0.39 (0.39)	0.36 (0.36)	1.92 (0.78)	0.88 (0.25)	3.13 (3.13)	1.22 (0.92)

Note: *a* = no predation index calculated ($n_{fish} \leq 5$ or $n_{runs} \leq 2$), dashes (—) = no sampling conducted, *b* = no mean calculated ($n \leq 2$).

Table 16. Annual consumption index values for Smallmouth Bass (≥ 200 mm FL) captured during biological evaluation in The Dalles and John Day reservoirs by season, 1990–2018. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, TR = tailrace, and Rkm = river kilometer.

Season,	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
Spring,						
1990	0.60	0.00	0.00	0.08	0.00	*a*
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	0.09	0.00	*a*
1993	0.00	0.03	0.00	*a*	*a*	*a*
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
2018	0.06	0.00	0.01	0.10	0.08	0.07
mean (SE)	0.10 (0.06)	0.01 (0.01)	0.01 (0.01)	0.05 (0.01)	0.02 (0.01)	0.04 (0.02)
Summer,						
1990	0.00	0.00	0.20	0.26	0.24	0.00
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	0.16	0.00	0.00
1993	0.00	0.00	0.00	0.26	0.00	0.00
1994	0.00	—	0.00	0.15	0.00	0.00
1995	0.00	—	0.00	0.32	0.00	0.00
1996	0.00	—	0.00	0.13	0.00	0.00
1999	—	—	0.00	0.12	—	0.00
2004	—	—	*a*	0.05	—	0.16
2006	0.00	0.03	0.01	0.07	0.02	0.03
2009	0.00	0.00	0.00	0.02	0.03	0.05
2012	0.00	0.07	0.00	0.09	0.05	0.09
2015	—	—	—	—	—	—
2018	0.06	0.03	0.00	0.03	0.05	0.14
mean (SE)	0.01 (0.01)	0.02 (0.01)	0.02 (0.02)	0.14 (0.03)	0.04 (0.02)	0.04 (0.02)

Note: *a* = no consumption index calculated ($n \leq 5$), dashes (—) = no sampling conducted.

Table 17. Annual predation index values for Smallmouth Bass (≥ 200 mm FL) captured during biological evaluation in The Dalles and John Day reservoirs by season, 1990–2018. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, TR = tailrace, and Rkm = river kilometer.

Season,	The Dalles Reservoir			John Day Reservoir		
Year	FB	Mid	TR	FB	Mid	TR
Spring,						
1990	0.49	0.00	0.00	0.19	0.00	*a*
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	0.55	0.00	*a*
1993	0.00	0.58	0.00	*a*	*a*	*a*
1994	0.00	—	—	0.20	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*	1.66	2.28	*a*
2006	0.00	0.30	0.00	0.00	1.11	0.07
2009	0.09	0.11	0.00	0.00	0.27	0.00
2012	0.84	0.45	0.12	0.22	1.43	0.03
2015	0.49	0.00	0.03	0.40	5.88	0.15
2018	0.74	0.00	0.05	0.83	14.20	0.53
mean (SE)	0.27 (0.11)	0.21 (0.09)	0.03 (0.01)	0.34 (0.14)	2.29 (1.30)	0.09 (0.06)
Summer,						
1990	0.00	0.00	0.10	0.88	2.71	0.00
1991	—	—	—	*a*	*a*	*a*
1992	—	—	—	0.70	0.00	0.00
1993	0.00	0.00	0.00	0.88	0.00	0.00
1994	0.00	—	0.00	0.99	0.00	0.00
1995	0.00	—	0.00	1.41	0.00	0.00
1996	0.00	—	0.00	0.28	0.00	0.00
1999	—	—	0.00	0.42	—	0.00
2004	—	—	*a*	0.83	—	0.88
2006	0.00	0.41	0.06	0.38	2.75	0.17
2009	0.00	0.00	0.00	0.17	1.54	0.08
2012	0.00	1.07	0.00	0.78	7.38	0.24
2015	—	—	*a*	—	—	—
2018	0.37	0.81	0.00	0.28	8.11	0.96
mean (SE)	0.04 (0.04)	0.38 (0.19)	0.02 (0.01)	0.67 (0.11)	2.25 (0.98)	0.19 (0.10)

Note: *a* = no predation index calculated ($n_{fish} \leq 5$ or $n_{runs} \leq 2$), dashes (—) = no sampling conducted.

Table 18. Number of stock-length (n_s) Northern Pikeminnow, Smallmouth Bass, Walleye, proportional size distribution (PSD, %), and proportional size distribution of preferred-length fish (PSD-P, %) collected by boat electrofishing during biological evaluation in The Dalles and John Day reservoirs, 1990–2018. Mean and SE were calculated across the time series.

	Northern Pikeminnow				Smallmouth Bass						Walleye					
	The Dalles Reservoir		John Day Reservoir		The Dalles Reservoir			John Day Reservoir			The Dalles Reservoir			John Day Reservoir		
Year	n_s	PSD	n_s	PSD	n_s	PSD	PSD-P	n_s	PSD	PSD-P	n_s	PSD	PSD-P	n_s	PSD	PSD-P
1990	466	53	331	68							15	*a*	*a*	11	*a*	*a*
1991	—	—	356	65	—	—	—	252	43	11	—	—	—	13	*a*	*a*
1992	—	—	269	66	—	—	—	269	30	8	—	—	—	9	*a*	*a*
1993	134	66	170	66	257	42	12	254	36	15	17	*a*	*a*	13	*a*	*a*
1994	121	42	118	72	169	50	10	334	28	7	11	*a*	*a*	54	91	22
1995	105	17	51	43	209	42	10	513	33	9	7	*a*	*a*	48	75	50
1996	123	34	54	54	156	56	15	225	45	13	23	91	39	58	97	59
1999	55	29	22	64	107	37	4	80	41	13	25	68	44	26	88	85
2004	7	*a*	11	*a*	0	*a*	*a*	441	39	13	2	*a*	*a*	56	79	27
2006	47	45	12	*a*	968	40	18	896	30	10	26	88	46	92	65	20
2009	12	*a*	7	*a*	287	63	17	548	44	4	28	54	25	39	41	23
2012	15	*a*	11	*a*	736	50	20	771	31	7	16	*a*	*a*	89	81	28
2015	8	*a*	1	*a*	339	62	35	214	47	11	9	*a*	*a*	8	*a*	*a*
2018	17	*a*	9	*a*	1095	47	14	889	33	4	54	81	24	126	82	23
mean (SE)	93 (37)	41 (6)	102 (34)	62 (3)	393 (111)	49 (3)	16 (3)	437 (75)	37 (2)	10 (1)	19 (4)	77 (7)	36 (5)	46 (10)	78 (5)	37 (7)

Note: *a* = no PSD or PSD-P value calculated ($n_s \leq 19$), dashes (—) = no sampling conducted

Table 19. Number (n) of Northern Pikeminnow digestive tracts examined from contract anglers' catches from the tailraces of The Dalles and John Day dams and proportions containing specific prey items (cray = crayfish, other invert. = all invertebrates not identified as crayfish, misc. = vegetation, rocks, inorganic matter, or unidentifiable items, sal = salmon/steelhead, lam = lamprey, ash = American Shad).

Reservoir, Year	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{other\ invert.}$	$\hat{p}_{misc.}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$	$\hat{p}_{ash}$	$\hat{p}_{other\ fish}$
Bonneville,										
2006	129	0.36	0.21	0.08	0.04	0.11	0.04	0.17	0.00	0.05
2007	340	0.61	0.40	0.04	0.22	0.09	0.13	0.31	0.00	0.06
2008	209	0.63	0.44	0.04	0.33	0.05	0.11	0.31	0.00	0.12
2009	223	0.70	0.64	0.06	0.19	0.10	0.09	0.50	0.01	0.14
2010	395	0.62	0.49	0.06	0.14	0.17	0.16	0.18	0.15	0.18
2011	329	0.66	0.44	0.07	0.19	0.17	0.36	0.09	0.00	0.08
2012	275	0.77	0.57	0.09	0.19	0.25	0.15	0.18	0.00	0.00
2013	216	0.77	0.43	0.12	0.34	0.16	0.17	0.22	0.04	0.06
2014	489	0.58	0.46	0.07	0.13	0.08	0.19	0.47	0.19	0.42
2015	474	0.75	0.53	0.13	0.29	0.13	0.07	0.53	0.21	0.15
2016	463	0.73	0.37	0.03	0.44	0.24	0.07	0.14	0.13	0.08
2017	415	0.76	0.53	0.03	0.35	0.19	0.14	0.18	0.17	0.14
2018	346	0.72	0.46	0.04	0.36	0.11	0.06	0.05	0.29	0.15
The Dalles,										
2007	453	0.58	0.37	0.02	0.27	0.03	0.13	0.08	0.11	0.21
2008	64	0.81	0.36	0.03	0.69	0.11	0.09	0.23	0.00	0.08
2009	224	0.61	0.56	0.08	0.31	0.04	0.11	0.40	0.00	0.14
2010	382	0.55	0.29	0.07	0.34	0.25	0.16	0.10	0.02	0.07
2011	283	0.70	0.22	0.06	0.56	0.04	0.15	0.07	0.00	0.02
2012	479	0.77	0.39	0.13	0.48	0.09	0.15	0.12	0.04	0.00
2013	447	0.78	0.47	0.22	0.34	0.04	0.23	0.16	0.09	0.05
2014	363	0.72	0.44	0.31	0.27	0.01	0.18	0.46	0.14	0.36
2015	337	0.79	0.45	0.24	0.37	0.04	0.14	0.45	0.12	0.16
2016	426	0.73	0.31	0.04	0.57	0.06	0.14	0.04	0.06	0.07
2017	329	0.61	0.30	0.05	0.48	0.10	0.11	0.07	0.09	0.08
2018	473	0.75	0.30	0.04	0.57	0.04	0.13	0.09	0.06	0.04

Table 20. Proportion of all diet samples containing specific prey fish families for Northern Pikeminnow collected during the Dam Angling Fishery from the angling-accessible zones of the powerhouse tailraces of The Dalles and John Day dams, May–August 2018.

Common name (Family)	May[a] (*n* = 58)	June (*n* = 263)	July (*n* = 304)	August[b] (*n* = 194)	Total (*n* = 819)
lampreys (Petromyzontidae)	0.41	0.10	0.03	0.01	0.07
shad (Clupeidae)	0.00	0.00	0.03	0.62	0.16
minnows (Cyprinidae)	0.00	0.00	<0.01	0.04	0.01
catfish (Ictaluridae)	0.00	<0.01	<0.01	0.03	<0.01
salmon and trout (Salmonidae)	0.05	0.13	0.15	0.02	0.10
Mountain Whitefish (Salmonidae)	0.00	0.00	0.00	<0.01	<0.01
sunfishes (Centrarchidae)	0.00	0.00	0.03	0.07	0.03
sculpins (Cottidae)	0.00	0.00	0.00	<0.01	<0.01
unidentified	0.03	0.03	0.03	0.03	0.03

Note: [a]Sampling began 22 May 2018, [b]sampling ended 23 August 2018. Multiple families may be represented in the gut contents of some individual fish. Sample sizes (*n*) listed below each month.

FIGURES

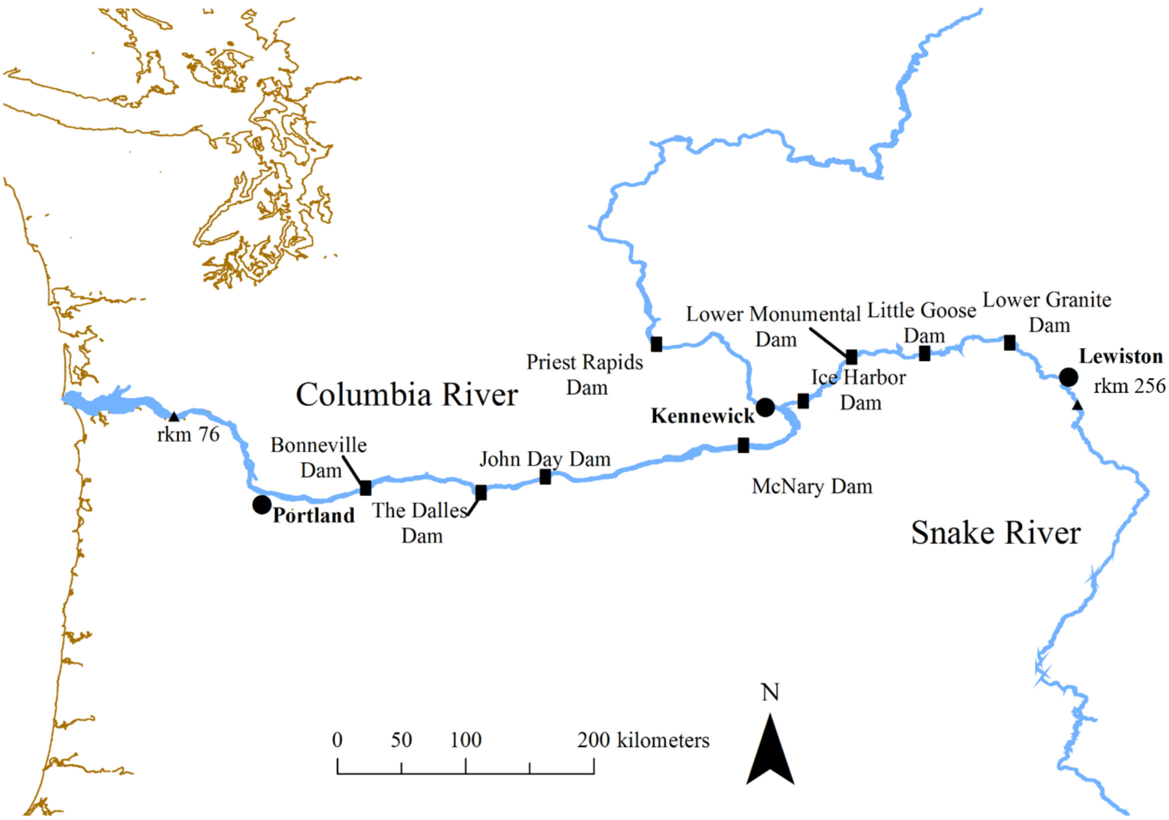

Figure 1. Study area in the Columbia and Snake rivers.

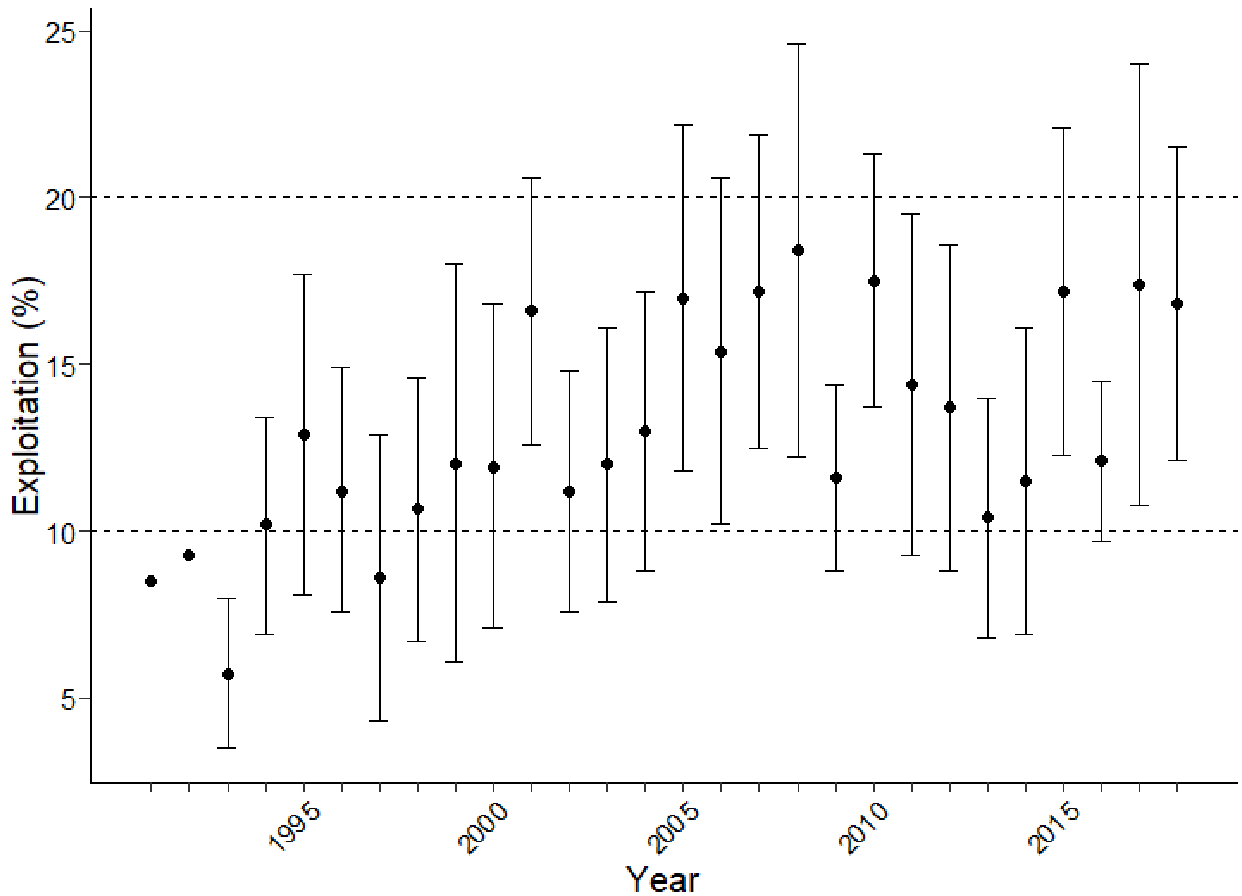

Figure 2. System-wide exploitation rates of Northern Pikeminnow (≥ 250 mm FL) in the Sport Reward Fishery, 1991–2018. Error bars represent 95% confidence intervals. Variation was not estimated for the years 1991–1992. Target exploitation is 10–20% (dashed lines).

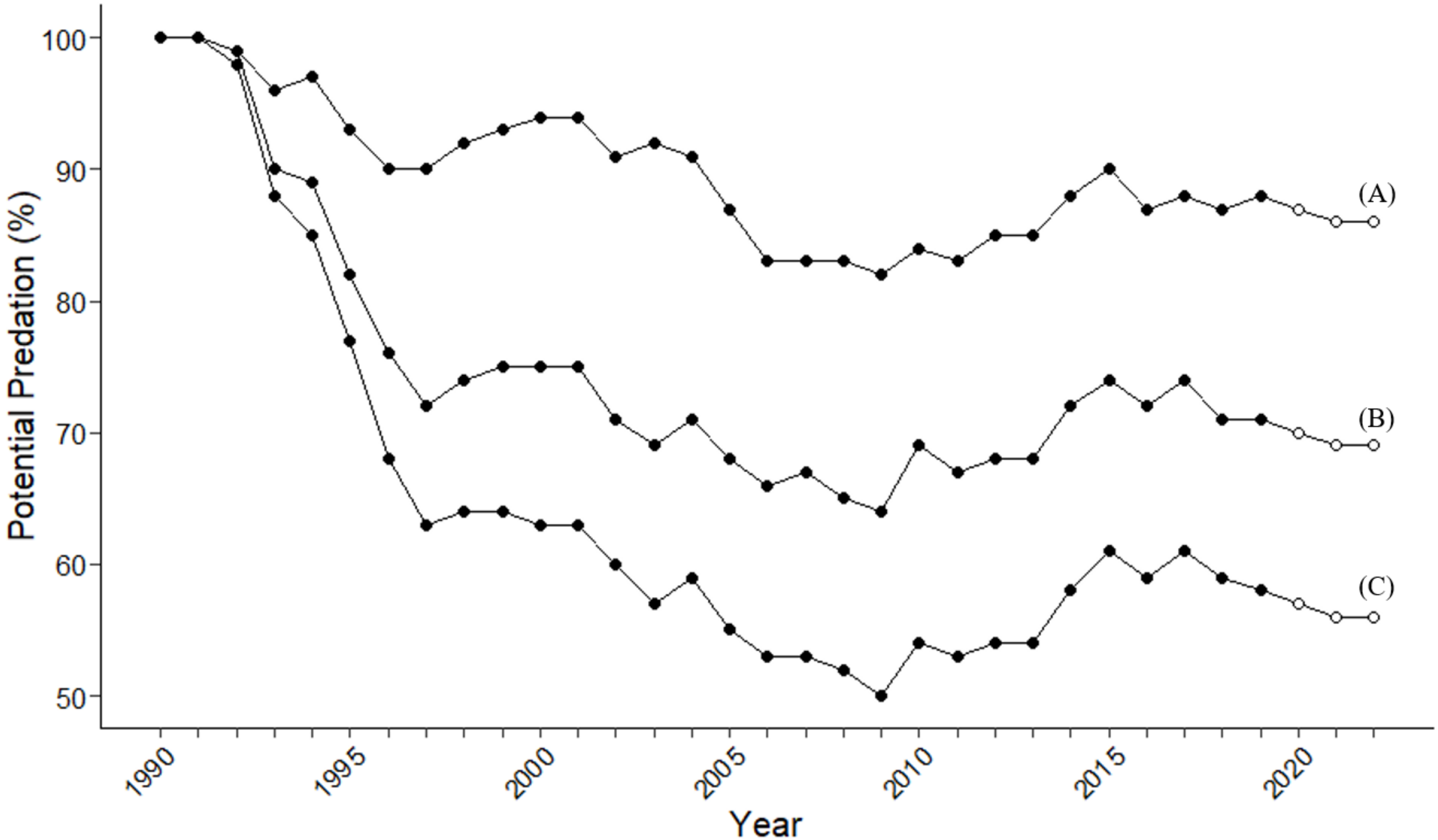

Figure 3. Estimates of (A) maximum, (B) median, and (C) minimum annual levels of potential predation by Northern Pikeminnow on juvenile salmon relative to predation levels before implementation of the Northern Pikeminnow Management Program. For the years 1991–2019, model estimates (filled circles) are based on exploitation levels from the previous year. Model forecast predictions after 2019 (open circles) are based on average exploitation estimates from years with similar fishery structure (2001, 2004–2018).

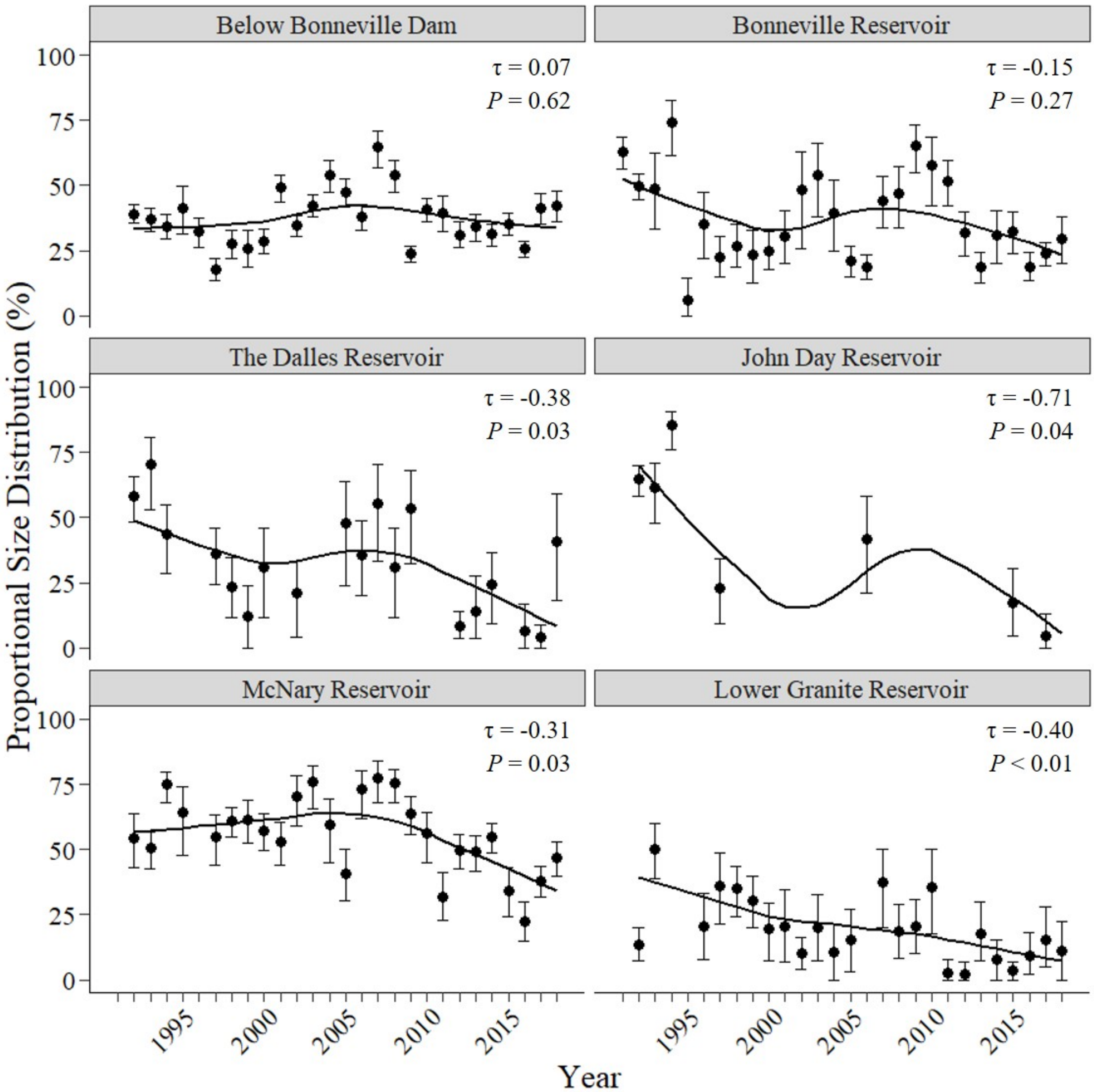

Figure 4. Estimates of proportional size distribution (PSD, %) for Northern Pikeminnow in the Columbia and lower Snake rivers, 1991–2018. Data were collected during fishery evaluation. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sample sizes were insufficient for analysis ($n_s \leq 19$).

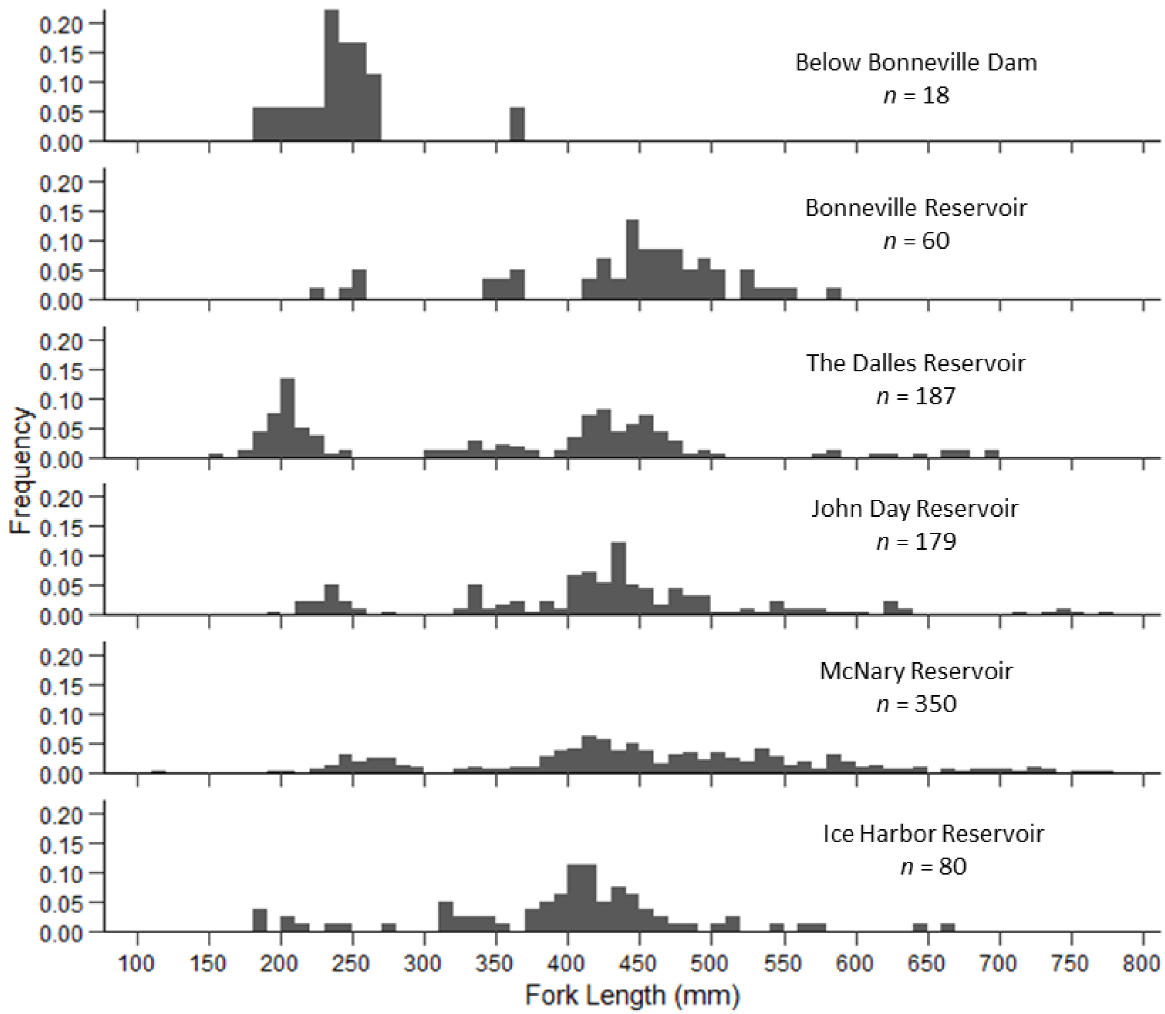

Figure 5. Length-frequency histogram of Walleye observed opportunistically during fishery evaluation during 2018 in the Columbia and lower Snake rivers. Fork length size bins are 10 mm.

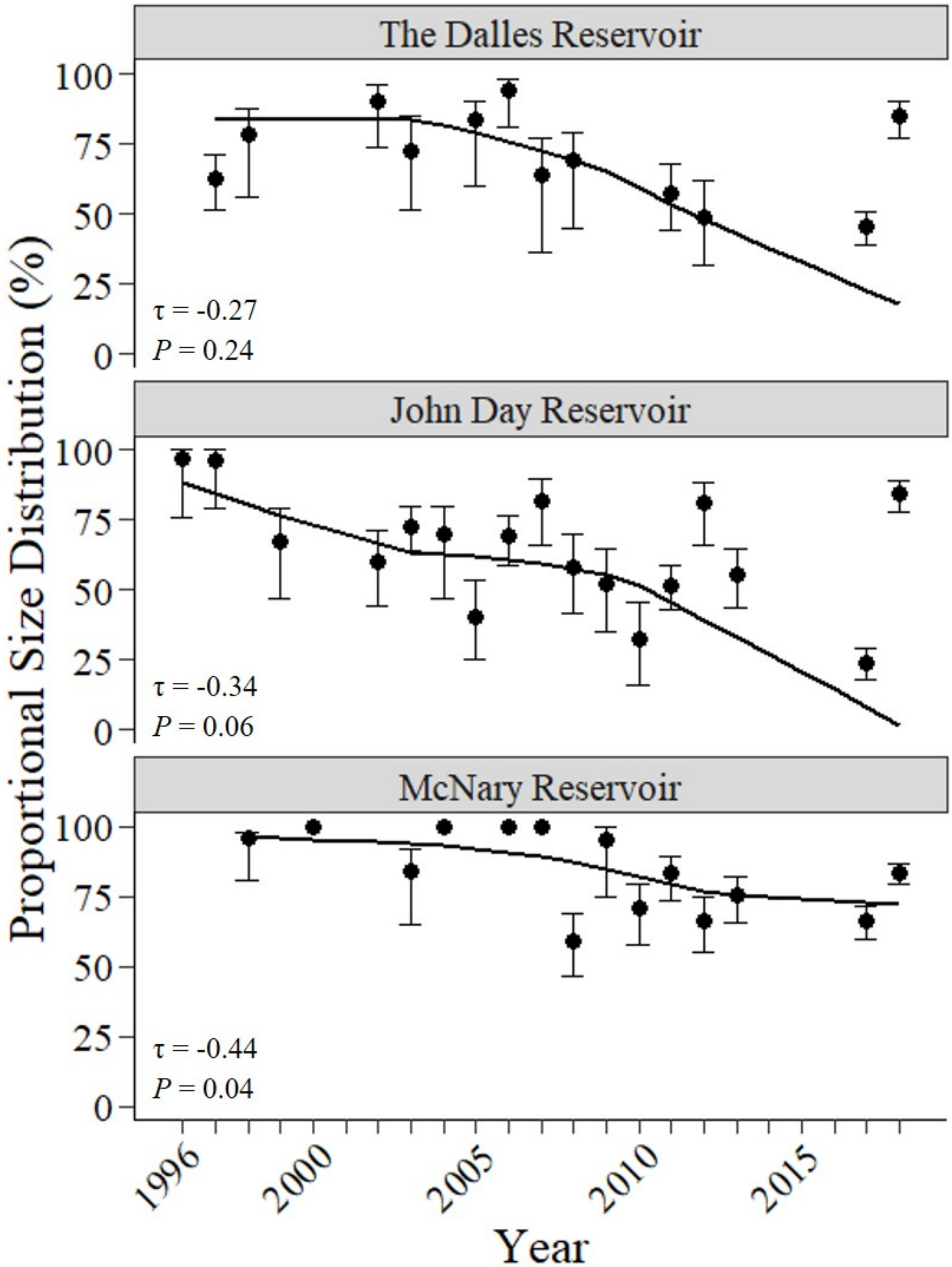

Figure 6. Estimates of proportional size distribution (PSD, %) of Walleye in The Dalles, John Day, and McNary reservoirs, 1996–2018. Data were collected during fishery evaluation. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate no sampling or sample sizes were insufficient for analysis ($n_s \leq 19$).

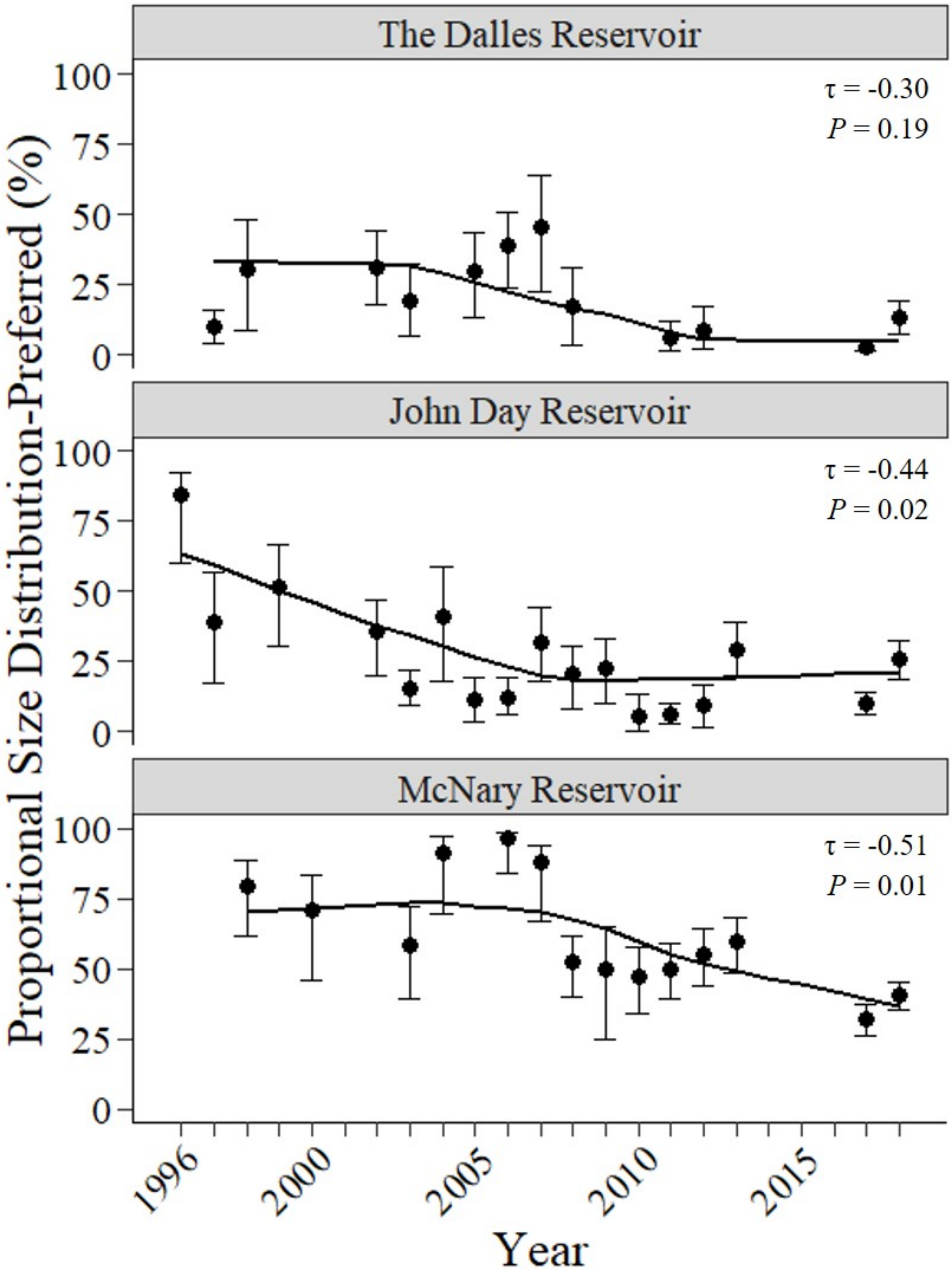

Figure 7. Estimates of proportional size distribution of preferred-length (PSD-P, %) Walleye in The Dalles, John Day, and McNary reservoirs, 1996–2018. Data were collected during fishery evaluation. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate no sampling or sample sizes were insufficient for analysis ($n_s \leq 19$).

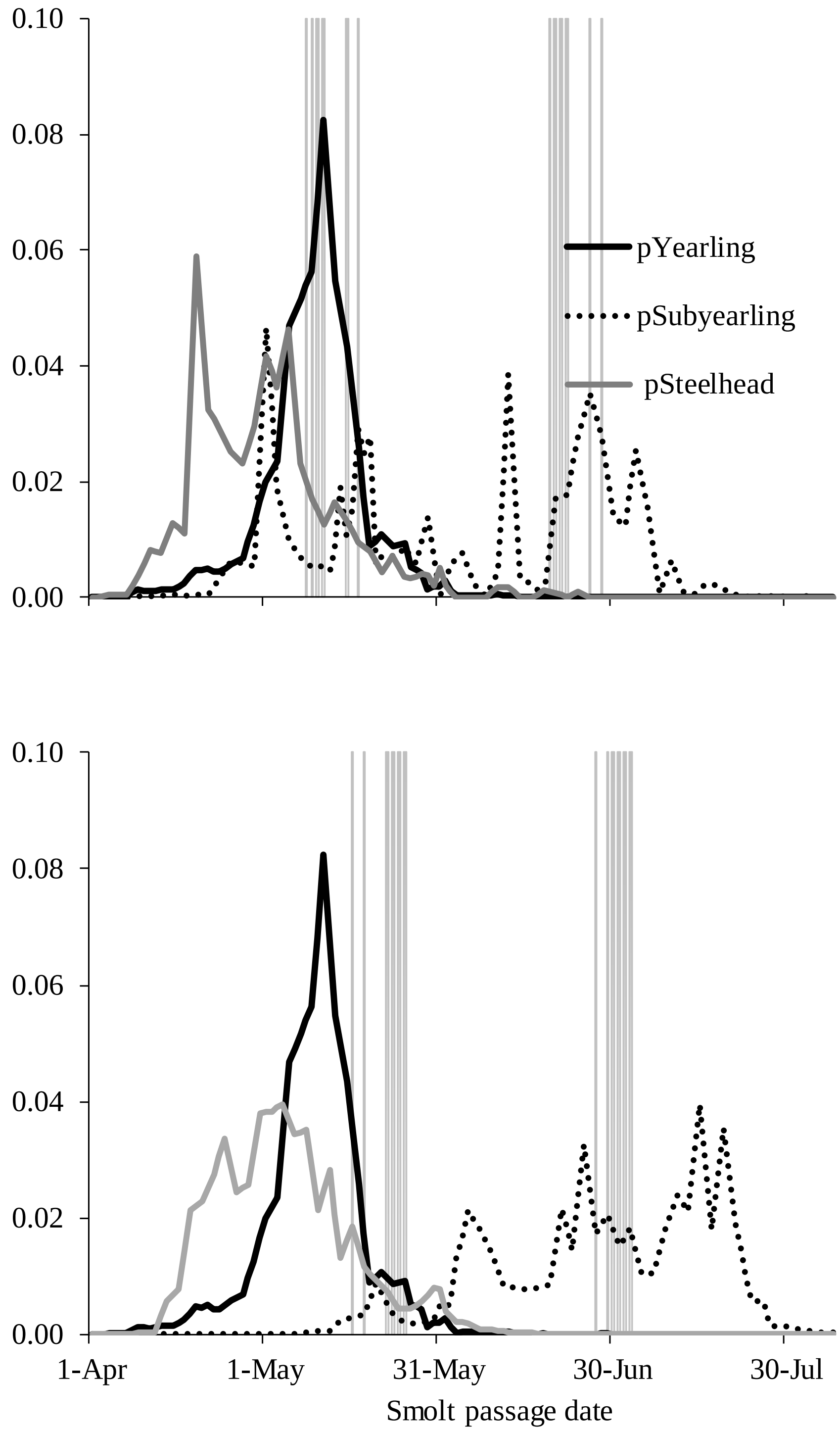

Figure 8. Periods of index sampling (shaded bars) in John Day (top panel) and The Dalles (bottom panel) reservoirs and smolt passage indices of juvenile salmon through McNary (top) and John Day (bottom) dams, 1 April – 31 August 2018.

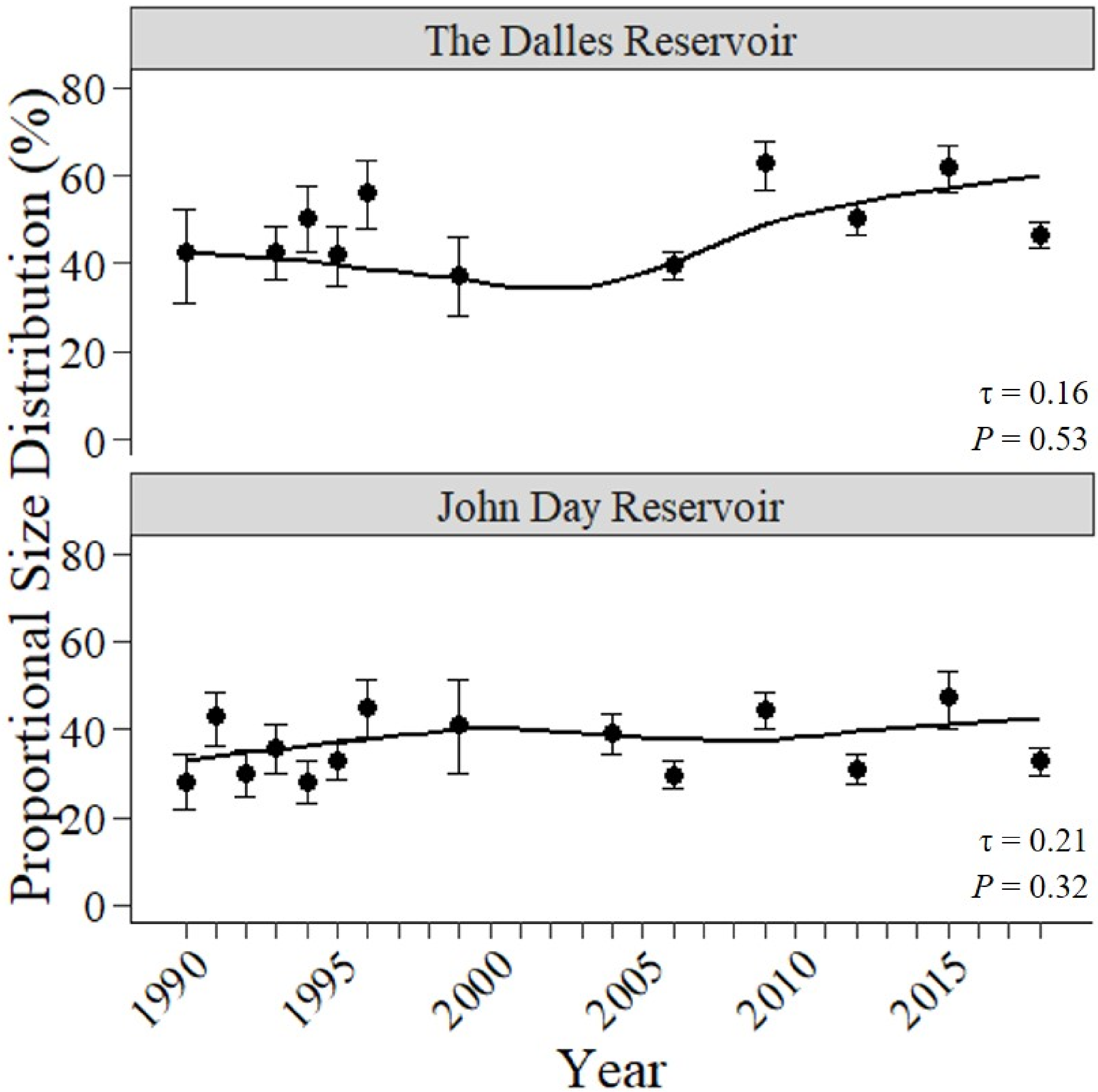

Figure 9. Estimates of proportional size distribution (PSD, %) of Smallmouth Bass collected during biological evaluation in The Dalles and John Day reservoir, 1990–2018. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or sample sizes were insufficient for analysis ($n_s \leq 19$).

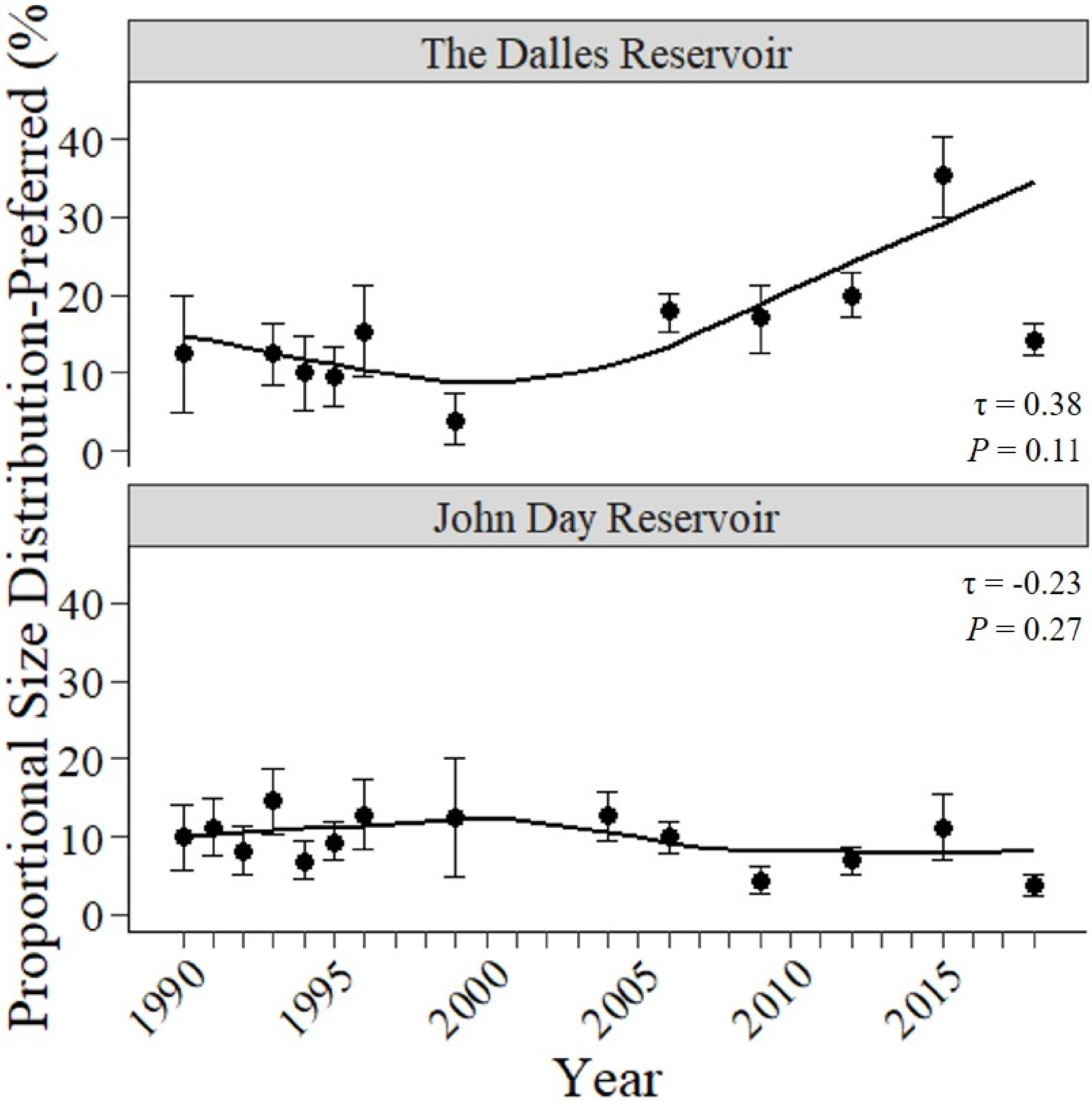

Figure 10. Estimates of proportional size distribution of preferred-length (PSD-P, %) Smallmouth Bass collected during biological evaluation in The Dalles and John Day reservoirs, 1990–2018. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or sample sizes were insufficient for analysis ($n_s \leq 19$).

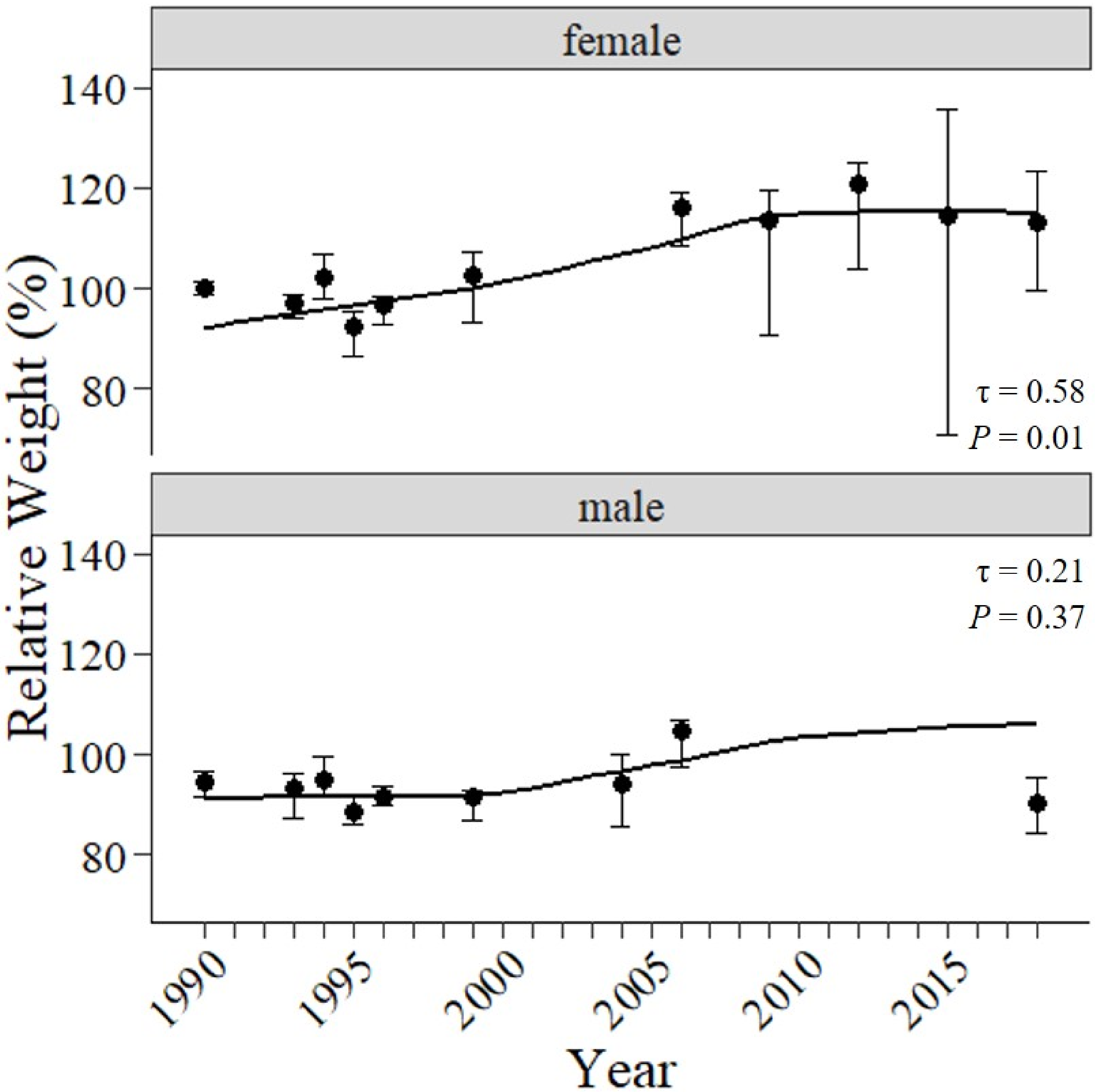

Figure 11. Median relative weight (W_r, %) for female and male Northern Pikeminnow collected during biological evaluation in The Dalles Reservoir, 1990–2018. Error bars represent 95% bootstrap (percentile) confidence intervals. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or sample sizes were insufficient for analyses ($n \leq 3$).

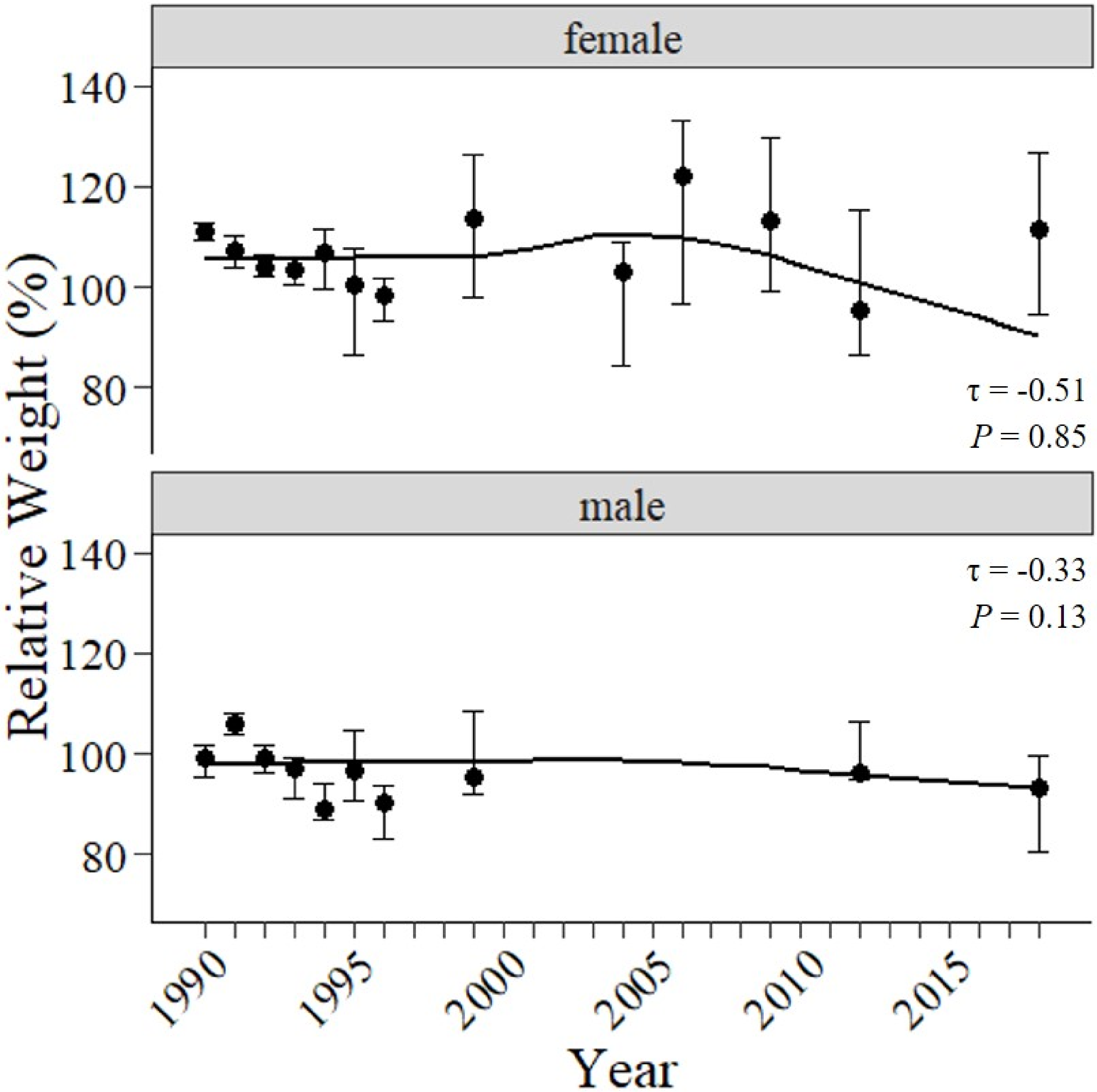

Figure 12. Median relative weight (W_r, %) for female and male Northern Pikeminnow collected during biological evaluation in John Day Reservoir, 1990–2018. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or sample sizes were insufficient for analyses.

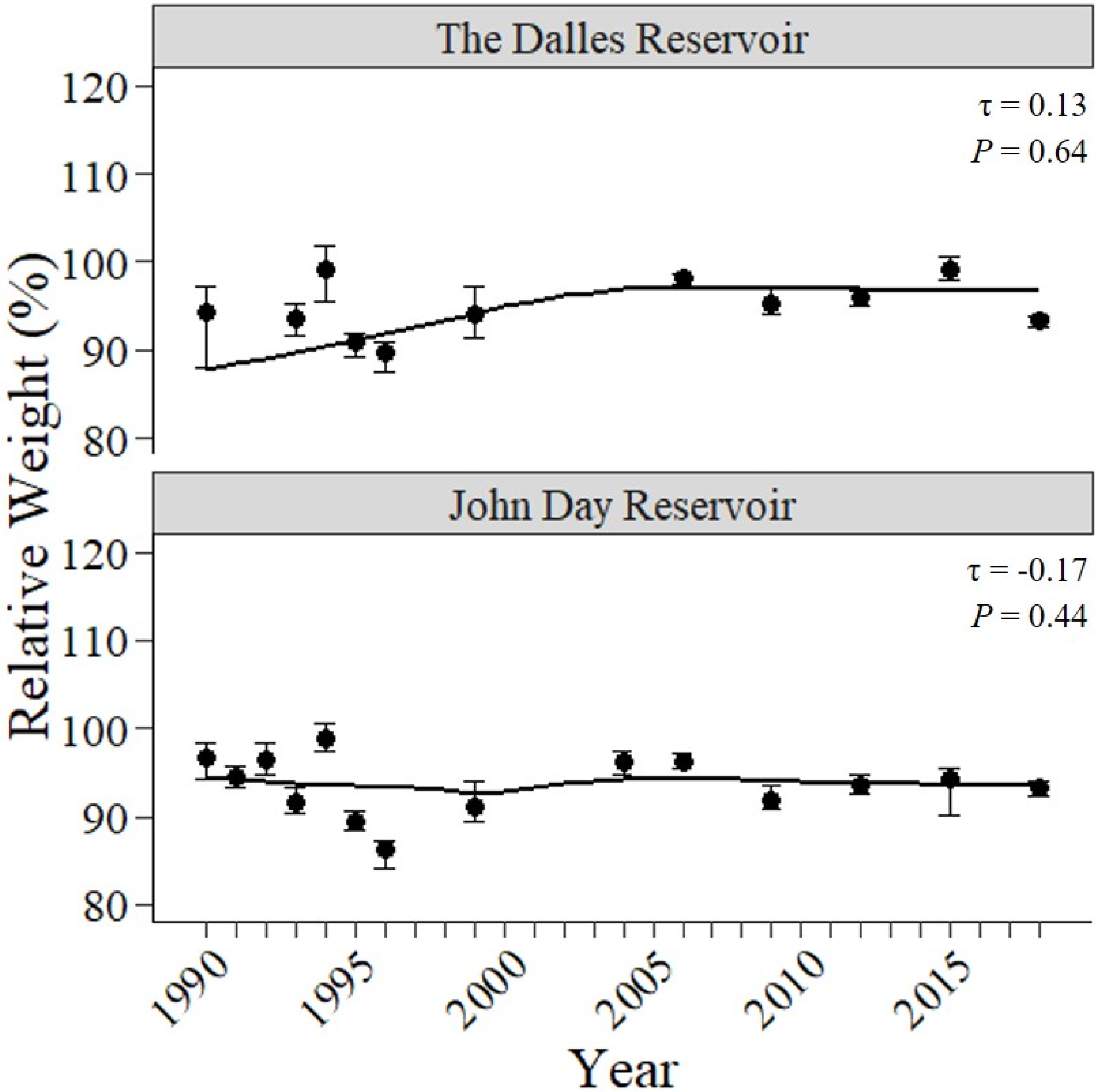

Figure 13. Median relative weight (W_r, %) for Smallmouth Bass collected during biological evaluation in The Dalles and John Day reservoirs, 1990–2018. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or sample sizes were insufficient for analyses ($n \leq 3$)

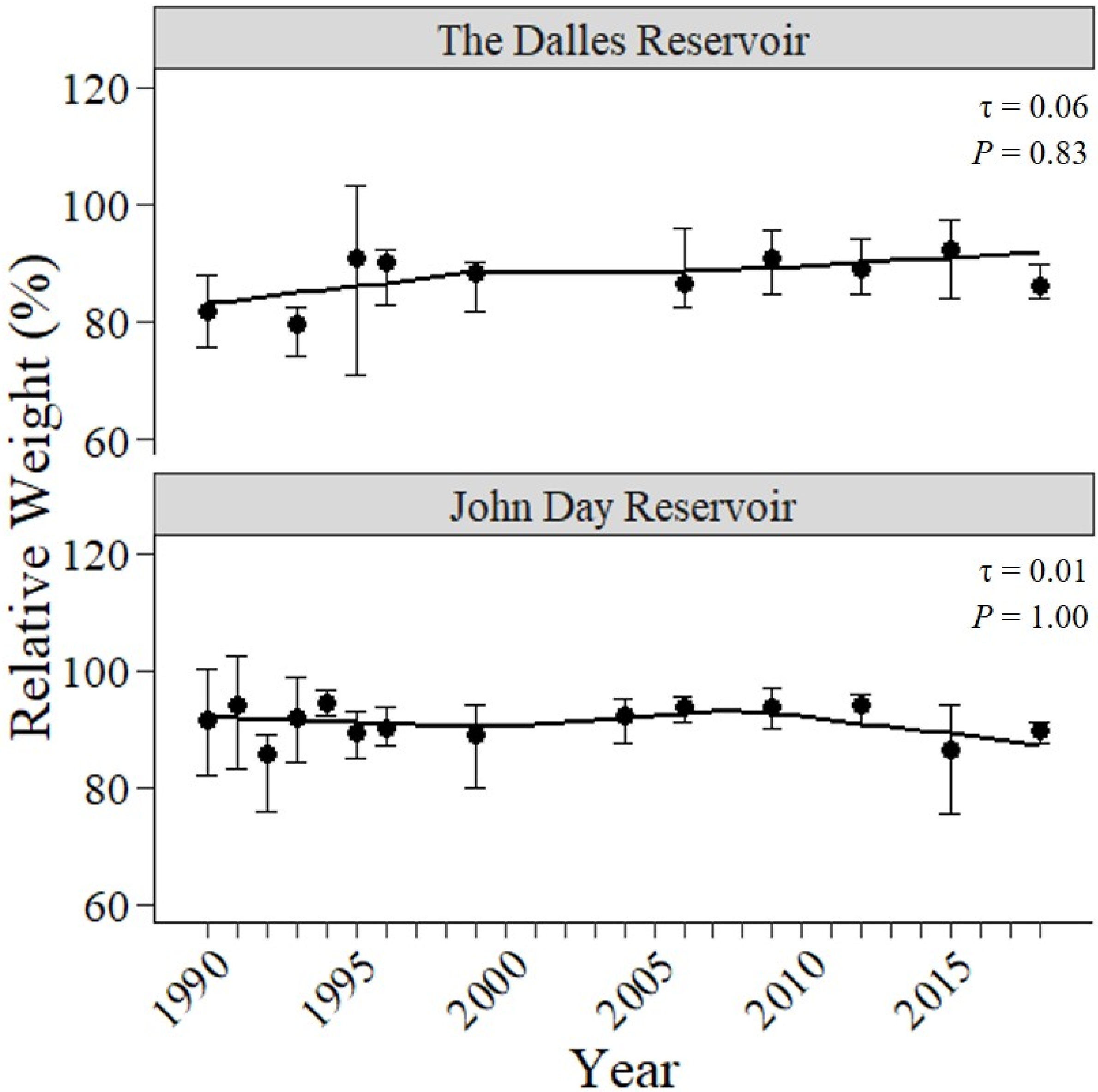

Figure 14. Median relative weight (W_r, %) for Walleye collected during biological evaluation in The Dalles and John Day reservoirs, 1990–2018. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with a LOWESS curve. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or sample sizes were insufficient for analyses ($n \leq 3$).

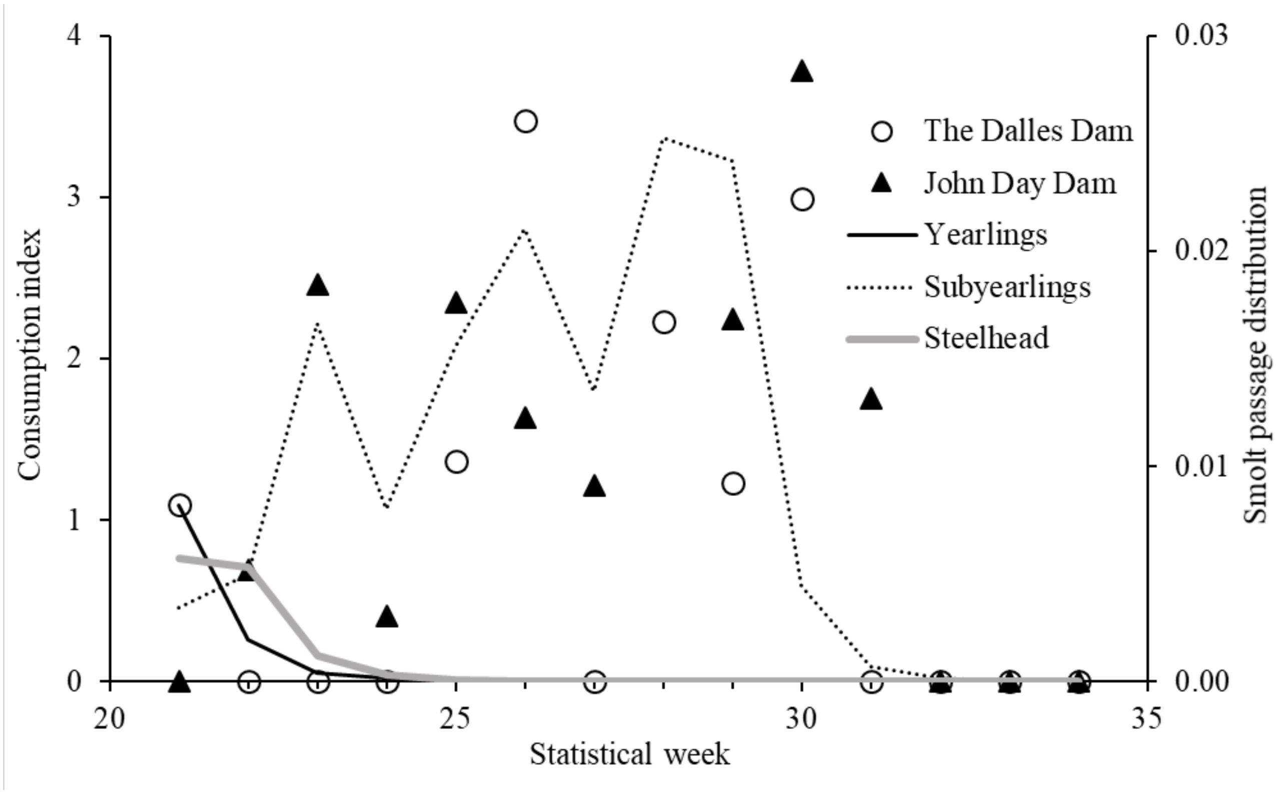

Figure 15. Mean weekly juvenile salmon consumption index for Northern Pikeminnow captured from the Dam Angling Fishery in Bonneville (open circles) and The Dalles (filled triangles) reservoirs compared with the smolt passage index at John Day Dam, 2018. Smolt passage data are summarized from Fish Passage Center (unpublished data).

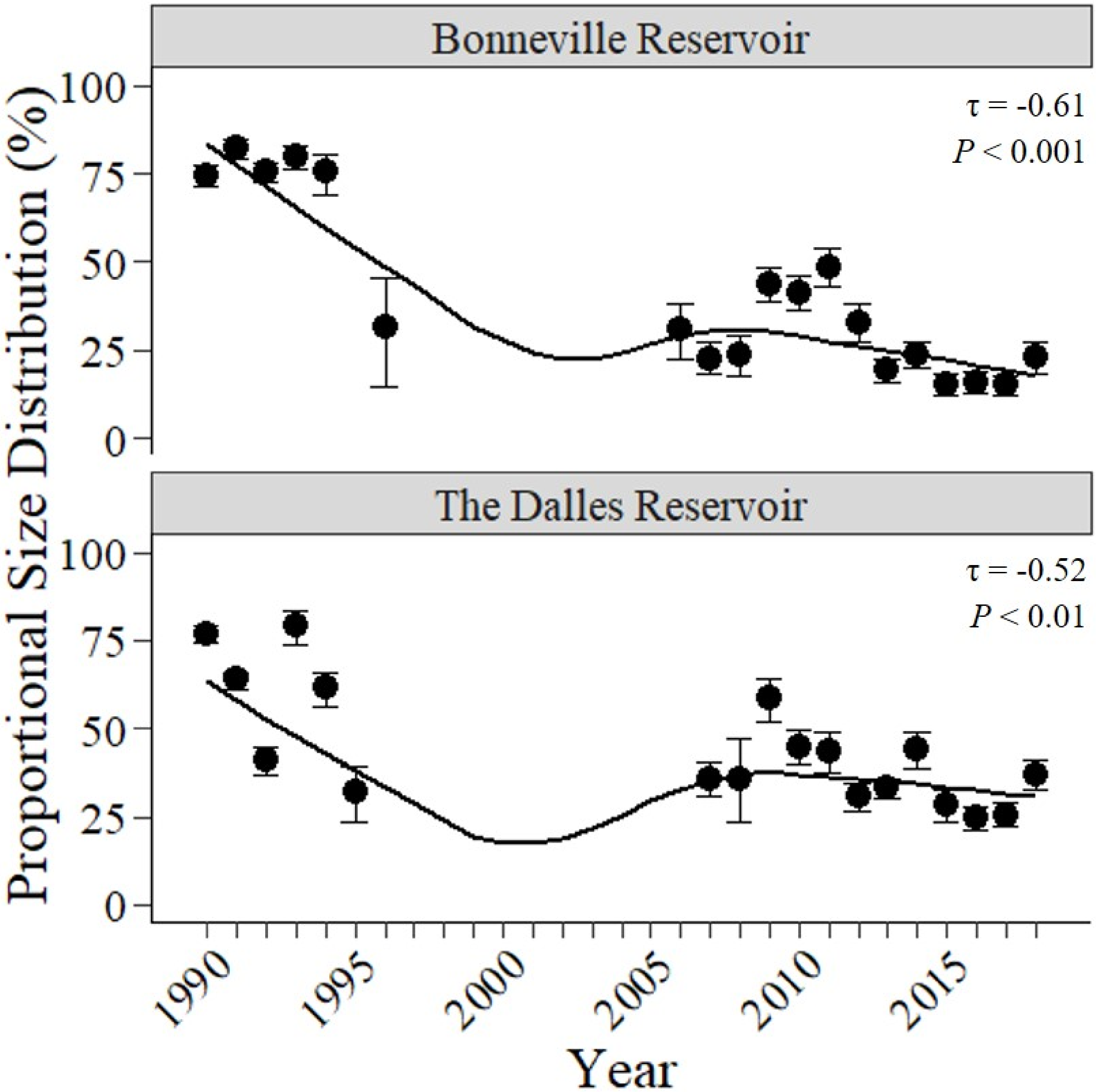

Figure 16. Estimates of proportional size distribution (PSD, %) of Northern Pikeminnow sampled in Bonneville and The Dalles reservoirs during the Dam Angling Fishery, 1990–2018. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years with no data indicate sampling was not conducted or sample sizes were insufficient for analyses ($n_s \leq 19$).

REPORT D

Northern Pikeminnow Dam Angling on the Columbia River

2018 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 Levandowsky and Steve Lines who served as our 2018 dam angler crew.

We also recognize Diana Murillo and Dennis Werlau for their work on Dam Angler data entry and document verification, and Dennis Werlau for producing the Dam Angling Weekly Field Activity Reports throughout the 2018 season.

ABSTRACT

We are reporting on the 2018 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 22 weeks from May 1st through October 3rd 2018. The objectives of this project were to (1) implement a recreational-type hook and line fishery harvesting Northern Pikeminnow from within the boat restricted zones (BRZs), where angling is 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 Dam Angler CPUE in order to maximize harvest of Northern Pikeminnow, (3) collect, compile and report data on Dam 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 Dam 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 predation studies, (5) collect relevant biological data on all Northern Pikeminnow and other fishes caught by the 2018 Dam Angling crew.

A Dam Angling crew of four anglers harvested 4,874 Northern Pikeminnow during the 2018 season. Of those, 1,785 Northern Pikeminnow were harvested at The Dalles Dam and 3,089 were harvested at the John Day Dam. The crew fished a total of 1,900 hours during the 22 week fishery, averaging 222 fish per week and for a combined overall average catch per angler hour (CPUE) of 2.6 Northern Pikeminnow. At The Dalles Dam, the crew averaged 2.5 fish per angler hour, and cumulatively 32 Northern Pikeminnow per day. At the John Day Dam, the crew averaged 2.6 fish per angler hour with a cumulative crew total of 44 fish per day.

Based on the success of the WDFW Dam Angling crew in implementing the Dam Angling component of the NPMP from 2010-17, the 2018 Dam Angling crew continued to use back bouncing soft plastic lures with rod and reel 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 2018 were Smallmouth Bass *Micropterus dolomieue* and Walleye *Sander vitreus.*

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). 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 and 2018 marked the ninth 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 2018.

The objectives of the 2018 Dam Angling component of the NPMP were to (1) implement a recreational-type hook and line fishery harvesting Northern Pikeminnow from within the boat restricted zones (BRZs), where angling is 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 Dam 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 Dam 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 predation studies, and (5) collect relevant biological data on all Northern Pikeminnow and other fishes caught by the 2018 Dam Angling crew.

METHODS

Project Area

In 2018, as a continuing supplemental component to the NPMP, Northern Pikeminnow removal activities were conducted at The Dalles and John Day Dams on the Columbia River utilizing a Dam Angling crew (Figure 1). Dam Angling activities in 2018 were planned for a five month season scheduled to be from May through September. At both The Dalles, and John Day Dams, all angling activities were conducted within the tailrace BRZs where no public angling was permitted. At The Dalles Dam, the Dam Angling crew fished primarily along the turbine deck (Figure 2). At the John Day Dam, the crew fished exclusively along the turbine deck (Figure 3).

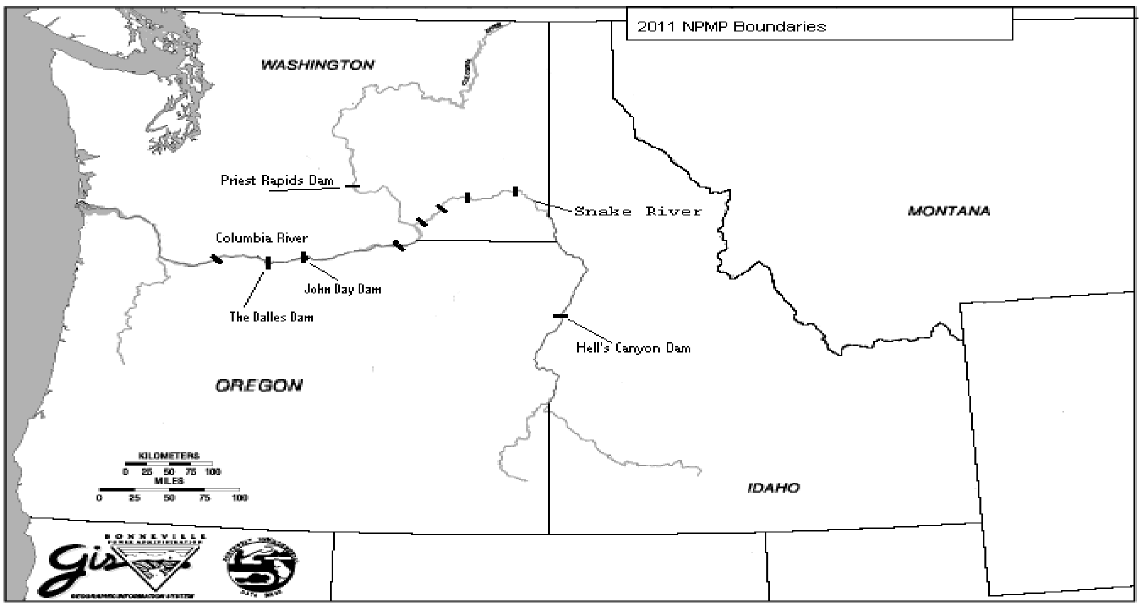

Figure 1. Northern Pikeminnow Management Program Boundaries, including 2018 Dam Angling sites

Figure 2. Angling Locations for the 2018 Dam Angling Crew at The Dalles Dam

Figure 3. Angling Locations for the 2018 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 in 2018, WDFW continued to use the Dam Angling Strategy (DAS) developed in 2011 where 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 2018 Dam Angler CPUE goal remained set at 2.0 fish/angler hour as established in our original 2011 DAS (Dunlap et al. 2012).

The Dam Angling Crew

The four member Dam Angling crew typically worked four ten hour days a week, (usually Tuesday - Friday) during the 2018 season (Figure 4). Angling start times in the morning 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. As part of the four person angling crew, a crew leader was present each day to ensure angler safety and supervision, to collect, record and compile data on Northern Pikeminnow harvest, other fish species caught, and so 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 a 4-6” 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 at 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.

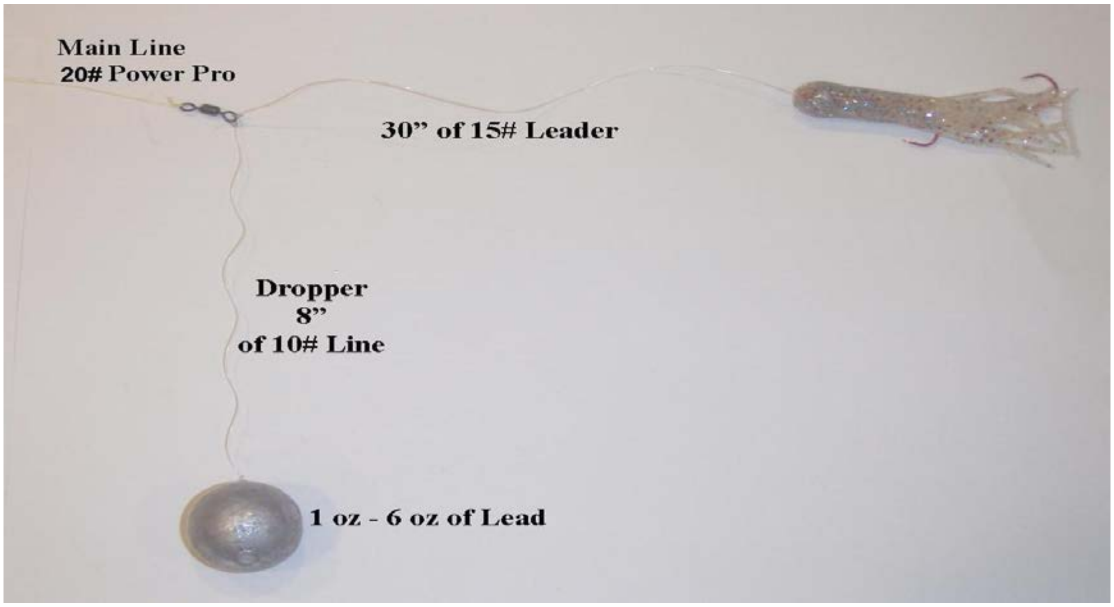

Figure 5. Example of Typical Rigging Used by 2018 NPMP Dam Anglers

Figure 6. Examples of Soft Plastic Tube Baits Used by 2018 NPMP Dam Anglers

Data Collection

Creel data were recorded onto data sheets for each individual angler and for each angling day. Angler data sheets were then combined and summarized into daily crew totals, which were then combined into weekly crew totals submitted for each of the two projects (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 lures used (and number of fish caught with each color/type 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, floy, etc.), 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 preserved for later data verification and/or tag recovery. Spaghetti tags from harvested Northern Pikeminnow along with biological data were recorded on a NPSRF tag envelopes and all tag data were submitted to WDFW Tag Lead Biologist for processing. Processed tag recovery data were then provided to ODFW for NPMP exploitation estimates.

PIT Tag Detection

All Northern Pikeminnow collected by Dam Anglers during 2018 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 Biomark portable transceivers (model #HPR.PLUS.04V1). Technicians also scanned all incidental catches of Walleye, Smallmouth Bass and Channel Catfish for PIT tags from ingested salmonids. 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 Northern 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 Tag Lead Biologist, entered into the PIT Tag Information System (PTAGIS) and provided to ODFW.

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 submitted 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 The Dalles / John Day Dam Findings

2018 Dam Angling Season

The 2018 Dam Angling Season took place from May 1st through October 3rd. River conditions were challenging and harvest was low during the first five weeks of the season (weeks 18-22) as reflected in Figure 7. Harvest did not really start to take off until runoff receded in week 23, and then remained good through week 31. Late season angling was also challenging, as Northern Pikeminnow in large numbers could not be consistently found. Total harvest for The Dalles and John Day dams combined was 4,874 Northern Pikeminnow in 1,900 angling hours, with a combined CPUE of 2.6 fish per angler hour. The Dam Angling crew exceeded the CPUE goal of 2.0 fish/angler hour (for the first time during the 2018 season) in week 23, and remained above it through week 31 during the 2018 season (Figure 8). Per our DAS protocol (Dunlap et al. 2012), weeks with CPUE under the 2.0 fish/angler hour goal were typically due to the Dam Angling crew deploying only a partial crew (< 50% effort) and "prospecting", to locate and/or determine if catchable numbers of fish were present and/or available.

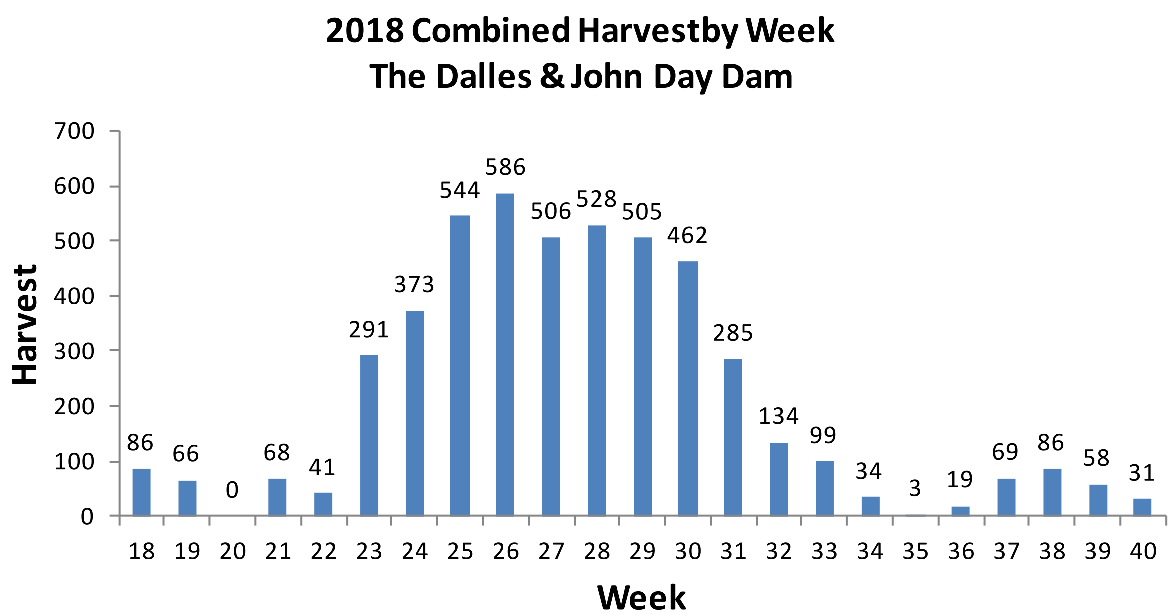

Figure 7. 2018 Weekly Harvest of The Dalles (TD) and John Day (JD) Dams Combined

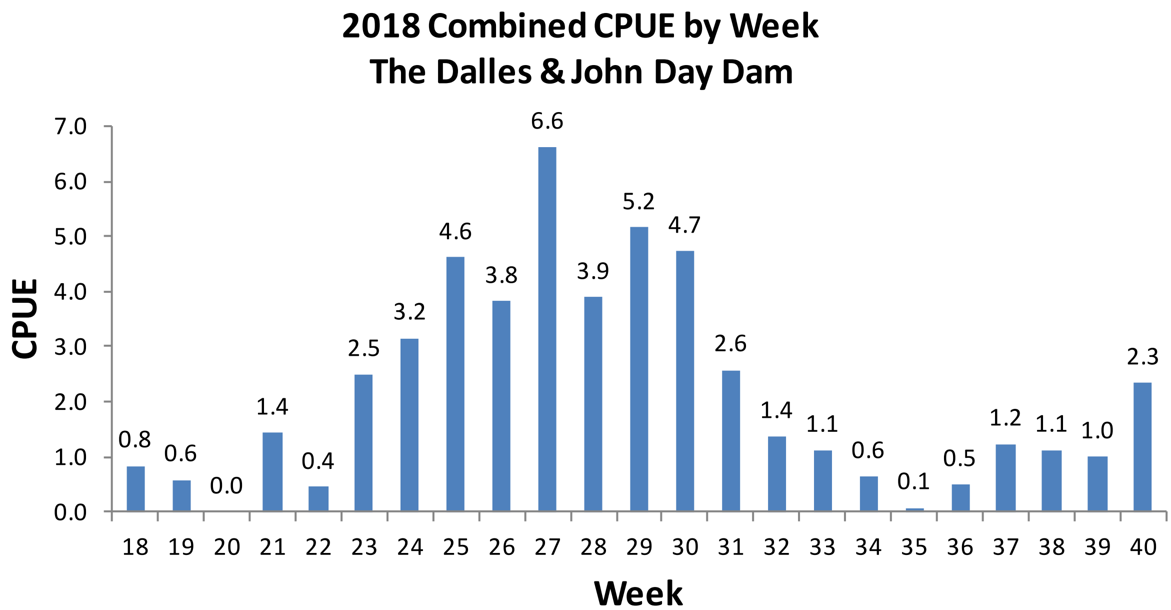

Figure 8. 2018 Weekly CPUE (fish/angler hour) of The Dalles (TD) and John Day (JD) Dams Combined

Angling Gear and Technique

The 2018 Dam Angling crew primarily targeted fishing areas and fishing times at each dam that had been productive in the past (Dunlap et al. 2018). Our top producing lure in 2018 was the 3.75" Gitzit tube in Smoke/Black Copper Glitter color soft plastic lure back bounced off the turbine decks, which accounted for 2,069 harvested Northern Pikeminnow. A list of the top 5 most productive soft plastic lures used by the Dam Angling crew in 2018 is presented in Table 1.

Table 1. Top 5 Northern Pikeminnow Lures used by 2018 WDFW Dam Angling Crew

Northern Pikeminnow Lures

Brand/style	Size	Color	# N. Pikeminnow Caught
Canyon/ tube bait	3.75"	Smoke/Black Copper Glitter	2,069
Gitzit/ tube bait	3.50"	Pearl/Black Smoke Purple	1,107
Gitzit/ tube bait	3.50"	Smoke Sparkle	476
Gitzit/ tube bait	3.50"	Smoke/Clear Pink Belly	196
Canyon/ tube bait	2.50"	Smoke/Black Copper Glitter	184

Angling Times

Time of day continued to make a difference in harvest success during the 2018 season. Dam Angler catch data from previous seasons had indicated that morning hours prior to noon were consistently the most productive times for harvesting Northern Pikeminnow (Dunlap et al. 2018). Results for the 2018 season indicated that 66% of the Dam Angler harvest of Northern Pikeminnow occurred prior to noon (Table 2). Evening hours also continued to show some productivity at The Dalles Dam in 2018 (Table 3).

Table 2. Combined 2018 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. – 6:00 a.m.	441	9%
6:00 a.m. – 7:00 a.m.	470	10%
7:00 a.m. – 8:00 a.m.	475	10%
8:00 a.m. – 9:00 a.m.	482	10%
9:00 a.m. – 10:00 a.m.	404	8%
10:00 a.m. – 11:00 a.m.	433	9%
11:00 a.m. – 12:00 p.m.	505	10%
12:00 p.m. – 1:00 p.m.	346	7%
1:00 p.m. – 6:00 p.m.	100	1%
6:00 p.m. – 7:00 p.m.	57	1%
7:00 p.m. – 8:00 p.m.	148	3%
8:00 p.m. – 9:00 p.m.	181	4%
9:00 p.m. – 10:00 p.m.	220	5%
10:00 p.m. – 11:00 p.m.	235	5%
11:00 p.m. – 12:00 a.m.	225	5%
12:00 a.m. – 1:00 a.m.	112	2%
1:00 a.m. – 4:00 a.m.	40	1%

Table 3. 2018 WDFW Dam Angler Hourly Northern Pikeminnow Harvest Comparison (TD vs JD)

	The Dalles Dam		John Day Dam	
Time of day	Harvest	% of Harvest	Harvest	% of Harvest
4:30 a.m. – 6:00 a.m.	161	9%	280	9%
6:00 a.m. – 7:00 a.m.	138	8%	332	11%
7:00 a.m. – 8:00 a.m.	139	8%	336	11%
8:00 a.m. – 9:00 a.m.	143	8%	339	11%
9:00 a.m. – 10:00 a.m.	112	6%	292	9%
10:00 a.m. – 11:00 a.m.	120	7%	313	10%
11:00 a.m. – 12:00 p.m.	112	6%	393	13%
12:00 p.m. – 1:00 p.m.	98	5%	248	8%
1:00 p.m. – 6:00 p.m.	9	1%	91	3%
6:00 p.m. – 7:00 p.m.	0	0%	57	2%
7:00 p.m. – 8:00 p.m.	47	3%	101	3%
8:00 p.m. – 9:00 p.m.	88	5%	93	3%
9:00 p.m. – 10:00 p.m.	148	8%	72	2%
10:00 p.m. – 11:00 p.m.	180	10%	55	2%
11:00 p.m. – 12:00 a.m.	186	10%	39	1%
12:00 a.m. – 1:00 a.m.	87	5%	25	1%
1:00 a.m. – 4:00 a.m.	17	1%	23	1%
Total	1,785	100%	3,089	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 2018. All incidentally caught fish species were released in 2018. Incidental species most often caught were Walleye *Sander vitreus and* Smallmouth Bass *Micropterus dolomieue*. The Dam Angling crew continued to observe 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. 2018 WDFW Dam Angler Incidental Catch by Project

Incidental Catch

Species	The Dalles Dam	John Day Dam
Smallmouth Bass	54	858
Walleye	12	197
Sculpin	13	12
American Shad	48	89
Channel Catfish	0	13
White Sturgeon	1	20
Peamouth	0	8
Yellow Perch	0	2
Sucker	0	4

Tag Recovery

All Northern Pikeminnow harvested by Dam Anglers in 2018 were visually examined for the presence of external spaghetti tags and 100% were individually scanned with PIT tag readers for the presence of PIT tags. Two Northern Pikeminnow retaining both the external ODFW spaghetti tags and ODFW secondary mark PIT tags were recovered by the Dam Angling crew in 2018 (Figure 9), equal to 2017 (Dunlap et al. 2018). In addition, there were a total of 9 Northern Pikeminnow recovered that had lost spaghetti tags, but retained PIT tags (tag-loss) implanted by ODFW as a secondary tag mark as part of ODFW's biological evaluation of the NPMP (Carpenter et al. 2019). This was 4 less tag-loss Northern Pikeminnow recovered than in 2017 (Dunlap et al. 2018). The 2018 Dam Angling crew also recovered 5 PIT tags from juvenile salmonids (all hatchery Chinook) ingested by Northern Pikeminnow at The Dalles and John Day dams (Figure 10). This was one less than the number of ingested recoveries from Northern Pikeminnow in 2017 (Dunlap et al. 2018). The overall occurrence rate for ingested PIT tagged fishes recovered from Northern Pikeminnow caught by Dam Anglers in 2018 was 1:975 Northern Pikeminnow, compared to 1:875 for the Dam Angling crew in 2017 (Dunlap et al. 2018) and 1:6,934 for the 2018 NPSRF (Hone et al. 2019).

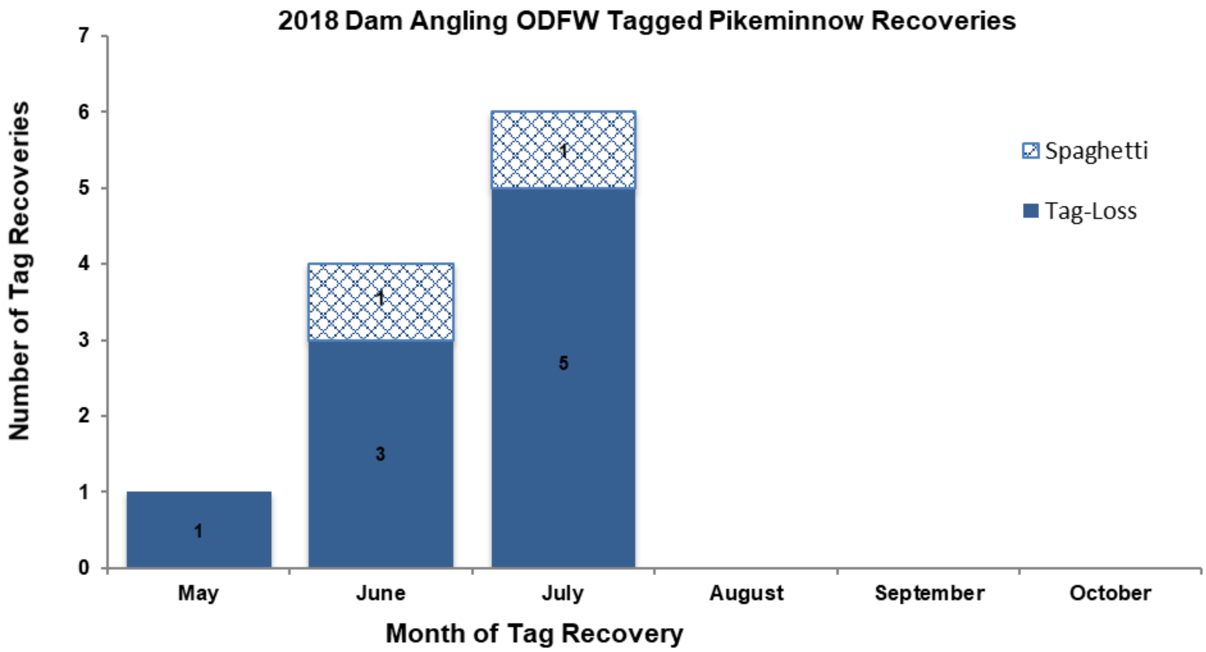

Figure 9. Recoveries of Spaghetti Tag and Tag-Loss Recoveries From the 2018 Dam Angling

Figure 9. Recoveries of Spaghetti Tag and Tag-Loss Recoveries From the 2018 Dam Angling

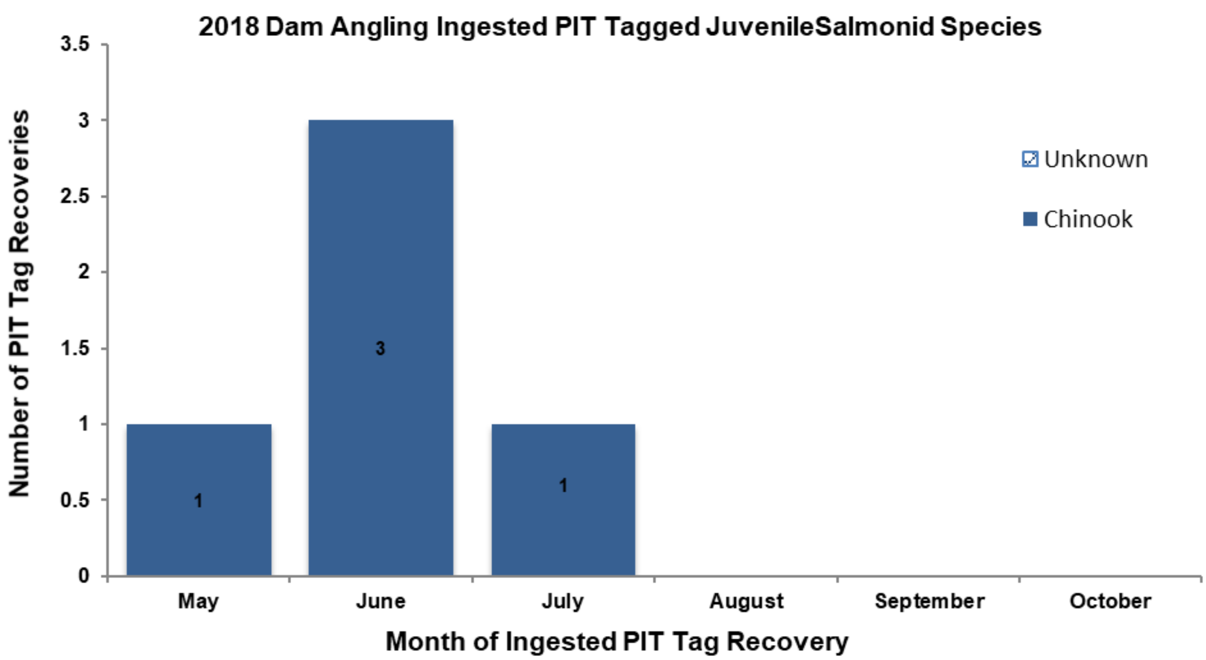

Figure 10. Recoveries of Ingested Salmonid PIT Tags From the 2018 Dam Angling

The Dalles Dam

Harvest

The Dam Angling crew harvested 1,785 Northern Pikeminnow in 20 weeks of Dam Angling at The Dalles Dam in 2018. Weekly harvest for the Dam Angling crew averaged 89 fish per week and ranged from peak harvest of 465 Northern Pikeminnow in week 26 (July 25 – July 1) to 0 fish in week 35 (no effort was spent during weeks 20 and 36) (Figure 11). River outflows during the first 5 weeks of 2018 (Figure 12) were more challenging than in 2017 and as a result, harvest was down during that time (Dunlap et al. 2018). Overall harvest at The Dalles Dam did end up slightly higher than in 2017 (Dunlap et al. 2018) and peak harvest for Dam Angling occurred the same week (26) as the 2018 NPSRF (Hone et al. 2019).

The 1,785 Northern Pikeminnow harvested at The Dalles Dam in 2018 included no spaghetti tagged and four tag-loss Northern Pikeminnow which were from ODFW's biological evaluation of the NPMP. The 2018 Dam Angling crew also recovered two Northern Pikeminnow that had ingested juvenile salmonids containing PIT tags.

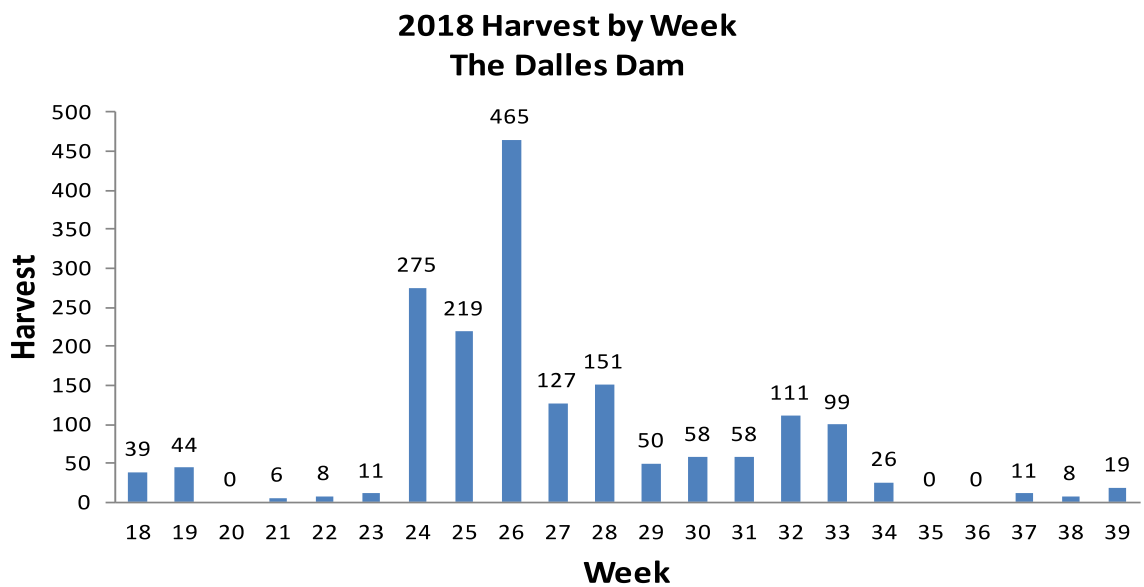

Figure 11. 2018 Weekly Dam Angler Harvest of Northern Pikeminnow at The Dalles Dam

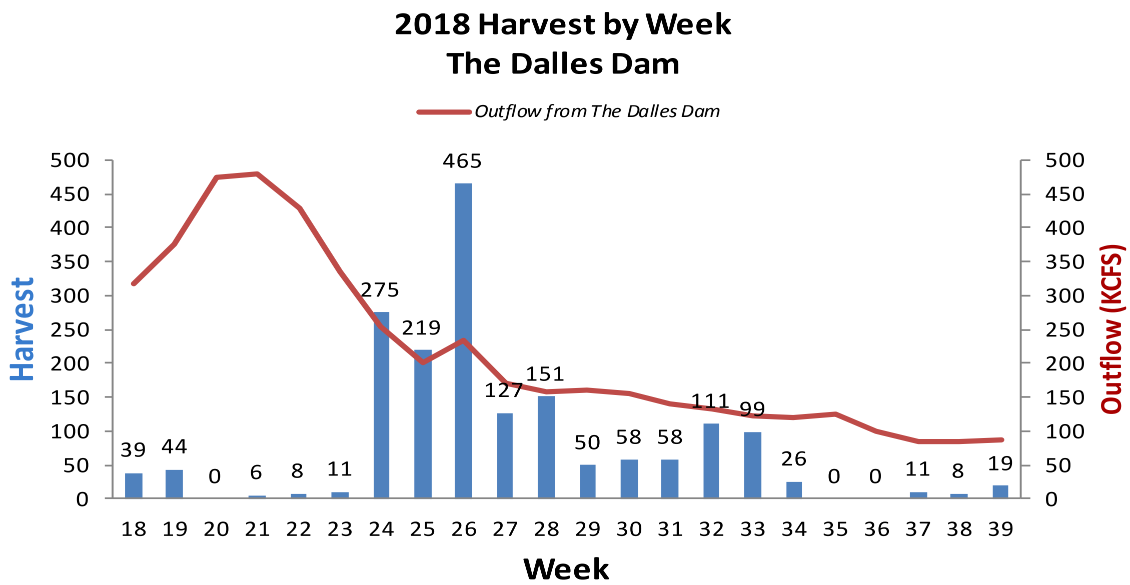

Figure 12. 2018 Weekly Northern Pikeminnow Harvest Compared to Outflow

As was the case in past Dam Angling seasons, certain areas and/or turbines at The Dalles Dam were better producers in 2018. The angling areas between Turbine #7 (T7) and Turbine #14 (T4) accounted for 47% of total harvest at The Dalles Dam in 2018, down from 61% in 2017 (Dunlap et al. 2018) (Figure 13). The Fishway (F) and Turbine 1 (T) were the two best angling locations accounting for 32% of total harvest. Due to USACE safety concerns the 2018 Dam Angling crew was advised to not fish the rock shore above the ice trash sluiceway. Historically this area contributes 25% of the overall Northern Pikeminnow harvest for The Dalles Dam (Dunlap et al. 2018).

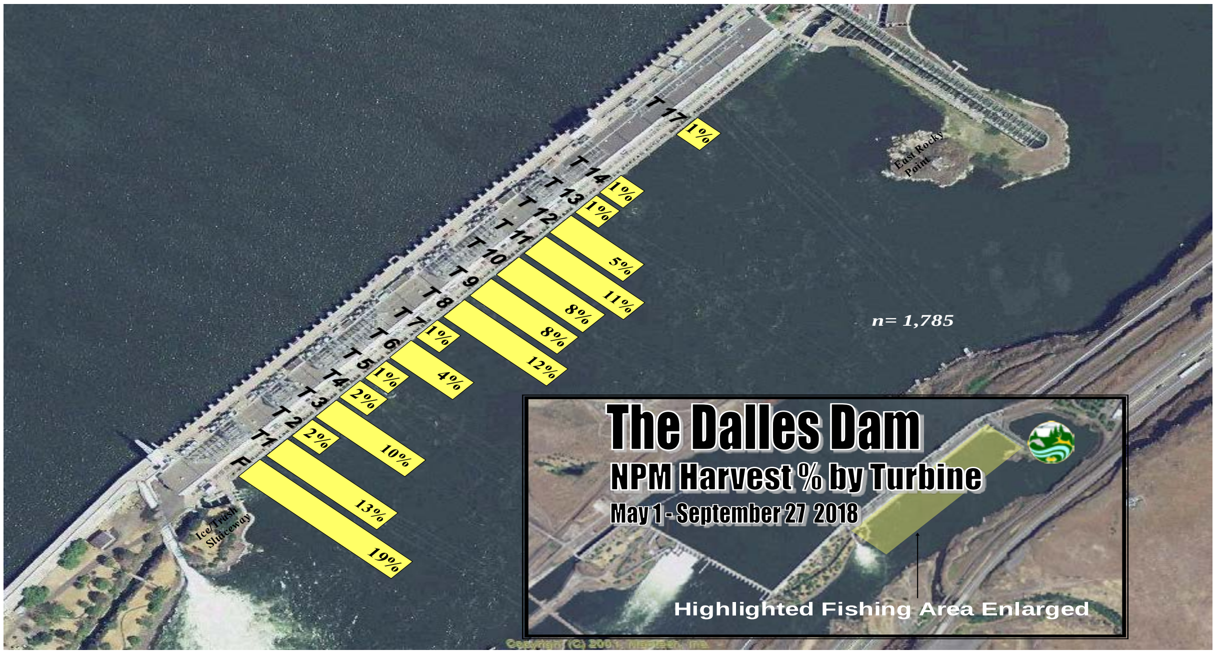

Figure 13. 2018 Overall Percent of Northern Pikeminnow Harvest by Area (T=turbine #, F = fishway)

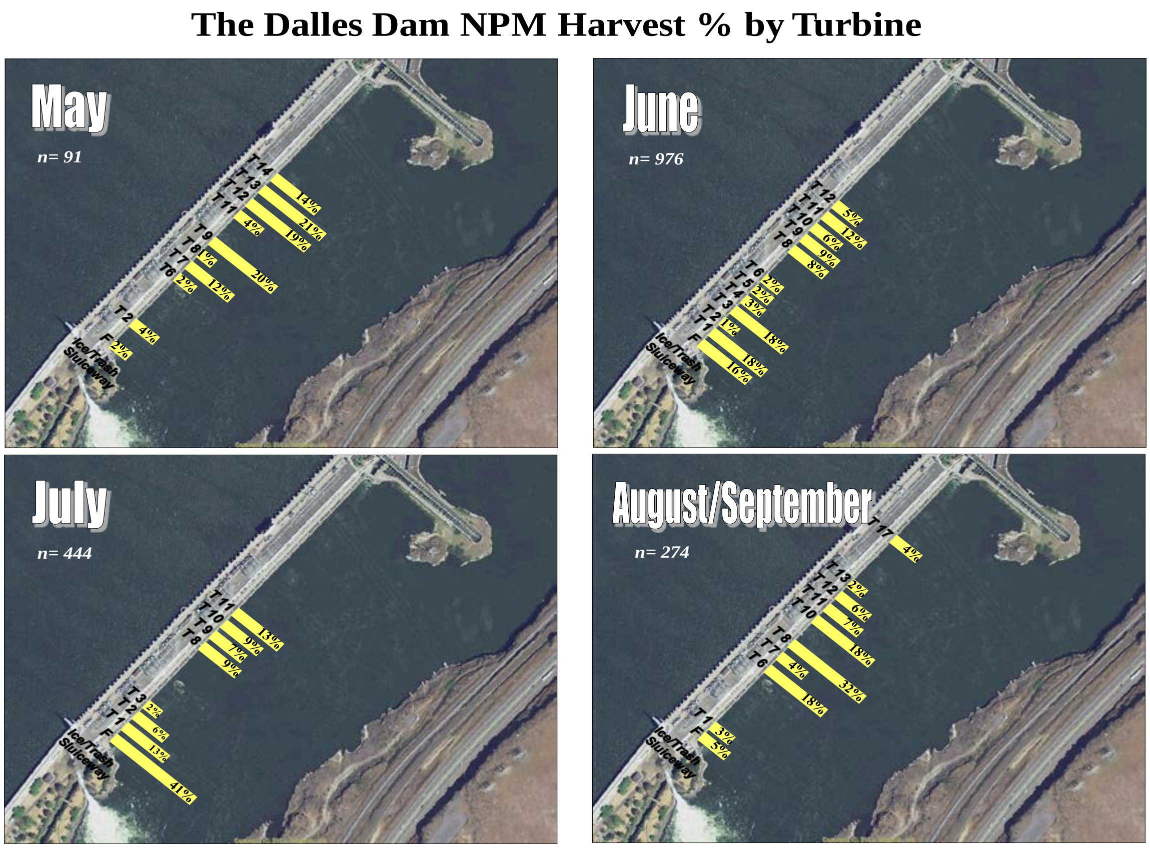

Figure 14. 2018 Monthly Harvest Percent (*rounded) by Area at The Dalles Dam (T=turbine#, F = fishway)

When we look at Northern Pikeminnow harvest at The Dalles Dam over the course of the 2018 Dam Angling season, our harvest data showed some variation in best harvest areas during the May-September Dam Angling season (Figure 14). In general, 2018 data shows the highest concentrations of Northern Pikeminnow were harvested near the ice/trash sluiceway in June and July, then more scattered harvest during the rest of the season.

Incidental Catch

While the Dam Angling crew did not target fish species other than Northern Pikeminnow in their angling activities during 2018, they did catch 54 Smallmouth Bass and 12 Walleye at The Dalles Dam in 2018 (Figure 15). The 12 Walleye caught in 2018 is much less than the 66 Walleye caught in 2017 and 55 Walleye caught in 2016 (Figure 15). Part of the reason that the Walleye catch was down was because USACE asked the Dam Angling crew not to fish the area between the Fishway and the Ice Trash Sluice Way due to safety concerns. Four of the 12 Walleye caught by Dam Anglers in 2018 were caught from the Fishway (Figure 16) and historically over 50% of all non-native predators (Smallmouth Bass and Walleye) are caught by the Dam Angling crew in the closed area between the Fishway and the Ice Trash Sluice Way (Dunlap et al. 2018). All Smallmouth Bass and Walleye were scanned for PIT tags and released, but no PIT tags from ingested salmonids were recovered from these fish at The Dalles Dam in 2018.

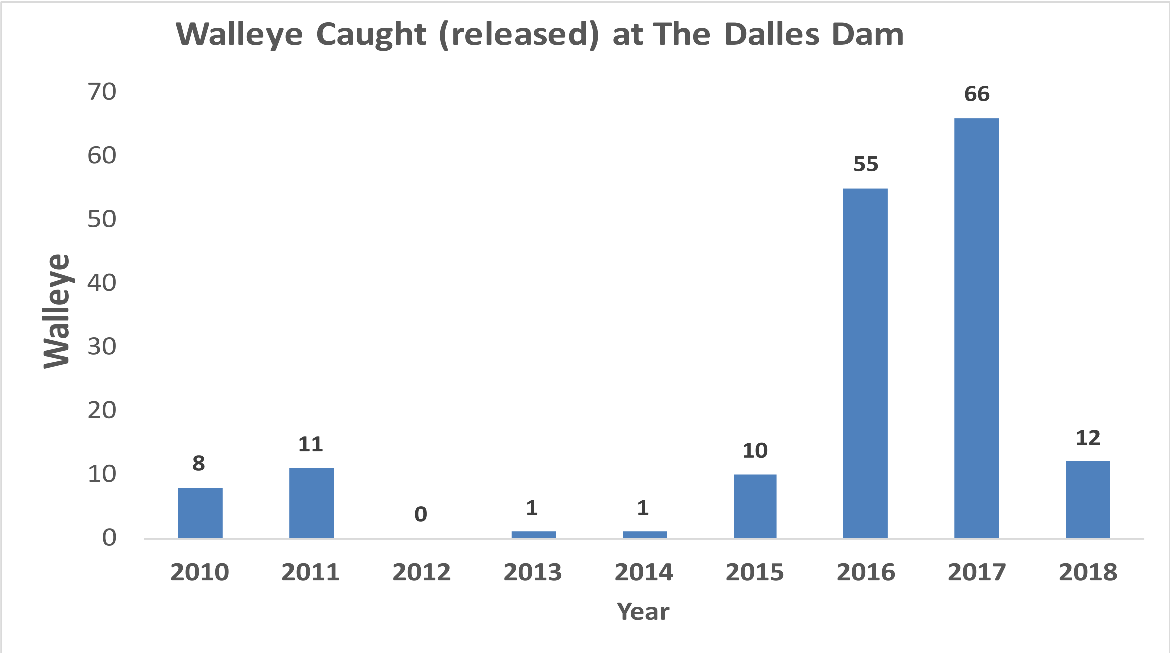

Figure 15. 2018 Annual Dam Angler Catch of Walleye at The Dalles Dam

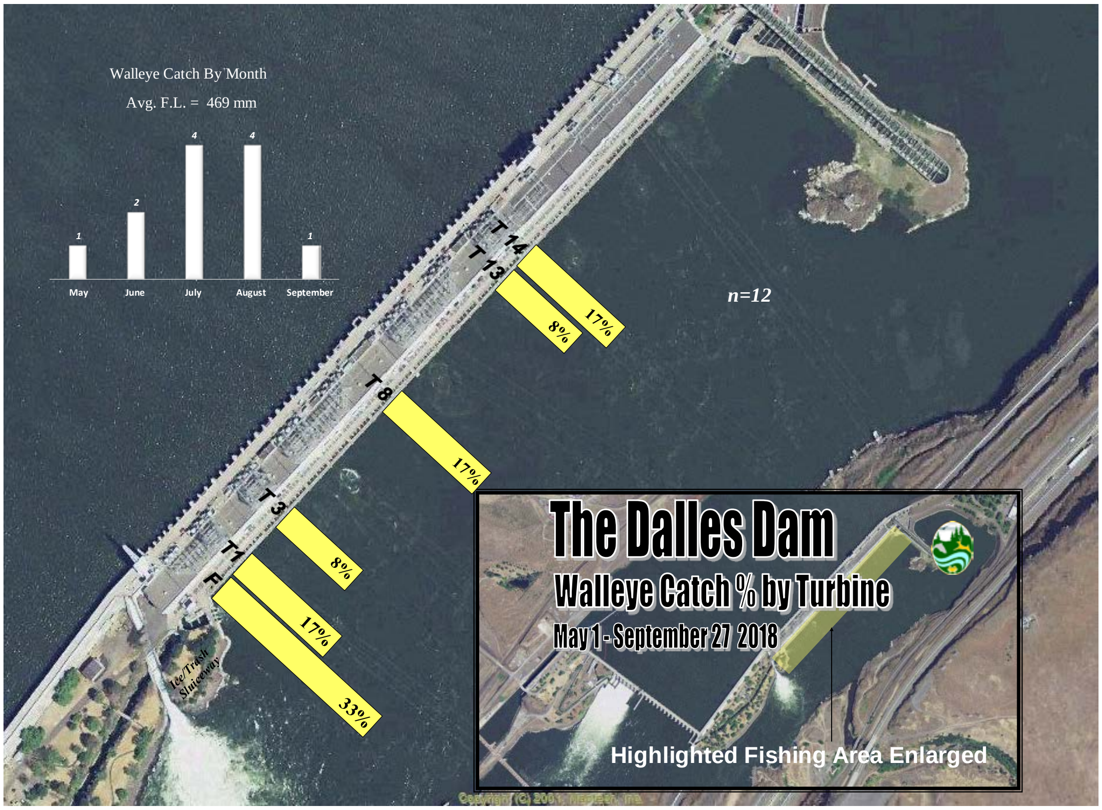

Figure 16. 2018 Incidental Catch of Walleye (*rounded) by Dam Angling Crew at The Dalles Dam

Effort

Total angler hours of effort at The Dalles Dam decreased to 700.8 hours in 2018 from 778.5 hours in the 2017 Dam Angling season (Dunlap et al. 2018). The Dam Angling crew fished 62 days at The Dalles Dam over 20 weeks and spent 37% of total Dam Angling effort at The Dalles Dam in 2018.

CPUE

The Dam Angling crew harvested 1,785 Northern Pikeminnow in 700.8 angler hours at The Dalles Dam in 2018 for an overall average CPUE of 2.5 fish/angler hour, up from 2.3 in 2017 (Dunlap et al. 2018). Peak weekly CPUE at The Dalles Dam occurred during week 29 (Figure 17). Challenging river conditions early and late in the 2018 season resulted in overall CPUE at The Dalles Dam exceeding the 2.0 fish/angler hour goal for only 10 of the 20 weeks fished (no effort was spent in weeks 20 & 36).

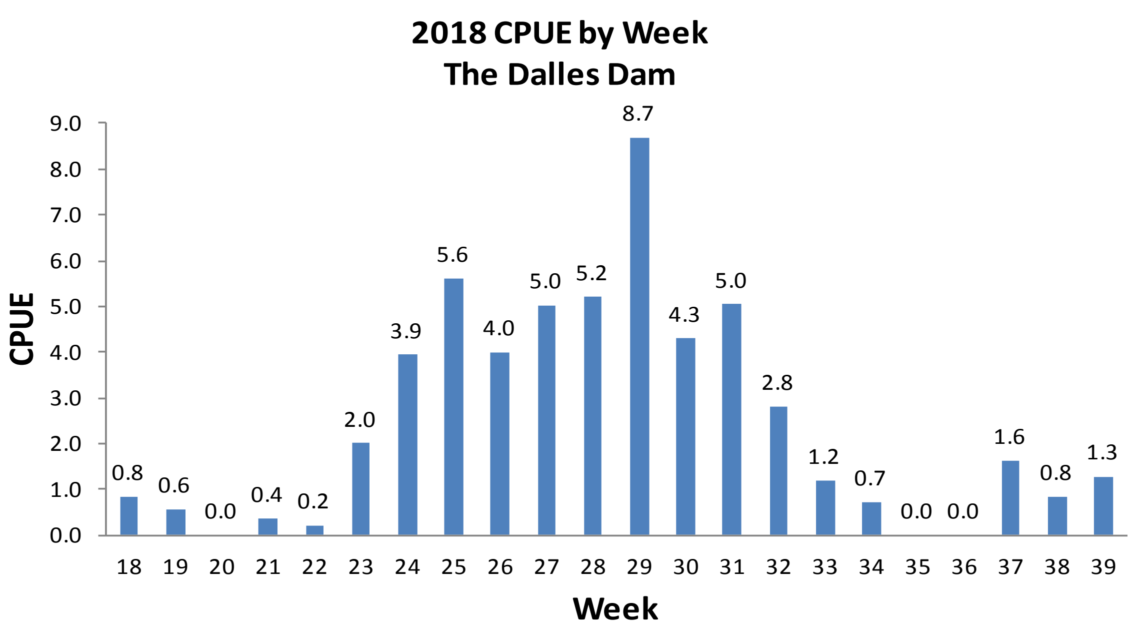

Figure 17. 2018 Weekly Dam Angler CPUE at The Dalles Dam

Fork Length Data

Fork lengths were recorded from 1,785 (100%) Northern Pikeminnow harvested by the Dam Angling crew at The Dalles Dam during the 2018 Season. The length frequency distribution of Northern Pikeminnow harvested at The Dalles Dam in 2018 is presented in Figure 18. Mean fork length for Northern Pikeminnow caught by the Dam Angling crew at The Dalles Dam in 2018 was 355 mm (SD=52.1), up from 332 mm in 2017 (Dunlap et al. 2018). By comparison, the mean fork length for the 2018 NPSRF was 272.6 (Hone et al. 2019).

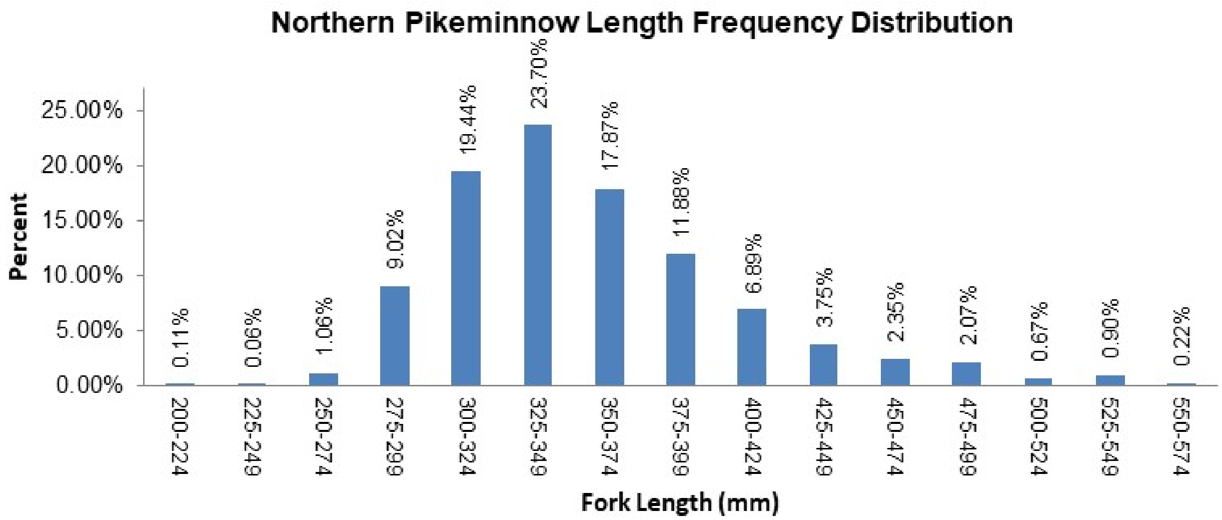

Figure 18. Northern Pikeminnow Length Frequency Distribution at The Dalles Dam in 2018

John Day Dam

Harvest

The Dam Angling crew harvested 3,089 Northern Pikeminnow over 22 weeks at the John Day Dam in 2018. Weekly harvest averaged 140 fish per week and ranged from zero fish in weeks 33 to a peak of 455 in week 32 (July 16 – July 22) (Figure 19). Peak weekly harvest at the John Day Dam occurred in week 29 which was one week earlier than in 2017 (Dunlap et al. 2018) and 4 weeks later than the week 26 peak for the 2018 Sport Reward Fishery (Hone et al. 2019). The 3,089 harvested Northern Pikeminnow included two spaghetti tagged and 5 tag-loss Northern Pikeminnow which were part of ODFW's biological evaluation of the NPMP (Carpenter et al. 2019). We also recovered three PIT tags from juvenile salmonids ingested by a Northern Pikeminnow at the John Day Dam in 2018.

Average outflows at the John Day Dam during the best harvest weeks of 2018 (weeks 27-30) was 175 kcfs (Figure 20).

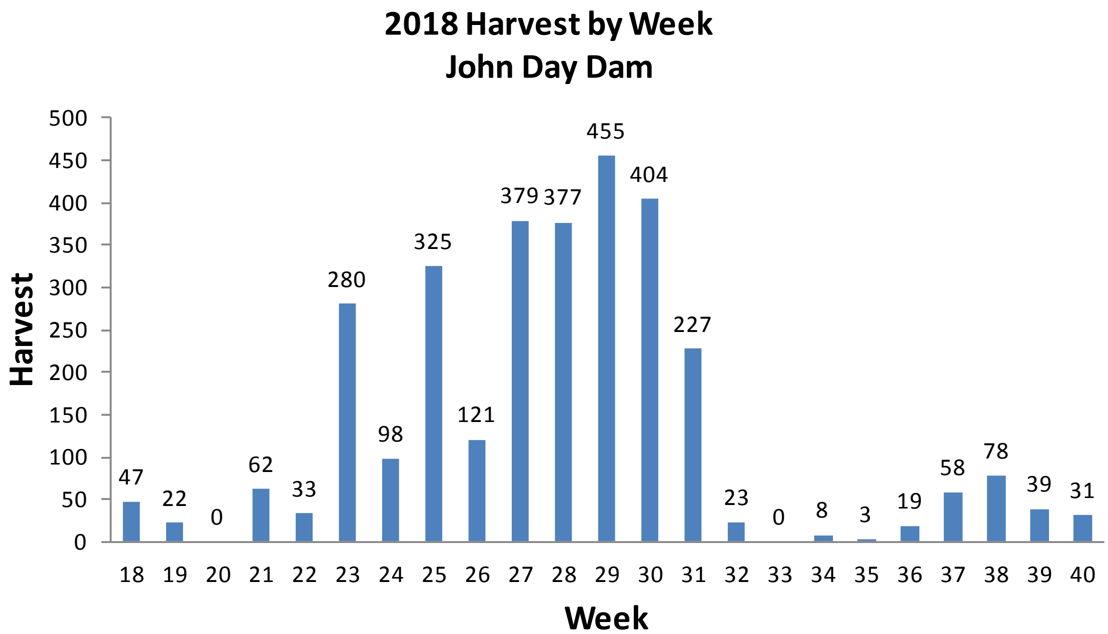

Figure 19. 2018 Weekly Dam Angler Harvest of Northern Pikeminnow at the John Day Dam

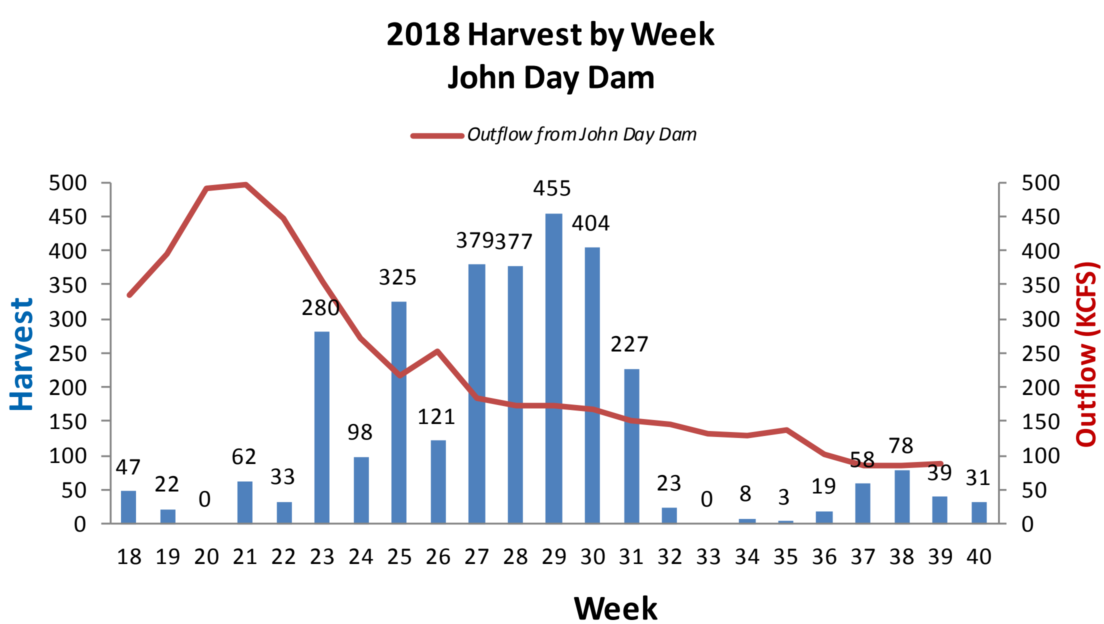

Figure 20. 2018 Weekly Dam Angler Harvest of Northern Pikeminnow at the John Day Dam vs Outflow

Certain turbines at the John Day Dam created water flow conditions that were more favorable for harvesting Northern Pikeminnow than others (Dunlap et al. 2018). Turbine #8 (T8) was the single best producing area at the John Day Dam in 2018 accounting for 28% of the total Northern Pikeminnow harvest (Figure 21). Harvest of Northern Pikeminnow peaked during July and was best at T8 (Figure 22).

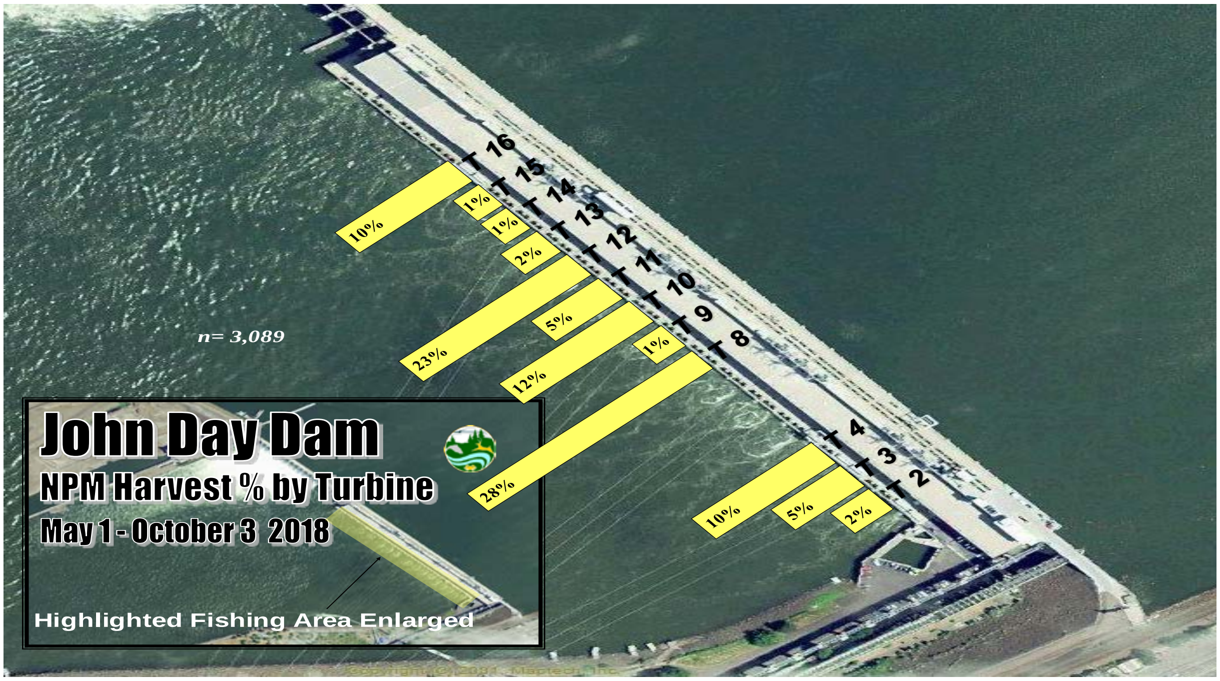

Figure 21. 2018 Overall Percent of Northern Pikeminnow Harvest by Area (T=turbine#)

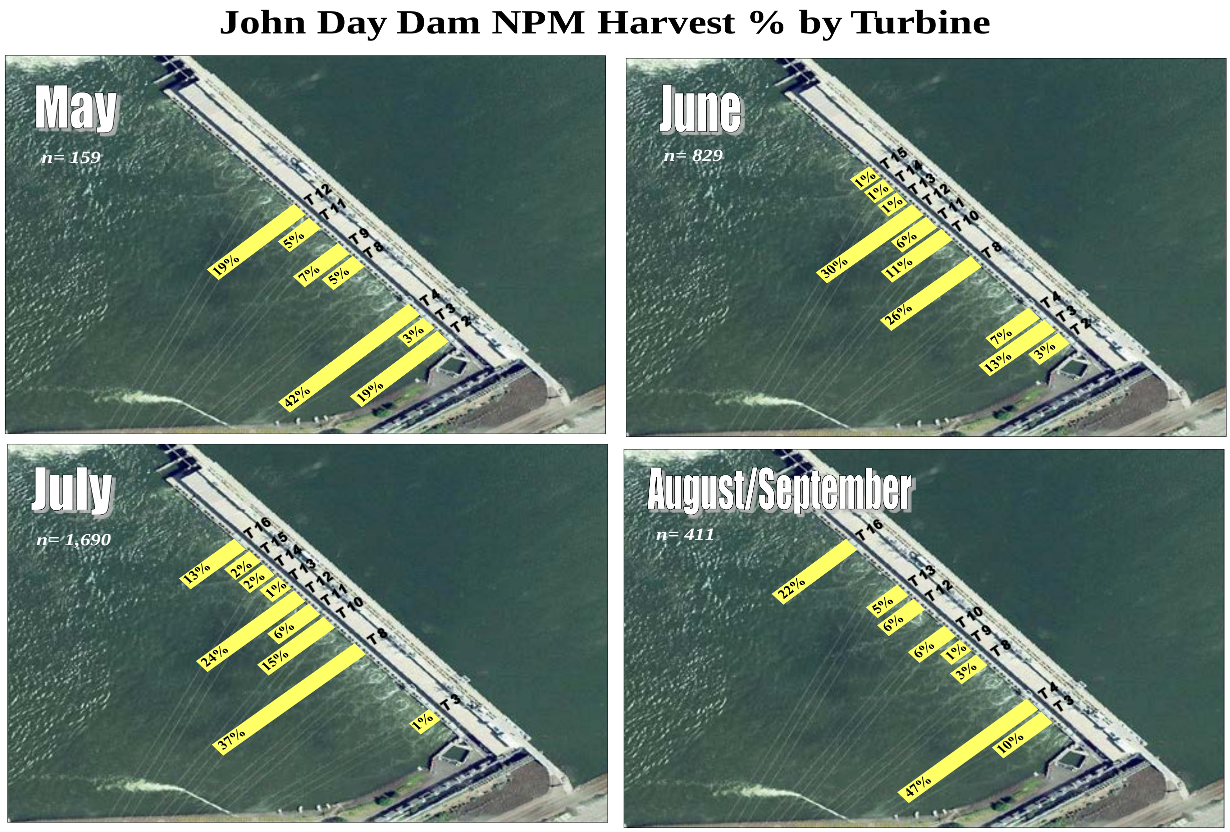

Figure 22. 2018 Monthly Percent (*rounded) of Northern Pikeminnow Harvest by Area (T=turbine#)

Incidental Catch

The Dam Angling crew did not target fish species other than Northern Pikeminnow in their angling activities, but they did catch, scan and release 197 Walleye at the John Day Dam in 2018. (Figure 23). Of the 197 Walleye caught by Dam Anglers at John Day, there was one positive PIT tag recovery from an ingested juvenile salmonid. Through PTAGIS queries, we were able to determine that this PIT tags was from a Hatchery Fall Chinook. The Dam Angling crew also caught and released 858 Smallmouth Bass (smb) at the John Day Dam in 2018.

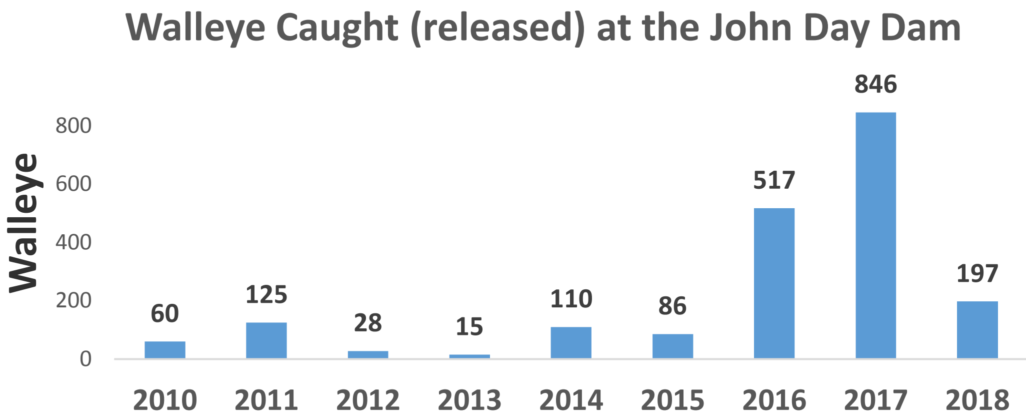

Figure 23. 2018 Annual Dam Angler Catch of Walleye at the John Day Dam

Effort

Total effort at the John Day Dam was 1,199.25 angler hours in 2018, up from 1,042.50 hours in 2017 (Dunlap et al. 2018). The crew averaged a combined 54.5 angler hours of effort per week and 16 angler hours of effort per day at the John Day Dam in 2018. The Dam Angling crew spent 63% of total Dam Angling effort (75 days over 22 weeks) at the John Day Dam in 2018.

CPUE

The Dam Angling crew harvested 3,089 Northern Pikeminnow in 1,199.25 angler hours at the John Day Dam in 2018 for an overall average CPUE of 2.6 fish/angler hour, down from 3.3 in 2017 (Dunlap et al. 2018). Peak weekly CPUE at the John Day Dam occurred during week 27 (Figure 24), 2 weeks earlier than at The Dalles Dam. The Dam Angling crew met or exceeded the overall CPUE goal of 2.0 fish/angler hour at the John Day Dam for 11 of the 22 weeks fished.

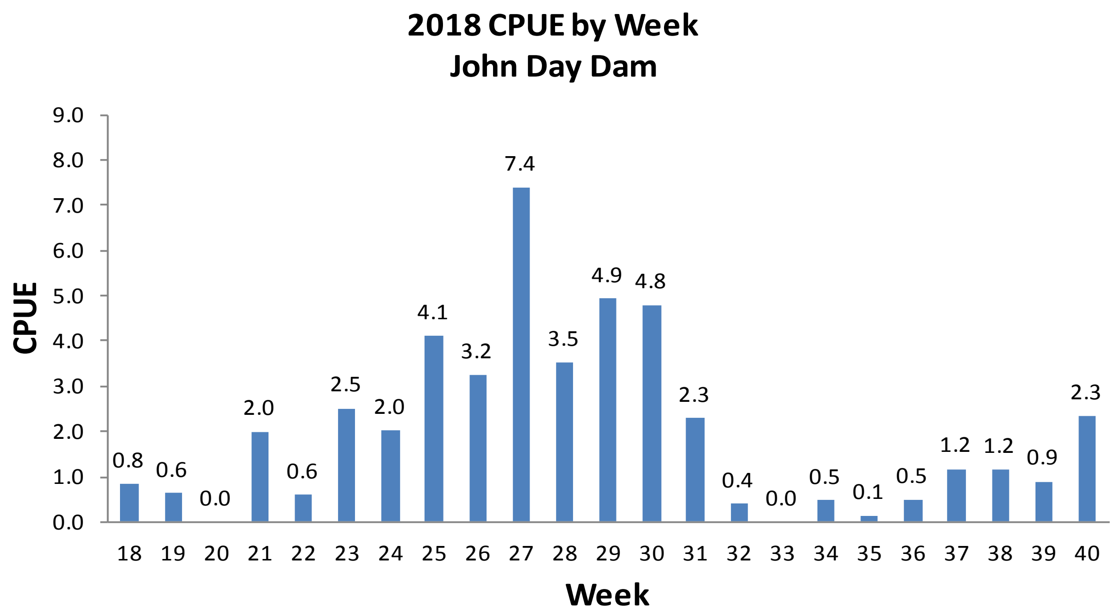

Figure 24. 2018 Weekly Dam Angling CPUE at John Day Dam

Fork Length Data

Fork lengths were recorded from 3,089 Northern Pikeminnow (100% of harvest) at the John Day Dam during the 2018 Dam Angling Season. The length frequency distribution of harvested Northern Pikeminnow from the John Day Dam in 2018 is presented in Figure 25. Mean fork length for Northern Pikeminnow from the John Day Dam in 2018 was 373 mm (SD=59.6) compared to 362 mm in 2017 (Dunlap et al. 2018). By comparison, the mean fork length for the 2018 NPSRF was 272.6 mm (Hone et al. 2019).

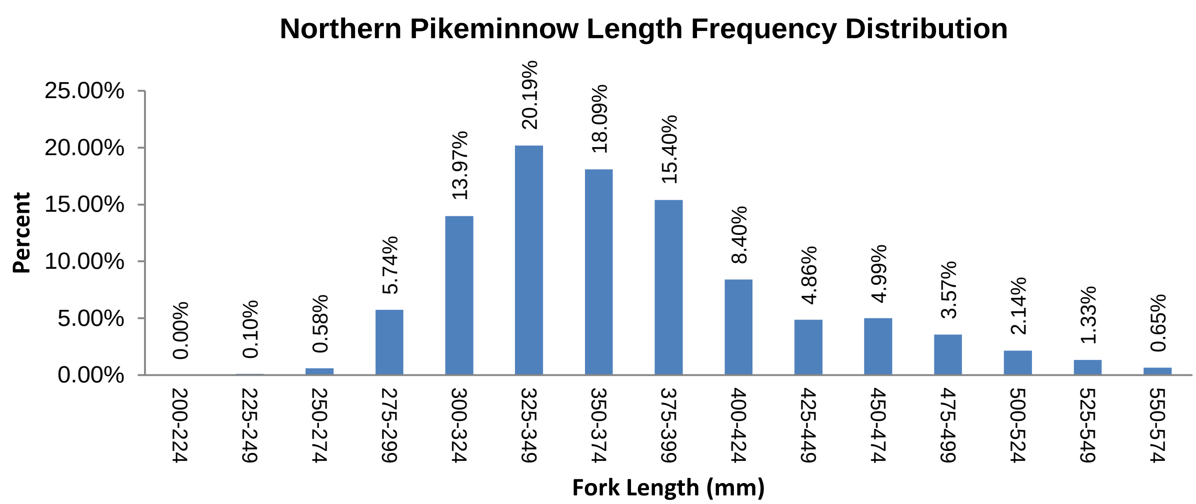

Figure 25. Northern Pikeminnow Length Frequency Distribution at the John Day Dam in 2018

SUMMARY

The 2018 Dam Angling crew harvested 4,874 Northern Pikeminnow at The Dalles and John Day Dams, with 1,785 coming from The Dalles Dam and 3,089 from the John Day Dam. Overall harvest was lower than 2017 although up at The Dalles Dam in 2018 (Dunlap et al. 2018). Dam Angling was conducted over the course of 23 weeks between May 1st and October 3rd 2018 although no Dam Angling effort took place during week 20.

During the 2018 season, the Dam Angling crew spent more than half their time fishing at the John Day Dam (63%) and exceeded the 2.0 CPUE goal for 11 weeks of the 22 week Dam Angling season. Angling hours prior to 1:00 pm were the most productive times and the top producing lure for 2018 was the 3.75” Gitzit tube in Smoke/Black Copper Glitter color.

Fork length data for Northern Pikeminnow harvested by the 2018 Dam Angling crew continued to show that Northern Pikeminnow harvested by Dam Anglers at both The Dalles and John Day dams were considerably larger than the mean fork length of Northern Pikeminnow harvested in the NPSRF (355 mm at The Dalles Dam and 373 mm at the John Day Dam compared to 272.6 mm in the 2018 NPSRF (Hone et al. 2019). The 2018 Dam Angling crew recovered two spaghetti tagged Northern Pikeminnow, nine tag-loss Northern Pikeminnow, and five PIT tags from fishes ingested by Northern Pikeminnow. The overall occurrence rate for ingested PIT tags from Northern Pikeminnow caught by the 2018 Dam Angling crew was 1:975. There was also one PIT tag recovered from a juvenile salmonid that had been ingested by a Walleye incidentally caught by the Dam Angling crew at the John Day Dam.

While targeting only Northern Pikeminnow, the 2018 Dam Angling crew incidentally caught a total of 912 Smallmouth Bass, 209 Walleye, 137 American Shad, 25 Sculpin, and 13 Channel Catfish between the two projects.

RECOMMENDATIONS FOR 2019

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 2019 Dam Angling activities to conduct the standard May-September Dam Angling season.

3.) Continue to utilize the DAS protocol developed in 2011 (using CPUE) to allocate Dam Angler effort and 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 2019.

5.) Continue using HPR PIT tag scanners for scanning all incidentally caught fishes.

6.) Continue to investigate and further develop Northern Pikeminnow angling techniques in 2019 that will improve Dam Angler CPUE and/or allow exploitation of Northern Pikeminnow in areas not currently fishable.

7.) Investigate the feasibility of recording data and retaining carcasses of non-native predator fishes as done with other Columbia River research projects.

8.) 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
Top 5 lures used by 2018 Dam Angler