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

2022 ANNUAL REPORT
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2022 Executive Summary
by

Allan Martin

This report presents results for year thirty-two in the basin-wide Northern Pikeminnow Sport Reward Program (NPMSRP), designed to harvest Northern Pikeminnow[1] (Ptychocheilus oregonensis) in the Columbia and Snake Rivers. The season started May 1 and ended September 30. During the five-month season, anglers earned tier rewards at the new rate of $6 each for the first 25 qualifying northern pikeminnow vouchered, $8 each for 26-200 fish and $10 each for 201 fish and greater. The development of an online registration application is ongoing and is now planned to go live for use during the 2023 season.

Prior to 2022, Oregon Department of Fish and Wildlife's (ODFW) tagging for biological evaluation involved both an external tag and an internal PIT tag. In an effort to reduce handling and post-tagging mortality, ODFW began a PIT tag only protocol for biological assessment of the fishery in 2022. During the season, Program partners decided to continue tagging some of the northern pikeminnow population with external tags for promotional purposes. This promotion only tagging was accomplished by Washington Department of Fish and Wildlife (WDFW) on an opportunistic basis.

The second annual Adaptive Management Committee meeting was held June 9. One of the topics discussed was the need to prioritize responding to the 2019 Independent Scientific Review Panel (ISRP) recommendations. The other priority identified was to begin implementing strategies to reduce take on ESA listed species during biological evaluation of the program per the 2020 CRS Bi-Op terms. A one-year contract was developed, utilizing savings within the Sport Reward Fund, to address these priorities with deliverables for both due by August 31, 2023.

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 accounted for a high percentage of mortality that juvenile salmonids experienced 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

[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.*

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 response in 1994. Results of these and other lessons learned over the 32-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

2022 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 the Giles French, Windust, Swallows parks, and the Greenbelt Boat Ramp; the Washington Department of Transportation for the use of the Vernita Bridge Rest Area; and Mike and Monica Omstead for the use of Boyer Park.

We appreciate the efforts of Joe Xiong, Ryan Chen, Michaela Davis, Ryan Grady, Janessa Cimfl, Rebecca Olsen-Missildine, Amber Santangelo, Brittney Salter, Emily Splitgerber, Robert Cornell, Anna Klundt, Leif Fox, Kyle Beckley, Eric Meyer, Nick Makiney, Garrett Morrison, Cassie Borcher, Jason Rictor, Marissa Zoubek, Breanne Rea, Mark Flahaut, William “Wick” Bouton, and John Paul Viviano for operating the 2022 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 Vert for her numerous phone survey interviews, and Dennis Werlau for producing our weekly field activity reports throughout the 2022 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, 2022. The objectives of this project were to (1) implement a recreational fishery that rewards recreational anglers for harvesting Northern Pikeminnow $\geq$ 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 140,121 Northern Pikeminnow $\geq$ 228 mm fork length (FL) and 2,948 Northern Pikeminnow < 228 mm FL were harvested during the 2022 NPSRF season. There were a total of 1,175 different individual anglers who spent 10,561 angler days of effort participating in the NPSRF during the 2022 season. Catch per unit effort for combined returning and non-returning anglers was 13.27 fish/angler day. The Oregon Department of Fish and Wildlife (ODFW) estimated that the Northern Pikeminnow harvest activities from the 2022 NPSRF resulted in an overall exploitation rate of 14.9% (Waltz et al. 2023).

Anglers submitted 37 Northern Pikeminnow with external spaghetti or Floy tags, all but one these had an internal ODFW PIT tag. There were also 140 Northern Pikeminnow with ODFW PIT tags, but missing spaghetti or Floy tags (tag-loss). Additionally, 23 PIT tags from ingested juvenile salmonids were recovered from Northern Pikeminnow received during the 2022 NPSRF.

Peamouth *Mylocheilus caurinus*, Smallmouth Bass *Micropteris dolomieui*, and Sculpin *Cottoidea Spp*, were the fish species most frequently caught by NPSRF anglers targeting Northern Pikeminnow. The incidental catch of salmonids *Oncorhynchus* spp, by participating anglers targeting Northern Pikeminnow continued to remain below established limits for the Northern Pikeminnow Management Program (NPMP).

INTRODUCTION

Mortality of juvenile salmonids *Oncorhynchus* spp. migrating through the Columbia River system is a major concern of the Columbia Basin Fish and Wildlife Program, and predation is an important component of mortality (Northwest Power Planning Council 1987a). Northern Pikeminnow *Ptychocheilus oregonensis*, formerly known as Northern Squawfish (Nelson et al. 1998), are the primary piscine predator of juvenile salmonids in the Lower Columbia and Snake River Systems (Rieman et al. 1991). Rieman and Beamesderfer (1990) predicted that predation on juvenile salmonids could be reduced by up to 50% with a sustained exploitation rate of 10-20% on Northern Pikeminnow > 275 mm FL (11 inches total length). The Northern Pikeminnow Management Program (NPMP) was created in 1990, with the goal of implementing fisheries to achieve the recommended 10-20% annual exploitation on Northern Pikeminnow >275 mm FL within the program area (Vigg and Burley 1989). In 2000, NPMP administrators reduced the minimum size for eligible (reward size) Northern Pikeminnow to 228 mm FL (9 inches total length) in response to recommendations contained in a 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 ($\geq$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 5.4 million reward sized Northern Pikeminnow and spent over 990,000 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 persistent declines in angler participation related to the effects of the Covid-19 pandemic of 2020-21, 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 once again modified prior to the 2022 season (Winther et al. 2022). Reward changes raised the base reward to $6 per fish for the first 25, $8 per fish for #26-200, and $10 per fish for each fish above 200. Anglers continued to be rewarded an additional amount for returning Northern Pikeminnow with external tags (spaghetti or Floy type by ODFW or Promotional by WDFW) and a lesser amount for fish with only PIT tags installed by the Oregon Department of Fish and Wildlife (ODFW) as part of the NPMP'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 2022 NPSRF were to (1) implement a public fishery that rewards recreational anglers for harvesting Northern Pikeminnow $\geq$ 228 mm (9 inches) total length, (2) collect, compile, and report data on angler participation, catch 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 2022 NPSRF season opened on May 1st and 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 as done since 1991 (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.

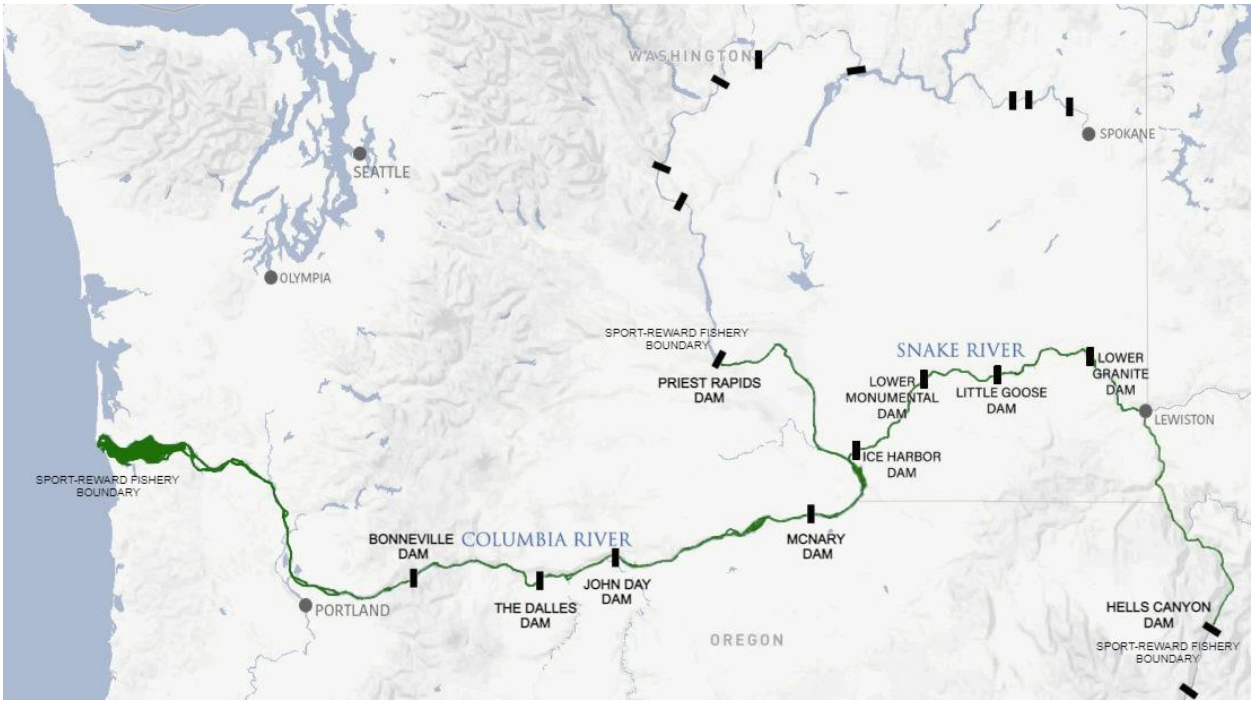


Figure 1. Northern Pikeminnow Sport-Reward Fishery Program Area

Registration Stations

Twenty 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 1.5 and 3.5 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 10:30 am -1:30 pm
2. Willow Grove 2:00 pm - 4:00 pm
3. Rainier Marina 8:00 am -9:30 am
4. Kalama Marina 3:00 pm - 4:30 pm
5. Ridgefield Marina 7:30 am - 9:30 am
6. Gleason Boat Ramp 12:30 pm - 2:00 pm
7. Chinook Land 10:15 am - 12:00 pm
8. Washougal 1:00 pm - 4:00 pm
9. Cascade Locks 8:00 am - 9:30 am
10. Stevenson 10:30 am - 12:00 pm
11. Bingen 8:30 - 10:00 am
12. The Dalles 1:00 pm - 4:30 pm
13. Giles French 11:00 am - 12:30 pm
14. Umatilla 9:30 am - 11:30 am
15. Columbia Point 12:30 pm - 3:00 pm
16. Vernita 4:00 pm - 5:30 pm (8/1-9/30)
17. Windust 4:00 pm - 5:30 pm (5/1-7/31)
18. Boyer Park 12:30 pm - 3:30 pm
19. Greenbelt 9:30 am - 11:00 am
20. Swallow's Park 5:00 pm - 6:30 pm

Figure 2. 2022 Northern Pikeminnow Sport-Reward Fishery registration stations and hours of operation

Reward System

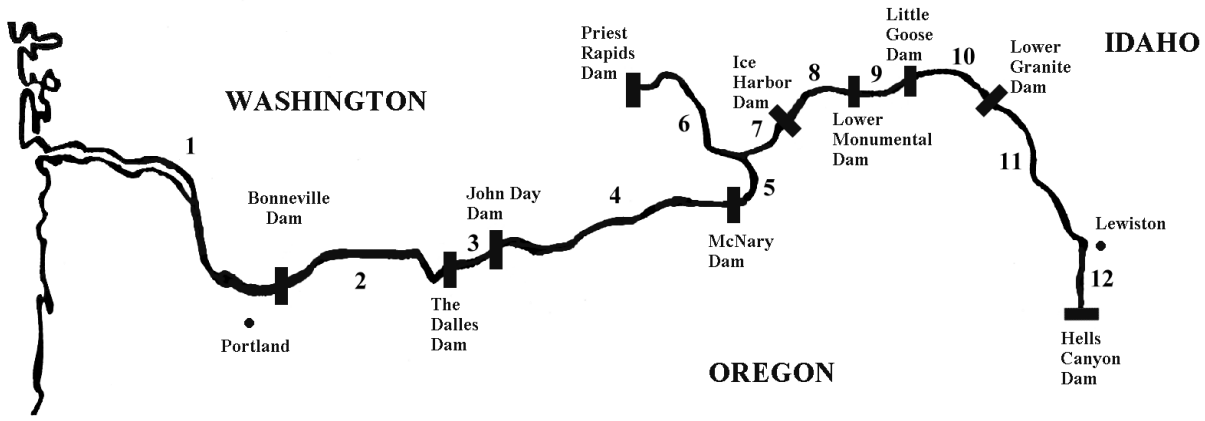
The 2022 NPSRF rewarded anglers for harvesting Northern Pikeminnow ≥ 228mm TL (9 inches TL) using a tiered reward system first implemented in 1995 (Hisata et al. 1996), which paid anglers a higher reward per fish once they had reached designated harvest levels over the course of the season. To receive 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 2022 season was originally developed and implemented in 1995 (Hisata et al. 1996), and reflects multiple changes to the rewards and/or tier levels in an effort to address periods of declining participation. The tiered reward system paid anglers higher rewards per fish based on achieving designated harvest levels. Tier 1 paid anglers $6 each for their first 25 Northern Pikeminnow, Tier 2 paid anglers $8 each for fish numbers 26-200, and Tier 3 paid anglers $10 each for all fish over 200.
Although ODFW discontinued externally tagging Northern Pikeminnow in 2022, anglers continued to be paid $500 for each Northern Pikeminnow retaining a valid external tag (spaghetti or Floy) used by ODFW for the biological evaluation of the NPMP (prior to 2022), or done by WDFW as a new promotional activity in 2022. NPSRF anglers were paid $200 for each

Northern Pikeminnow without an external tag, but retaining an ODFW PIT tag (formerly tag-loss) since no external tags were used by ODFW in 2022.

Angler Sampling

Angler data and creel data for the NPSRF were compiled from angler registration forms. One registration form represented one angler day. Angler data consisted of name, date, fishing license number, phone number, and city, state, zip code of participating angler. Creel data recorded by WDFW technicians included fishing location (Figure 3), and primary species targeted. Anglers were asked if they specifically fished for Northern Pikeminnow at any time during their fishing trip. A "No" response ended the exit interview. A "Yes" response prompted technicians to ask the angler (and record data), how many of each species of fish were caught, harvested or released while targeting Northern Pikeminnow. A fish was considered "caught" when the angler touched the fish, whether it was released or harvested. Fish returned to the water alive were defined as "released". Fish that were retained by the angler or not returned to the water alive were considered "harvested".



Fishing Locations:

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

Figure 3. Fishing Location codes used for the 2022 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 2022 per NPSRF protocol (Fox et al. 2000).

Northern Pikeminnow Handling Procedures

Biological Sampling

Technicians examined all fishes returned to registration stations and recorded basic biological data such as species and number of fish per species. Fork lengths and sex of Northern Pikeminnow as well as any other harvested fish species were recorded whenever possible. Technicians checked all Northern Pikeminnow for the presence of external tags (spaghetti, Floy, dart, etc.), fin-clip marks, and/or signs of tag-loss. All externally tagged Northern Pikeminnow had complete biological data collected whether the fish had a spaghetti tag as used by the NPMP since 1991, or with Floy type anchor tags used by ODFW from 2019-21. Data collected from externally tagged Northern Pikeminnow included Fork Length (FL), tag number, sex (determined by evisceration), and scale samples (if specified). Data from tagged Northern Pikeminnow were recorded both on corresponding tag voucher and on WDFW data form. The external tag was then removed from the Northern Pikeminnow and placed in a tag envelope, stapled to the tag voucher and then given to the angler to submit by mail to ODFW for verification. All tagged Northern Pikeminnow carcasses were then processed or labeled and frozen for data verification and/or PIT tag recovery at a later date.

Tag Detection

PIT tags

All Northern Pikeminnow collected during the 2022 NPSRF were scanned for Passive Integrated Transponder (PIT) tags. PIT tags (prior to 2022) have been used by ODFW as a secondary mark in all Northern Pikeminnow fitted with external, spaghetti or Floy, tags (beginning in 2003) as part of the NPMP's biological evaluation activities (Takata and Koloszar 2004). In 2022, ODFW discontinued using external Floy or Spaghetti tags and exclusively used PIT tags for conducting the biological evaluation of the NPMP. Northern Pikeminnow harvested by anglers participating in the NPSRF have also been found to ingest juvenile salmonids that have been PIT tagged by other studies within the basin (Glaser et al. 2001). 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 entire 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 on site, or labeled and preserved for later dissection and PIT 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. Anglers were eligible for an additional $200 reward from PSMFC for ODFW PIT tagged (formerly "tag-loss") fish which were defined as Northern Pikeminnow with no external tags, but retaining ODFW PIT tags as part of the NPMP.

External tags

On a trial basis, WDFW conducted limited external tagging of NPM in 2022 as a promotional activity intended to highlight productive angling areas real-time using WDFW SRF knowledge and expertise to conduct hook and line capture and Floy tagging of reward sized NPM. Promotional tagging was conducted by WDFW since ODFW discontinued using external tags in 2022 (Waltz et al. 2023). Promotional tagging was followed by real-time promotion advertising of NPM catch opportunities via social media and/or other SRF promotion. Once caught, all reward sized NPM were measured, scanned for PIT tags and affixed with a Floy tag only (unless NPM already had a PIT tag). Tagged NPM were released in the same area in which they were caught and all promotional tag data was provided to ODFW for angler tag verification. Floy tags used for this angler incentive were not deployed according to ODFW's protocols for spatial distribution of tags, were not used in ODFW's biological evaluation of the NPSRF, and were simply a $500 tagged fish incentive, similar to how ODFW's externally tagged NPM (spaghetti and floy) have been used as SRF angler incentives in the past.

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. 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

During the 2022 NPSRF, anglers harvested a total of 140,121 reward size Northern Pikeminnow (≥ 228 mm TL) over the course of a 23-week field season. Harvest was below mean 1991-2021 harvest of 165,488 fish, but 50,579 fish more than the 2021 record low harvest (Winther et al. 2022) (Figure 4). The 2022 NPSRF harvest was estimated to equal an exploitation rate of 14.9% (Waltz et al. 2023). In addition to harvesting 140,121 reward size Northern Pikeminnow, anglers participating in the 2022 NPSRF also harvested 2,948 Northern Pikeminnow < 228 mm TL.

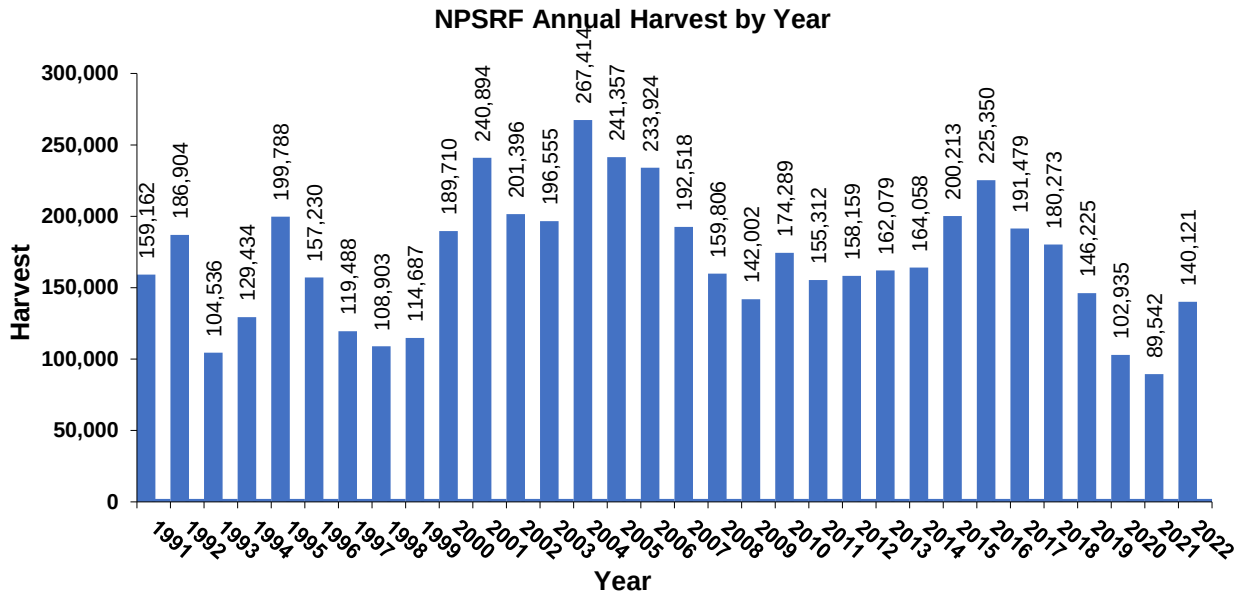


Figure 4. Annual harvest totals for the Northern Pikeminnow Sport-Reward Fishery

Harvest by Week

Peak weekly harvest was in week 26 (although technically there were 17 more Northern Pikeminnow harvested in week 36, which is when the familiar, second NPSRF late season peak usually occurs) (Figure 5). Peak harvest for 2022 was unusual in that there were two peaks, ten weeks apart (Figure 6), rather than the typical peak in week 26, followed by a smaller second peak around week 36 (Fox et al. 2000). Peak harvest in 2022 was 2,065 fish higher than in 2021 (6,356) and was part of the NPSRF's first "dual peak season" as above (Figure 7). Mean weekly harvest

was higher in 2022 (6,092) than in 2021 (4,679) and total weekly harvest was above 2021 weekly harvest for 22 of the 23 weeks of the season (Winther et al. 2022). Once again, the 2022 season did not achieve harvest of 10,000 fish per week during the critical first 6 weeks of the season. If the 2022 NPSRF had been able to achieve that level of high weekly harvest early in the season, 2022 NPSRF season harvest total would likely have been above the 1991-21 average.

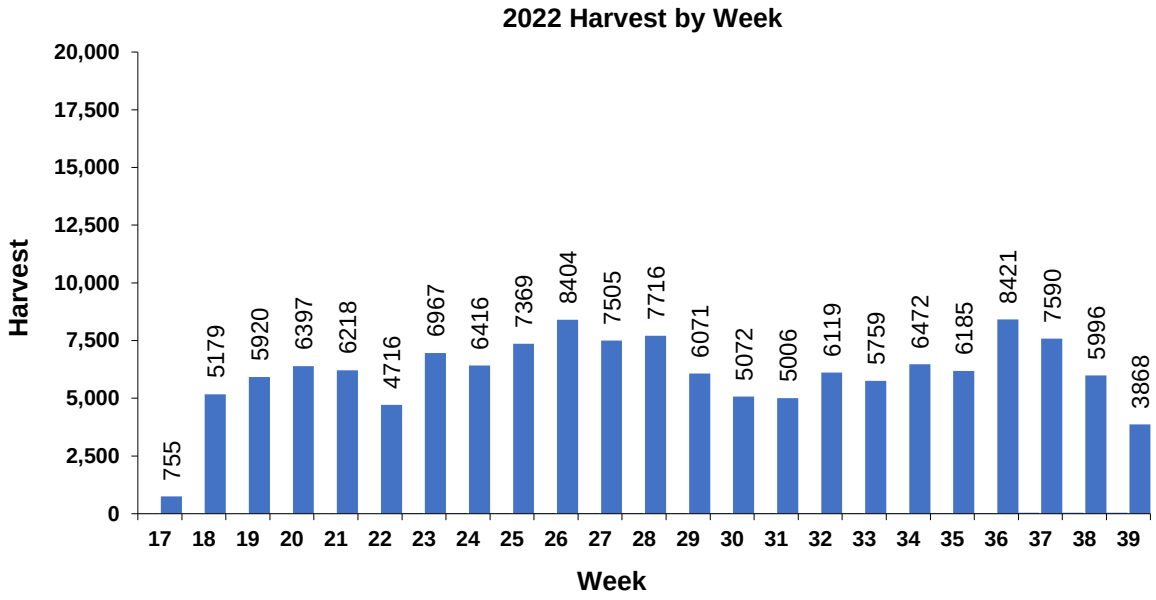


Figure 5. 2022 Weekly Northern Pikeminnow Sport-Reward Fishery harvest

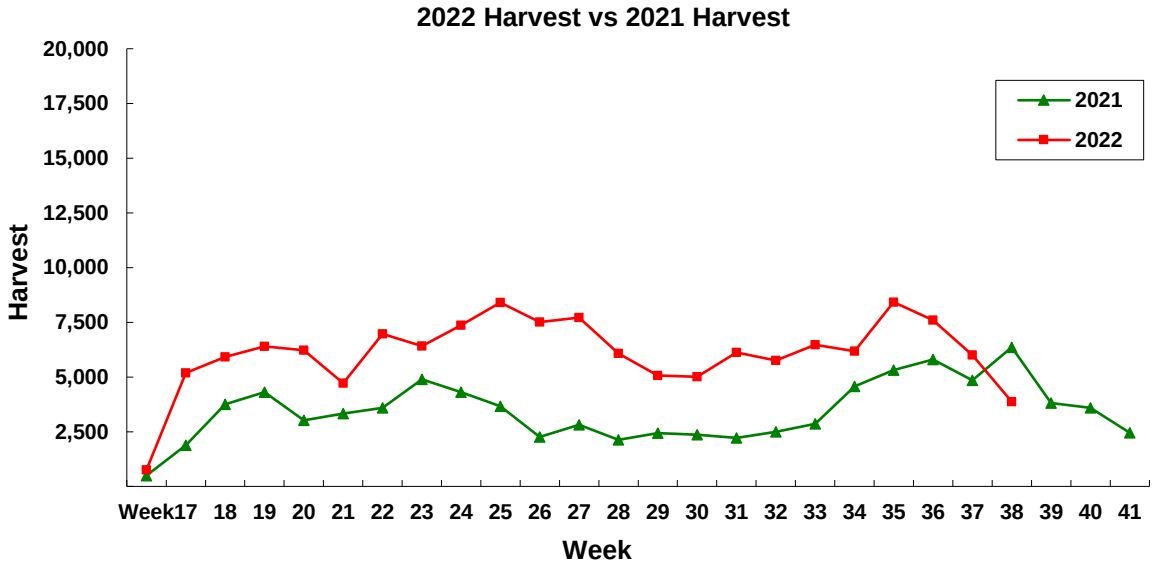


Figure 6. 2022 Weekly NPSRF harvest vs 2021 weekly harvest

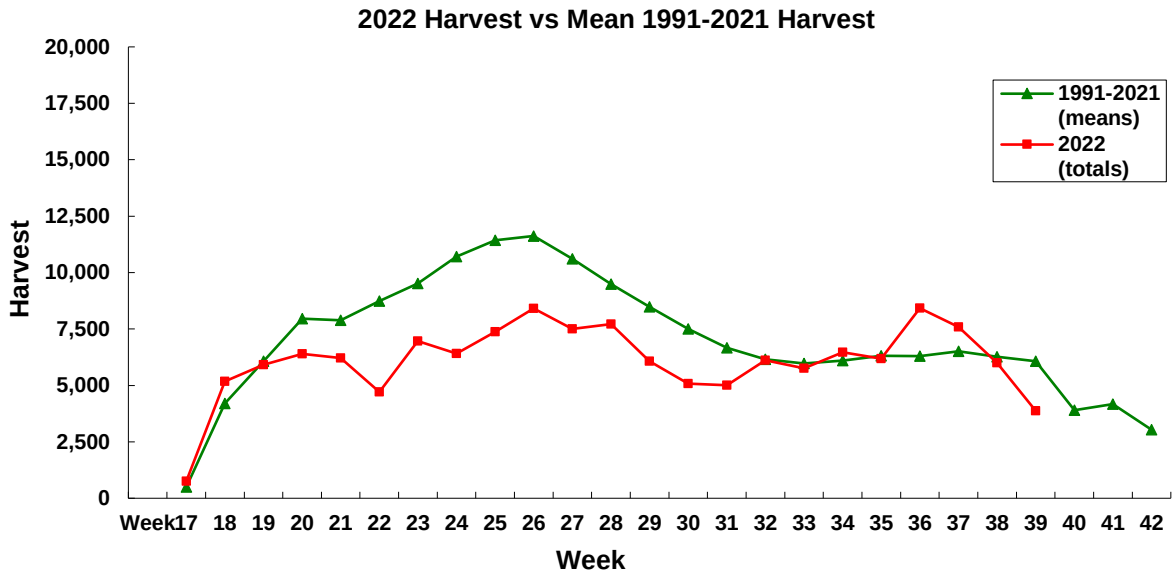


Figure 7. Comparison of 2022 NPSRF weekly harvest to 1991-21 mean weekly harvest

Harvest by Fishing Location

The mean harvest by fishing location for the 2022 NPSRF was 11,677 Northern Pikeminnow (compared to 8,578 in 2021) and ranged from 62,381 reward size Northern Pikeminnow in fishing location 01 (Below Bonneville Dam) to only 30 Northern Pikeminnow from fishing location 5 (McNary Dam to the mouth of the Snake River) (Figure 8). Harvest from fishing location 01 (the Columbia River below Bonneville Dam) increased from 42.37% of total NPSRF harvest in 2021 to 44.5% of total NPSRF harvest in 2022. Fishing location 01 remained the highest producing location in 2022, as it has been for all but one of the preceding 30 NPSRF seasons (Winther et al. 2022). Bonneville Reservoir (Fishing Location 02) remained the second highest producing area accounting for 24.6% of total 2022 NPSRF harvest.

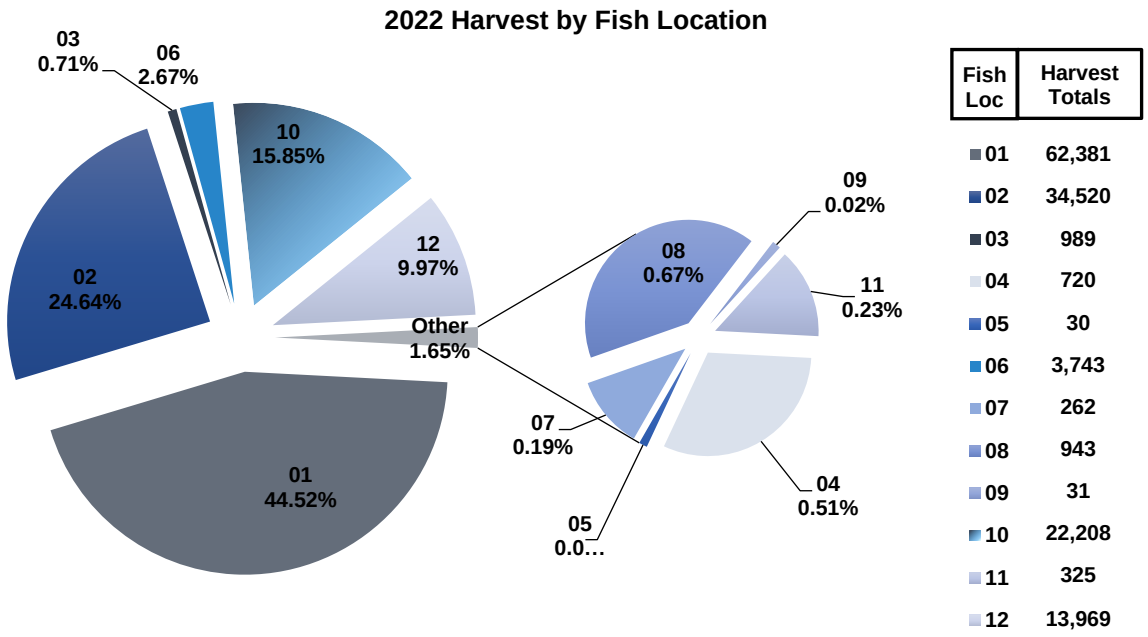


Figure 8. 2022 Northern Pikeminnow Sport-Reward Fishery harvest by fishing location*

*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 2022 was up from 2021 at 15 of the 20 registration stations. The Boyer Park registration station was once again the NPSRF's top producing station in 2022, where anglers harvested 21,862 Northern Pikeminnow, equaling 15.6% of total NPSRF harvest (Figure 9). The Washougal registration station finished with the second highest total of 20,497 Northern Pikeminnow (14.6% of total) harvested in 2022. The Dalles station finished a close third behind Cathlamet with 20,213 harvested fish. The average harvest per registration station was 7,006 reward size Northern Pikeminnow, up from 5,719 per station in 2021 (Winther et al. 2022). The registration station with the smallest harvest was Vernita where anglers harvested only 89 Northern Pikeminnow during the 2022 season. Seven registration stations had significant increases in their harvest from the preceding year, including Rainier, Kalama, Gleason, Chinook, Washougal, Bingen, The Dalles, and Swallows, which each had harvest more than twice their 2021 harvest (Winther et al. 2022).

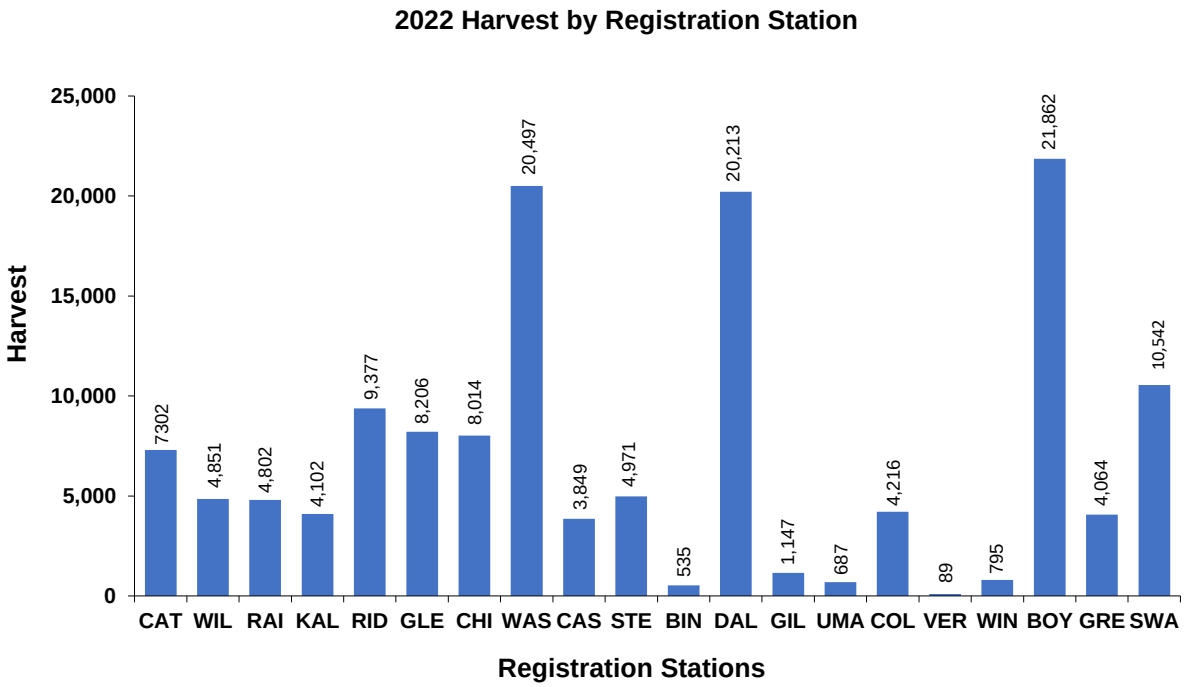


Figure 9. 2022 Northern Pikeminnow Sport-Reward Fishery harvest by registration station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, CAS-Cascade Locks, STE-Stevenson, BIN-Bingen, DAL- The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, WIN-Windust, BOY-Boyer Park, GRE-Greenbelt, SWA-Swallows.

Harvest by Species/ Incidental Catch

Returning anglers

In addition to catching Northern Pikeminnow, returning anglers participating in the 2022 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 2022.

Salmon			
Species	**Caught**	**Harvest**	**Harvest Percent**
Trout (Unknown)	17	0	0%
Chinook (Adult)	13	5	38.5%
Chinook (Juvenile)	12	0	0%
Steelhead (Juvenile, unclipped)	11	0	0%
Steelhead (Juvenile, clipped)	8	0	0%
Chinook (Jack)	8	0	0%
Cutthroat (Unknown)	6	0	0%
Steelhead Adult (clipped)	4	1	25%
Steelhead Adult (unclipped)	2	0	0%
Sockeye (Adult)	1	0	0%

Anglers reported that all juvenile salmonids caught during the 2022 NPSRF were released. Per NPSRF protocol, technicians recorded all juvenile steelhead caught by NPSRF anglers as “wild”,

(except those specifically reported as missing the adipose fin). Harvested adult salmonids that were caught incidentally during the 2022 NPSRF were only retained during legal salmonid fisheries. NPSRF protocol is to immediately 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 2022 were most often Peamouth, Smallmouth Bass, and Sculpin (Table 2).

Table 2. Catch and harvest of non-Salmonids by returning anglers targeting Northern Pikeminnow in 2022

Non-Salmonid

Species	Caught	Harvest	Harvest Percent
Northern Pikeminnow >228mm	140,121	140,117	99.99%
Northern Pikeminnow <228mm	36,228	2,948	8.14%
Peamouth	19,414	8,245	42,47%
Smallmouth Bass	8,405	659	7.84%
Sculpin (unknown)	6,381	3,980	62,37%
Yellow Perch	1,997	684	34.25%
Walleye	1,568	949	60.52%
White Sturgeon	1,414	0	0%
Sucker (unknown)	936	118	12.61%
Catfish (unknown)	910	109	11.98%
Channel Catfish	728	60	8.24%
Bullhead (unknown)	553	111	20.07%
Chiselmouth	366	35	9.56%
Carp	140	24	17.14%
Bluegill	49	5	10.20%
Starry Flounder	41	7	17.07%
Pumpkinseed	32	10	31.25%
Largemouth Bass	18	0	0%
American Shad	16	10	62.50%
Crappie (unknown)	11	3	27.27%
Sandroller	8	0	0%
Whitefish	4	1	25%

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 20 stations in order to determine and record their catch and/or harvest of reward sized Northern Pikeminnow and other incidentally caught fish species. In 2022, there were 2,256 non-returning angler days recorded and a total of 480 calls were completed to non-returning anglers (21.3% 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 2022 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 2022 NPSRF. Estimated totals are listed in columns 5 and 6 of Table 3.

Table 3. 2022 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	70	9	12.9%	329	42
Northern Pikeminnow ≥ 228 mm	20	19	95%	94	89
Chinook Salmon (Adult)	1	1	100%	5	5
Chinook Salmon (Juvenile)	1	0	0%	5	0

N=2,256 n=480

Fork Length Data

The length frequency distribution for harvested Northern Pikeminnow (≥ 200 mm) from the 2022 NPSRF is presented in Figure 10. Fork length data from 55,152 Northern Pikeminnow ≥ 200 mm FL (39.4% of total harvest) were taken during the 2022 NPSRF. The mean fork length for all measured Northern Pikeminnow (≥ 200 mm) in 2022 was 263 mm (SD= 60.98 mm), up from 277.7 in 2021 (Winther et al. 2022).

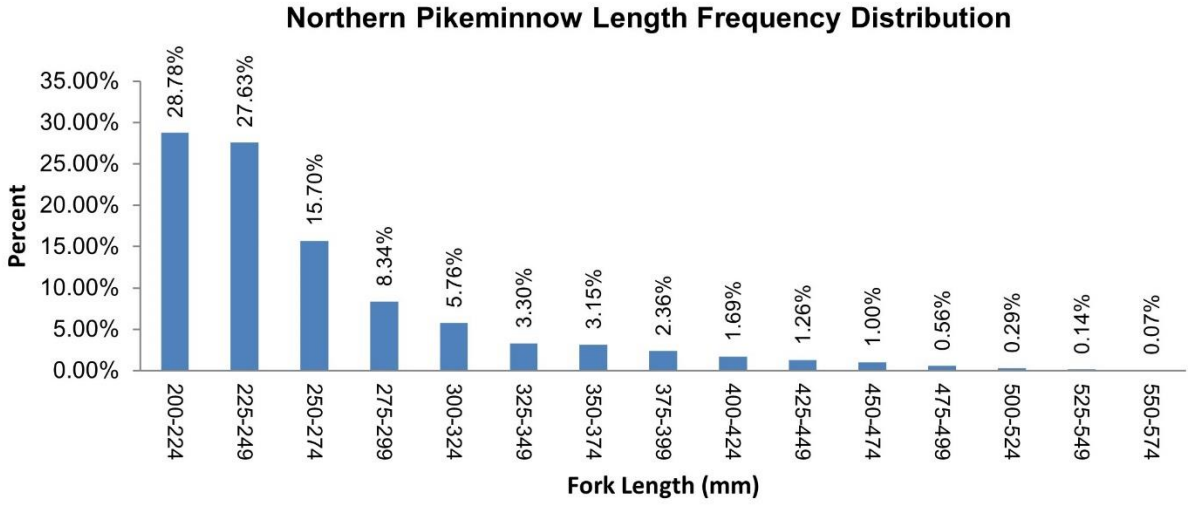


Figure 10. Length frequency distribution of Northern Pikeminnow ≥ 200 mm FL from 2022 NPSRF. n=55,152

Angler Effort

The 2022 NPSRF recorded total effort of 10,561 angler days spent during the season, a decrease of 992 angler days from 2021 (Winther et al. 2022) (Figure 11). Residual effects of the COVID-19 pandemic appeared to still have some negative effect on angler participation in 2022 despite the fact that overall river conditions were more conducive to catching fish (based on angler CPUE). When total effort is divided into returning and non-returning angler days, 8,305 angler days (78.6%) were recorded by returning anglers, and 2,256 angler days (21.4%) were spent by non-return anglers. The percentage of returning anglers in 2022 (78.6%) was higher than the 2021 (74%) season (Winther et al. 2022). In addition, 71.8% of total effort, and 91% of returning angler effort (7,583 angler days, 91%), was attributed to successful anglers who harvested at least one Northern Pikeminnow in 2022.

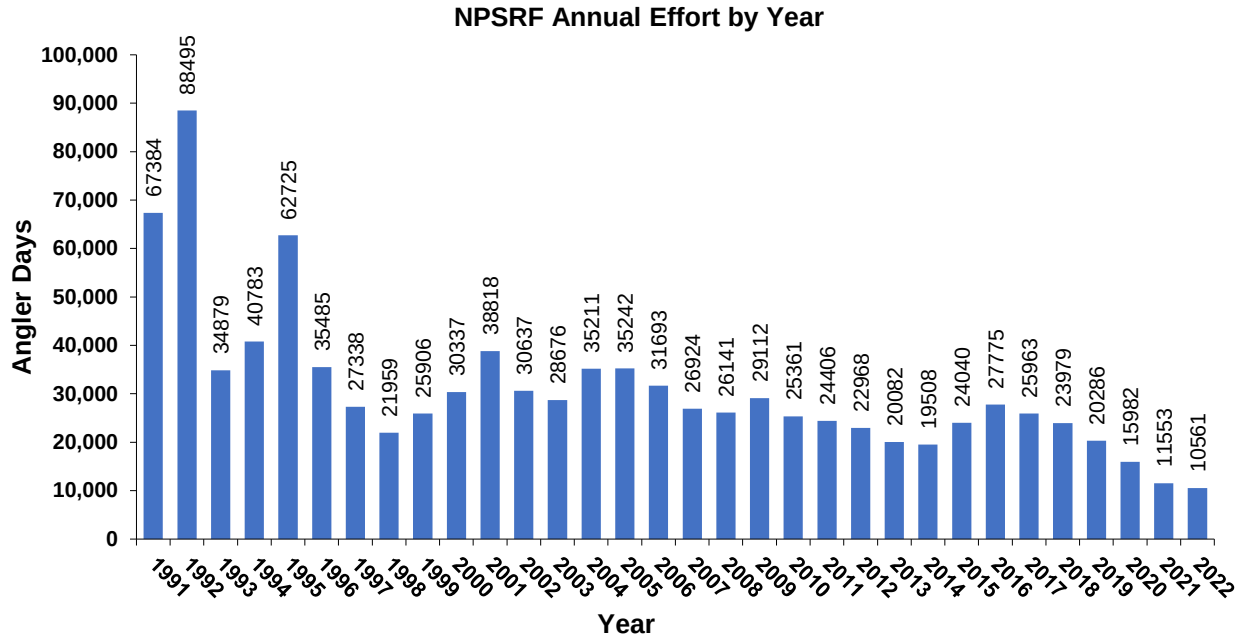


Figure 11. Annual Northern Pikeminnow Sport-Reward Fishery effort

Effort by Week

Mean weekly effort for the 2022 NPSRF was 459 angler days during the season, with the peak occurring in week 21 (Figure 12). Overall, mean weekly effort increased from 444 in 2021 (Winther et al. 2022) and when we compare weekly effort totals between years, weekly effort totals for 12 of the 23 weeks in 2022 were up from those of 2021 (Winther et al. 2022) (Figure 13). Peak weekly effort in 2022 occurred one week later than in 2021 and weekly effort totals continued to follow the pattern seen since 2015, where peak effort occurs near the first full week of the season (Figure 14). This pattern is different from the historical 1991-2015 (Winther et al. 2016) pattern for effort where the peak typically occurred around the same week as peak harvest and is likely the result of lowering angler tier levels, which incentivizes anglers to reach higher tier levels earlier in the season as a way to maximize their reward total.

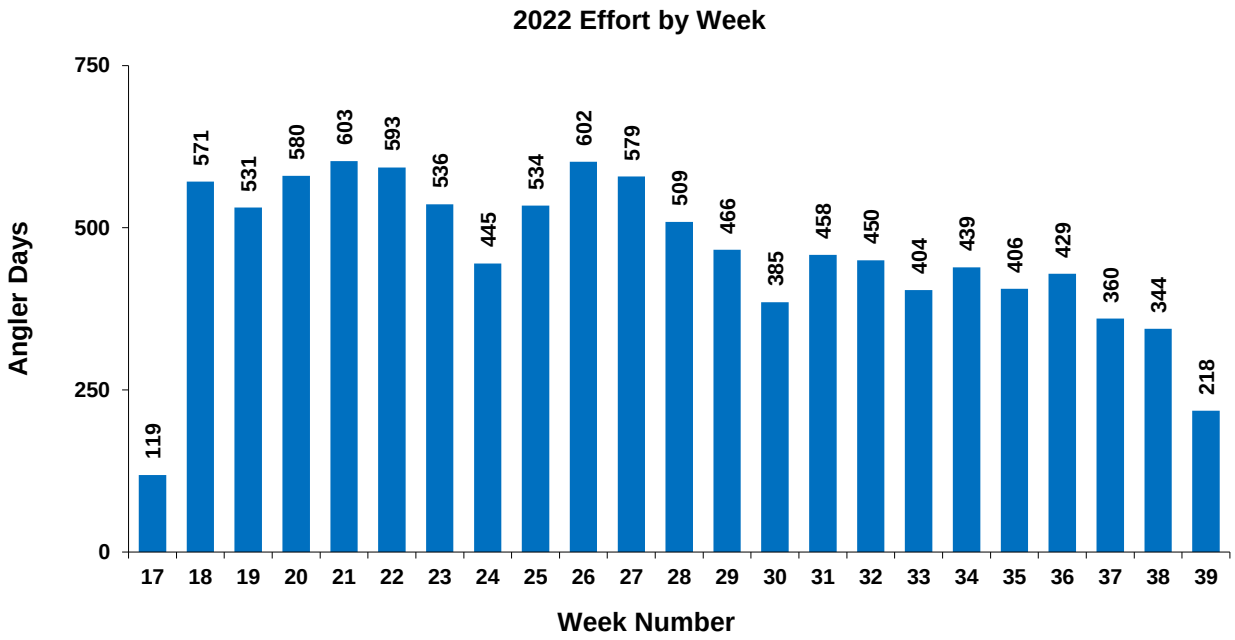


Figure 12. 2022 Weekly Northern Pikeminnow Sport-Reward Fishery angler effort

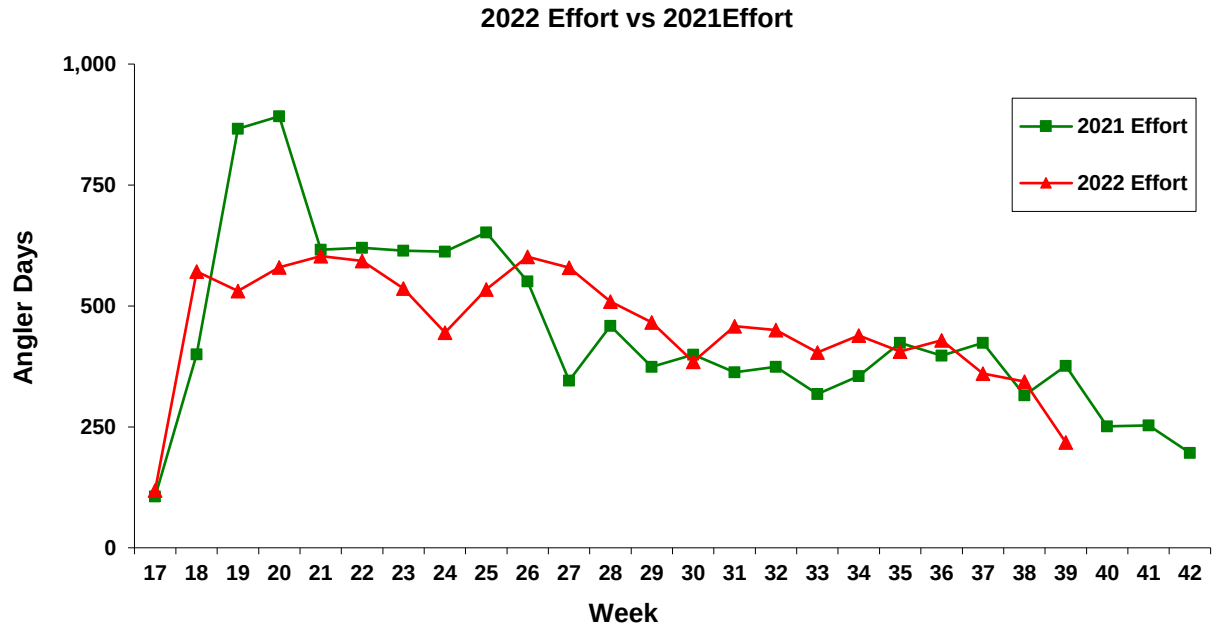


Figure 13. Effort 2022 Northern Pikeminnow Sport-Reward Fishery effort vs 2021 effort

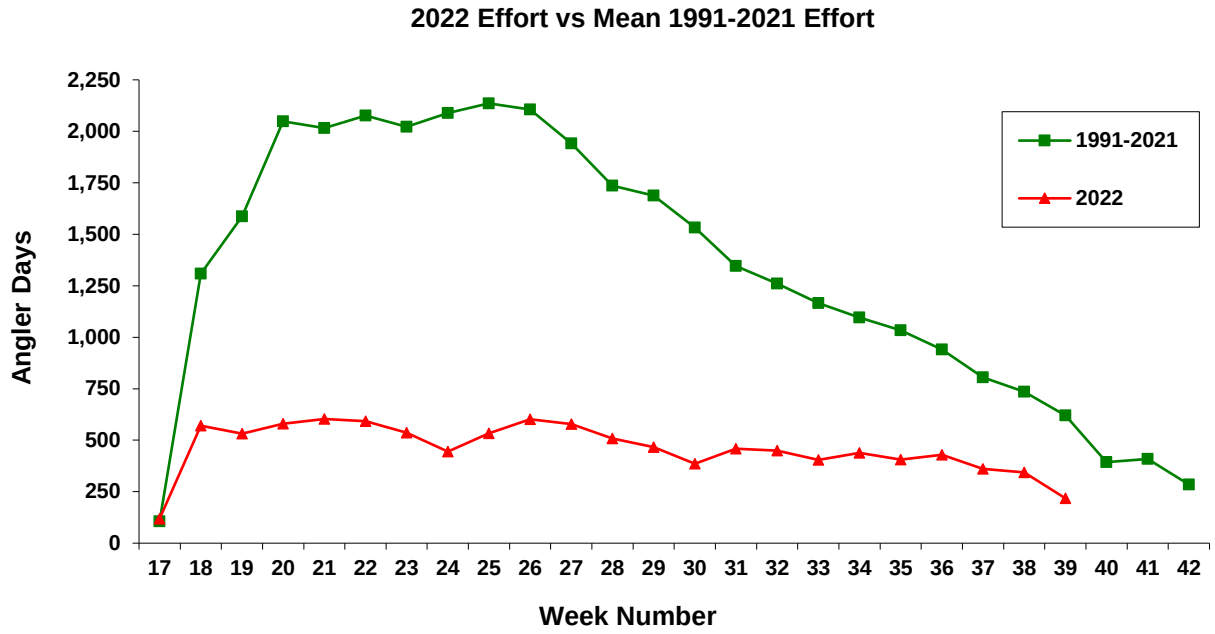


Figure 14. 2022 NPSRF weekly effort vs mean 1991-2021 effort

Effort by Fishing Location

Mean annual effort by fishing location for the 2022 NPSRF (returning anglers only) decreased from 963 angler days in 2021 (Winther et al. 2022) to 880 angler days in 2022. Effort totals ranged from 3,436 angler days spent in fishing location 01 (below Bonneville dam) to only 1 angler day spent in fishing location 09 on the Snake River (Lower Monumental Reservoir) (Figure 15). Only three of the 12 NPSRF fishing locations recorded an increase in angler effort (from 2021) in 2022.

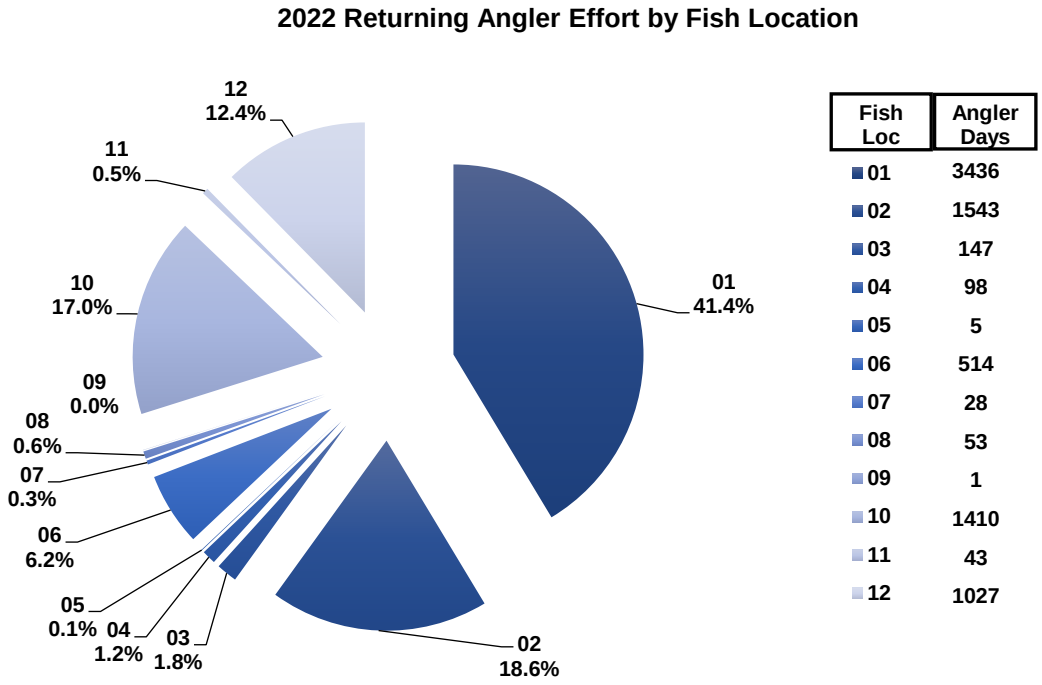


Figure 15. 2022 NPSRF angler effort by fishing location* (returning anglers only).
*Fishing Location Codes for **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth of the 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 2022 NPSRF was 528 angler days compared to 481 angler days in 2021 (Winther et al. 2022). Effort totals ranged from a high of 1,513 angler days at The Dalles station to a low of 16 angler days at the Vernita station (Figure 16). Although effort decreased at 11 of the 20 registration stations, there were notable increases in angler effort at the Gleason, Washougal, and Swallows registration stations in 2022.

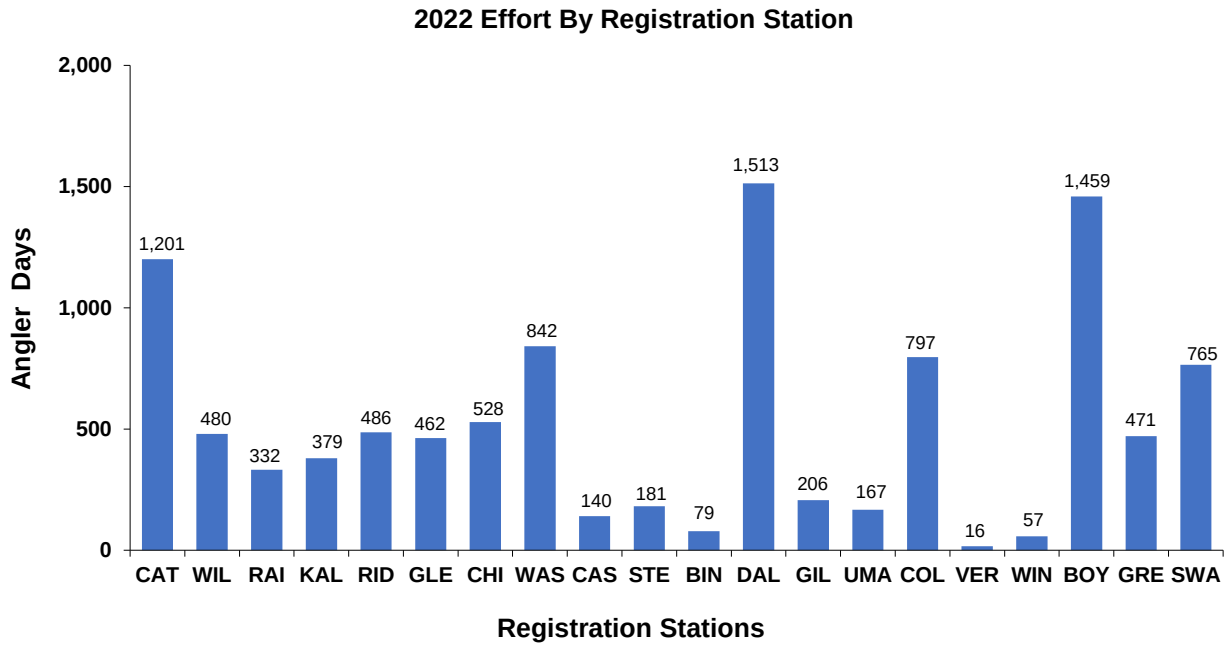


Figure 16. 2022 Northern Pikeminnow Sport-Reward Fishery angler effort by registration station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, CAS-Cascade Locks, STE-Stevenson, BIN-Bingen, DAL-The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, WIN-Windust, BOY-Boyer Park, GRE-Greenbelt, SWA-Swallows.

Catch Per Angler Day (CPUE)

The 2022 NPSRF recorded an overall (returning + non-returning anglers) catch per unit of effort (CPUE or "catch rate") of 13.27 Northern Pikeminnow harvested per angler day during the season. This catch rate was nearly double the 2021 overall CPUE of 7.75 (Figure 17), indicating that angling conditions throughout the NPSRF area were much more favorable during 2022 than in 2021. Angler CPUE resumed the upwards trend seen throughout the NPSRF's 31-year history, after falling in recent years, and was the highest it has ever been in NPSRF history. Returning angler CPUE during the 2022 NPSRF was 16.87 Northern Pikeminnow per angler day, up from the 2021 returning angler CPUE of 12.32 (Winther et al. 2022). The estimated CPUE for non-returning anglers was 0.15 reward size Northern Pikeminnow per angler day based on 2022 NPSRF phone survey results and has remained constant throughout recent NPSRF history.

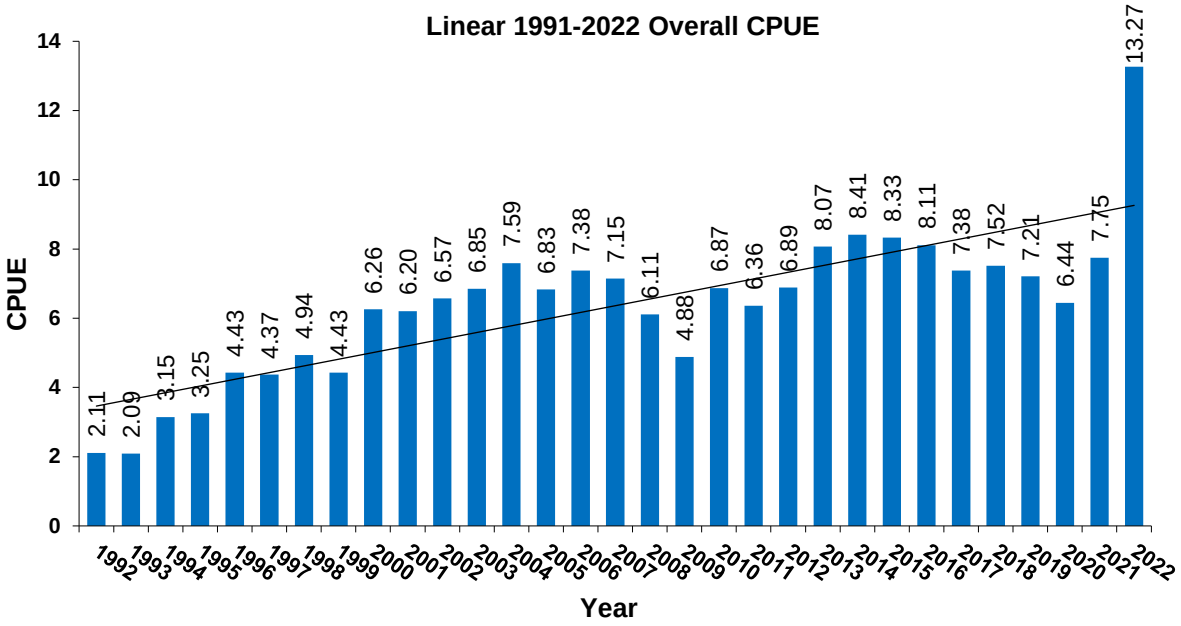


Figure 17. Annual NPSRF CPUE (returning + non-returning anglers) for the years 1991-2022

CPUE by Week

Mean angler CPUE by week for the 2022 NPSRF was 13.48 fish per angler day compared to 7.75 in 2021 (Winther et al. 2022) and ranged from a low of 6.34 in week 17 (May 1) to a peak of 21.08 in week 37 (September 12-18) (Figure 18). Weekly CPUE for the 2022 NPSRF followed a typical two-peak pattern with the first peak in week 28 near the historical Northern Pikeminnow spawning peak and then again late in the season (week 37) when favorable water and angling conditions were present in the lower Columbia and Snake rivers (Winther et al. 2011).

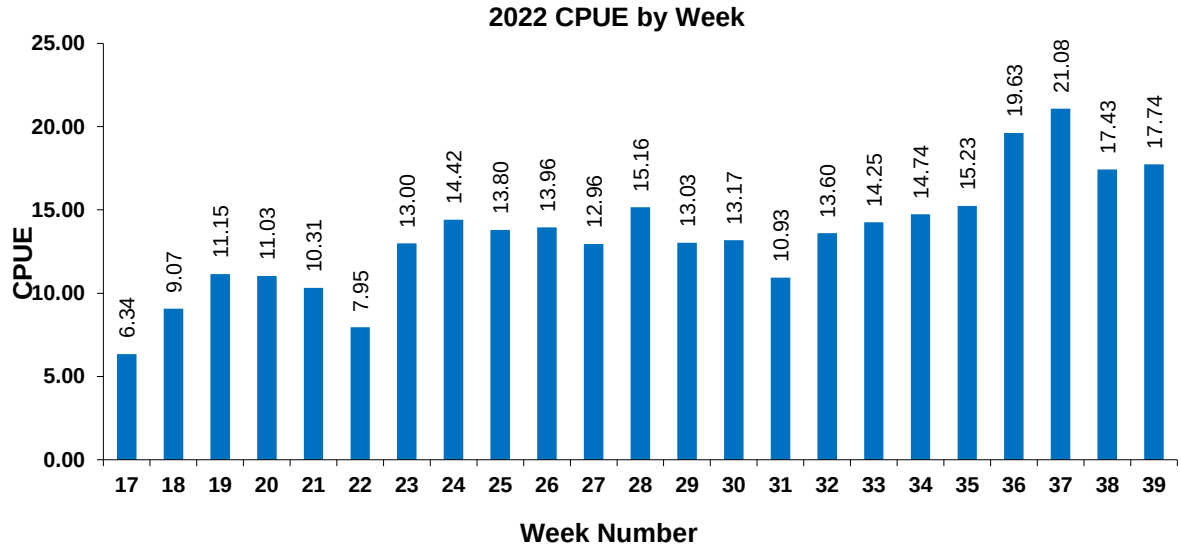


Figure 18. 2022 Northern Pikeminnow Sport-Reward Fishery angler CPUE by week

CPUE by Fishing Location

Angler success rates for the 2022 NPSRF (as indicated by CPUE), represent returning anglers only and varied by fishing location. Success rates ranged from a high of 31.00 Northern Pikeminnow per angler day in fishing location 09 (Lower Monumental Reservoir) to a low of 6.00 fish per angler per day in fishing location 05 (McNary Dam to the mouth of the Snake River) (Figure 19). CPUE increased at all of the fishing locations except in fishing location 07 (Mouth of Snake River to Ice Harbor Dam) in 2022. The average CPUE by fishing location was 13.58 Northern Pikeminnow per angler day in 2022 compared to 8.93 in 2021 (Winther et al. 2022).

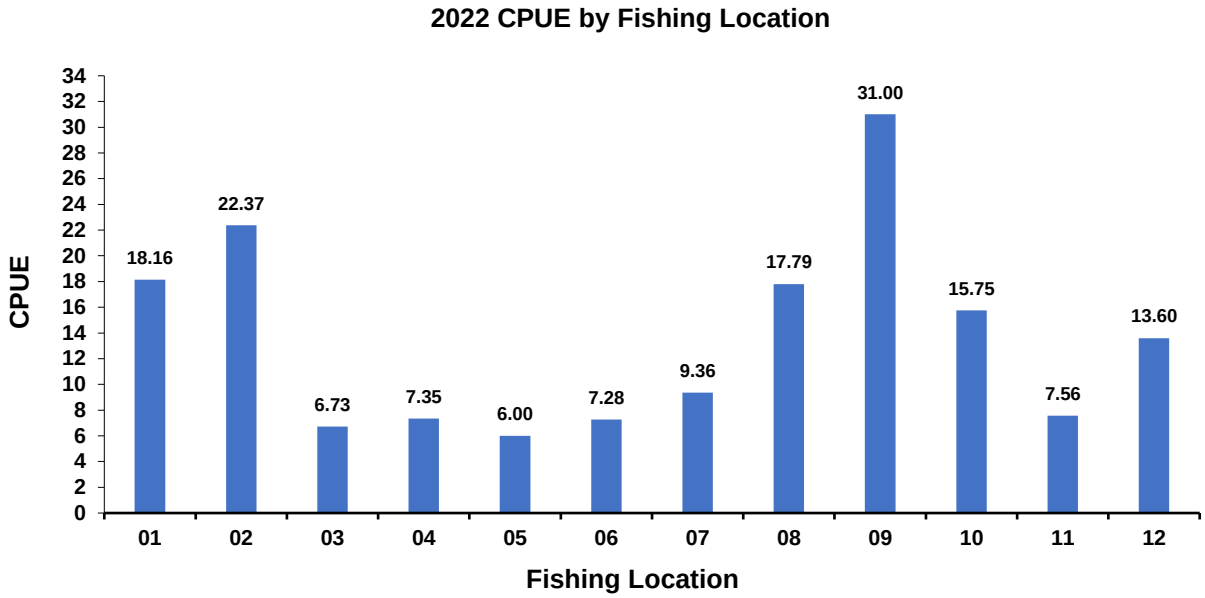


Figure 19. 2022 Northern Pikeminnow Sport-Reward Fishery angler CPUE by fishing location.*
*Fishing Location Codes for **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth 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 stations with the highest CPUE during the 2022 NPSRF were the Cascade Locks and Stevenson stations where anglers averaged 27.49 and 27.46 Northern Pikeminnow per angler day respectively (Figure 20). The next highest registration station CPUE was the Washougal station with 24.34 fish per angler, per day and the station with the lowest CPUE was the Umatilla station with a CPUE of 4.11 Northern Pikeminnow per angler day. The station average for angler CPUE was 13.25 in 2022, up from 7.5 in 2021 (Winther et al. 2022). Angler CPUE by registration station increased at all stations during the 2022 NPSRF season, except at the Stevenson and Greenbelt stations. The largest CPUE increase occurred at the Gleason station, where CPUE increased from 7.21 in 2021 (Winther et al. 2022) to 17.76 in 2022.

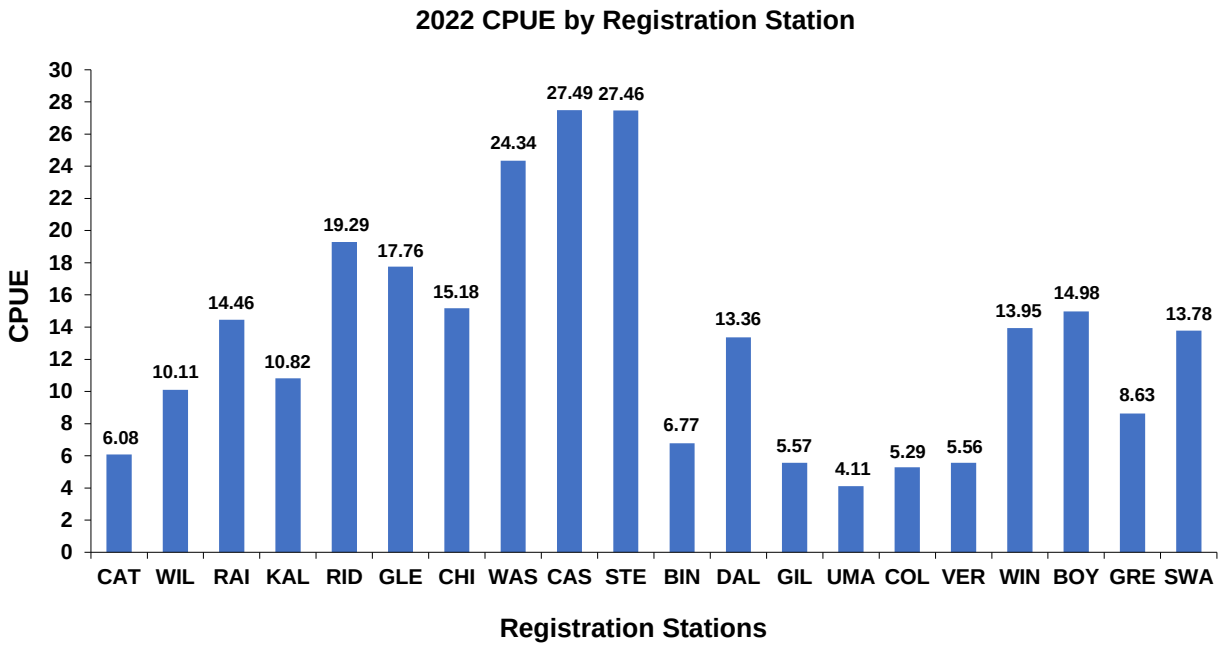


Figure 20. 2022 Northern Pikeminnow Sport-Reward Fishery angler CPUE by registration station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Angler Totals

There were 1,175 separate anglers who participated in the 2022 NPSRF, a decrease of 433 participants from 2021. Five hundred seventy-four of these anglers (48.9% of total vs. 40.0% in 2021 were classified as successful, harvesting at least one reward size Northern Pikeminnow (for which a voucher was issued) during the 2022 season. Of the successful anglers, 77.5% (445 anglers) sent in their vouchers to PSMFC for payment (PSMFC 12/5/22 Sport-Reward Payment Summary) while 129 anglers (22.5%) did not. The average successful angler harvested 244 Northern Pikeminnow during the 2022 NPSRF compared to 138 in 2021 (Winther et al. 2022).

When we break down the 574 successful anglers by tier, 442 of these anglers (77.0%) harvested fewer than 25 Northern Pikeminnow and were classified as Tier 1 anglers (Figure 21). This is down slightly from the 450 individual Tier 1 anglers in 2021 (Winther et al. 2022). The number of Tier 2 anglers declined to 59 (10.28%) in 2022, from 115 in 2021 and the number of Tier 3 anglers (known as "highliners") decreased slightly from 80 anglers to 73 (12.72%) in 2022 (Winther et al. 2022).

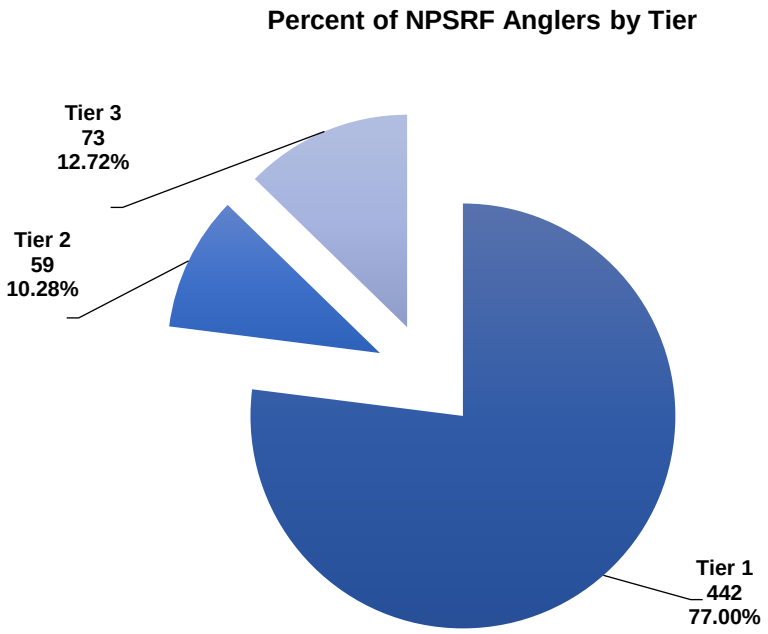


Figure 21. 2022 Percentage of NPSRF anglers by tier (returning anglers) based on total harvest

Despite continued lower than average levels of angler participation recorded for the NPSRF during the 2020-22 COVID-19 pandemic years, the continued high percentage of overall NPSRF harvest by Tier 3 anglers was especially important for successfully achieving 2022 NPSRF harvest and exploitation objectives. Historically, Tier 3 anglers have much higher harvest and CPUE levels than Tier 1 or 2 anglers (Hisata et al. 1996), and even though there were reduced levels of participation at all tier levels during the 2022 NPSRF, the overall effect was mitigated by the fact that the high harvest percentage of Tier 3 anglers remained relatively stable. In addition, while the numbers of anglers at Tiers 1, 2 and 3 were down from 2021, Tiers 1 and 2 anglers nearly doubled their percentage of harvest from the 2021 NPSRF.

While Tier 1 anglers made up 77.0% of all successful NPSRF participants in 2022, they accounted for only 5.4% of total NPSRF harvest (7,568) Northern Pikeminnow) (Figure 22). Tier 2 anglers made up 10.38% of all successful anglers and harvested 18.7% of total NPSRF harvest (26,202 fish). Tier 3 anglers made up only 6.2% of all NPSRF participants (both returning and non-returning anglers) but were 12.72% of all successful anglers and accounted for 75.92% of total 2022 NPSRF harvest (106,351 fish).

Average annual harvest per angler was up for Tier 1, Tier 2 and Tier 3 anglers. Tier 1 anglers annual average harvest was 17.1 fish per year in 2022, nearly triple the 5.78 fish per year from 2021. Tier 2 anglers harvested an annual average of 444 fish per year in 2022, up from 77.54 fish per year in 2021. Average annual harvest for Tier 3 anglers increased to 1,457 fish per year in 2022 compared to 975.3 fish per year in 2021 (Winther et al. 2022).

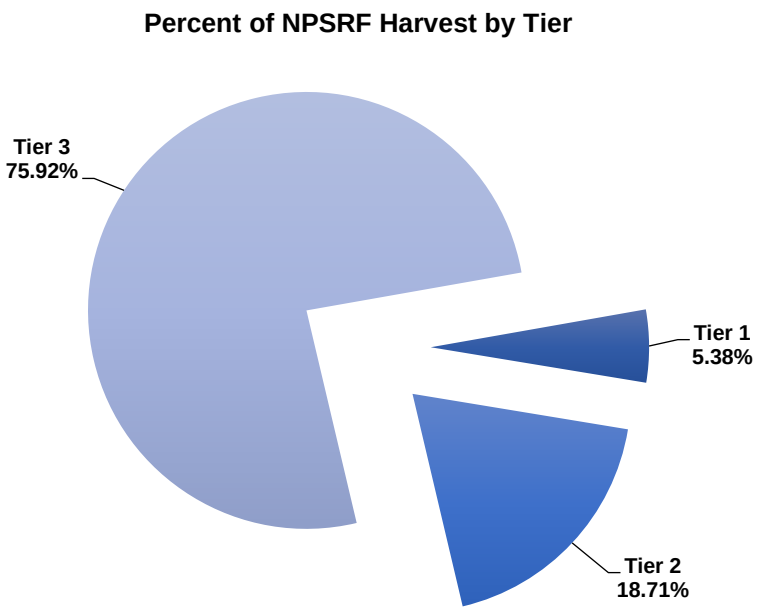


Figure 22. 2022 NPSRF harvest by angler tier (Tier 1 = ≤25, Tier 2 =26-200, Tier 3 = > 200)

The overall average NPSRF participant (returning + non-returning anglers) expended more effort pursuing Northern Pikeminnow during the 2022 season than in 2021 (8.99 vs. 7.18 angling days of effort). When we look at successful anglers only, the average successful angler spent slightly less average annual effort during the 2022 NPSRF with 13.21 average angler days spent in 2022 compared to 13.27 days in 2021. When we break down successful angler effort by tier, two of the three tier levels spent more annual effort in 2022 than they did in 2021. Tier 1 anglers spent an average of 3 days fishing in 2022, down from 5 days in 2021 (Figure 23). Tier 2 anglers spent an average of 36 days fishing in 2022, up from 21 days in 2021. Tier 3 anglers averaged 84 days fishing in 2022, up from 67 days in 2021 (Winther et al. 2022).

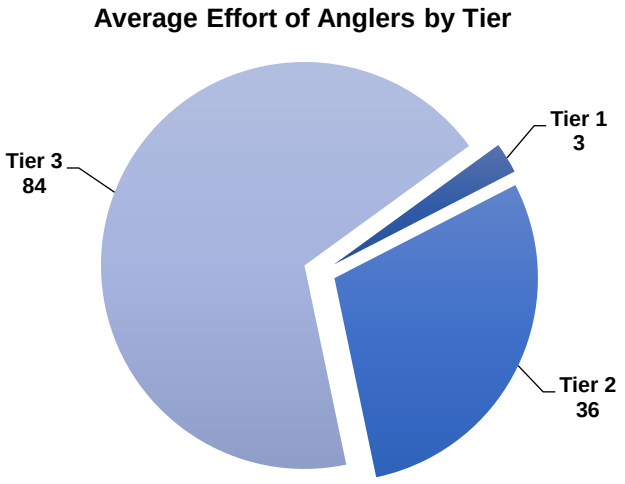


Figure 23. Average effort (angler days) of 2022 NPSRF anglers by tier (Tier 1 = ≤ 25, Tier 2 = 26-200, Tier 3 = > 200)

When 2022 CPUE by tier is compared to 2021 there was an increase in CPUE at all three tier levels. CPUE for anglers at Tier 1 increased from 1.16 fish per angler day in 2021 to 5.39 in 2022 (Figure 24). CPUE for Tier 2 anglers increased from 3.62 fish per angler day in 2021 to 12.41 in 2022. CPUE for Tier 3 anglers decreased from 14.63 fish per angler day in 2021 to 17.38 in 2022 (Winther et al. 2022).

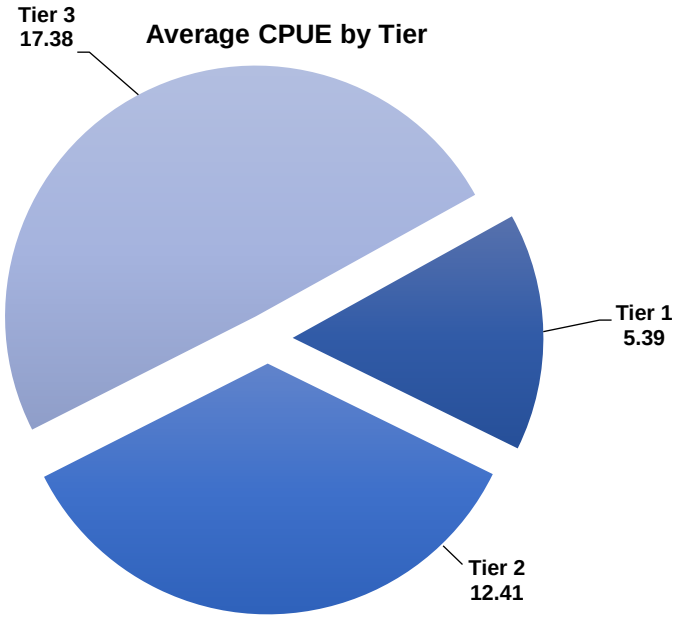


Figure 24. Average CPUE of 2022 NPSRF anglers by tier (Tier 1 = ≤25, Tier 2 =26-200, Tier 3 = > 200)

The top individual angler (based on number of fish caught) for the 2022 NPSRF harvested 6,858 Northern Pikeminnow, which also included 1 externally tagged Northern Pikeminnow and 3 tag-loss Northern Pikeminnow worth a total earnings of $69,230 (PSMFC 12/5/2022 Sport-Reward Payment Summary). The 2022 top angler caught 327 less reward sized Northern Pikeminnow than the top angler did in 2021. The CPUE for this year's top angler 60.2 fish per angler day) was up from the top angler in 2021 (55.7 fish per angler day) reflecting more productive fishing/river conditions seen for all Tier 3 anglers in 2022. The angler with the top harvest for the 2022 season spent 15 fewer days of effort (114 days total) than the top angler did in 2021 (Winther et al. 2022). By comparison, the top angler in terms of participation (rather than harvest) for the 2022 NPSRF fished 146 days of the 153 available days (95.4% of available days) and harvested 2,726 Northern Pikeminnow.

Tag Recovery

Northern Pikeminnow Tags

Returning anglers harvested 37 Northern Pikeminnow tagged with external spaghetti or Floy tags during the 2022 NPSRF compared to 75 external spaghetti/Floy tags harvested in 2021 (Winther et al., 2022). There were 140 Northern Pikeminnow recovered containing ODFW PIT tags in 2022

(ODFW did not deploy any external tags in 2022, using only PIT tags). Tag recoveries (both external and PIT) peaked during weeks 26 and 27 (Figure 25), which was six weeks later than the week 20 peak tag recovery in 2021 (Winther et al. 2022). Of the 37 externally tagged Northern Pikeminnow recovered in the 2022 NPSRF, 36 retained PIT tags added by ODFW as a secondary mark (37th tag was a WDFW promotional tag). ODFW used WDFW's tag recovery data from the 2022 NPSRF (Spaghetti/Floy and/or PIT) to estimate a 14.9% exploitation rate for the NPMP in 2022 (Waltz et al. 2023).

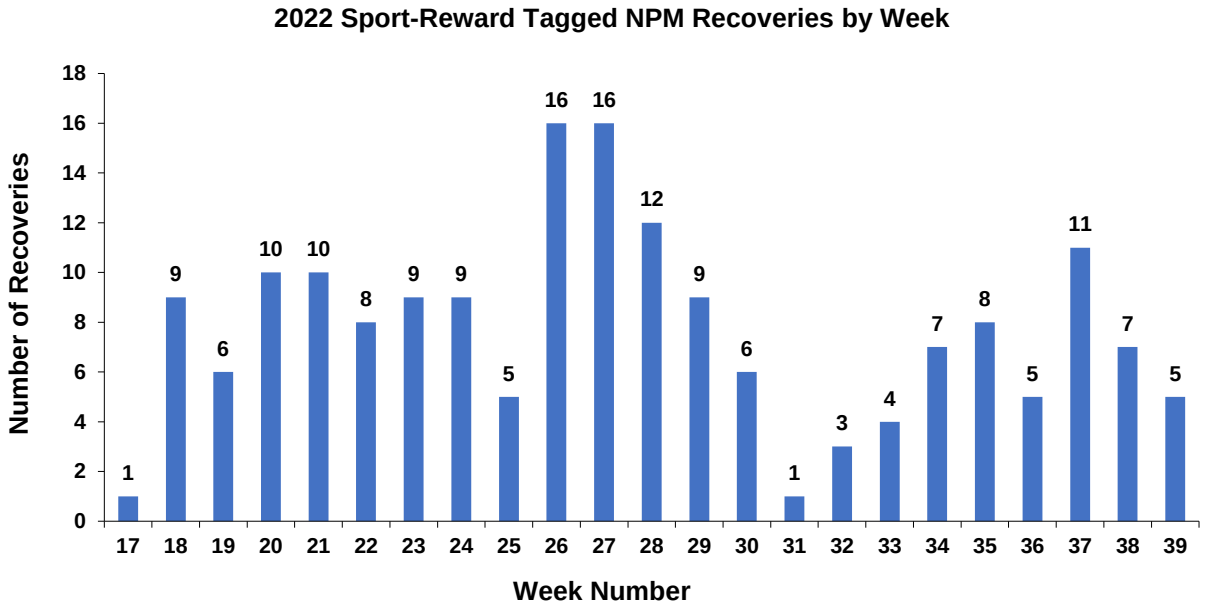


Figure 25. 2022 NPSRF tagged NPM recoveries by week

Promotional tags

WDFW deployed 30 Floy tags as part of an angler incentive, promotional activity on a trial basis in 2022. Ten fish were tagged near Kalama (Fish location 01), 16 were tagged near Stevenson (Fish location 02), and 4 fish were tagged at The Dalles (Fish location 02). One promotional tag (from this trial group) was returned during the 2022 SRF. Based on the WDFW knowledge gained in this trial, and on further coordination and protocol refinement with SRF cooperators, plans are to continue, and hopefully expand areas for this activity during the 2023 SRF.

Ingested PIT Tags

A total of 140,121 Northern Pikeminnow were individually scanned for the presence of PIT tags in 2022. This represents 100% of the total harvest of reward-size fish for the 2022 NPSRF (Northern Pikeminnow not qualifying for rewards were also scanned whenever possible). Technicians recovered a total of 23 PIT tags from consumed smolts that had been ingested by Northern Pikeminnow harvested during the 2022 NPSRF, an overall occurrence ratio of 1:6,092 compared to 1:1,990 in 2021. Total ingested PIT tag recoveries in 2022 was 22 recoveries less than the previous year. PIT tag recoveries of salmonid smolts ingested by Northern Pikeminnow

peaked during week 19 of the 2022 NPSRF and the final ingested PIT tag recoveries for the 2022 NPSRF occurred during week 35 (August 29th – Sept 4th) (Figure 26).

Ingested PIT tag recoveries by fishing location during the 2022 NPSRF showed that Northern Pikeminnow harvested from fishing location 02 (Bonneville Reservoir) consumed the largest number of PIT tagged juvenile salmonids totaling 7 (Figure 27).

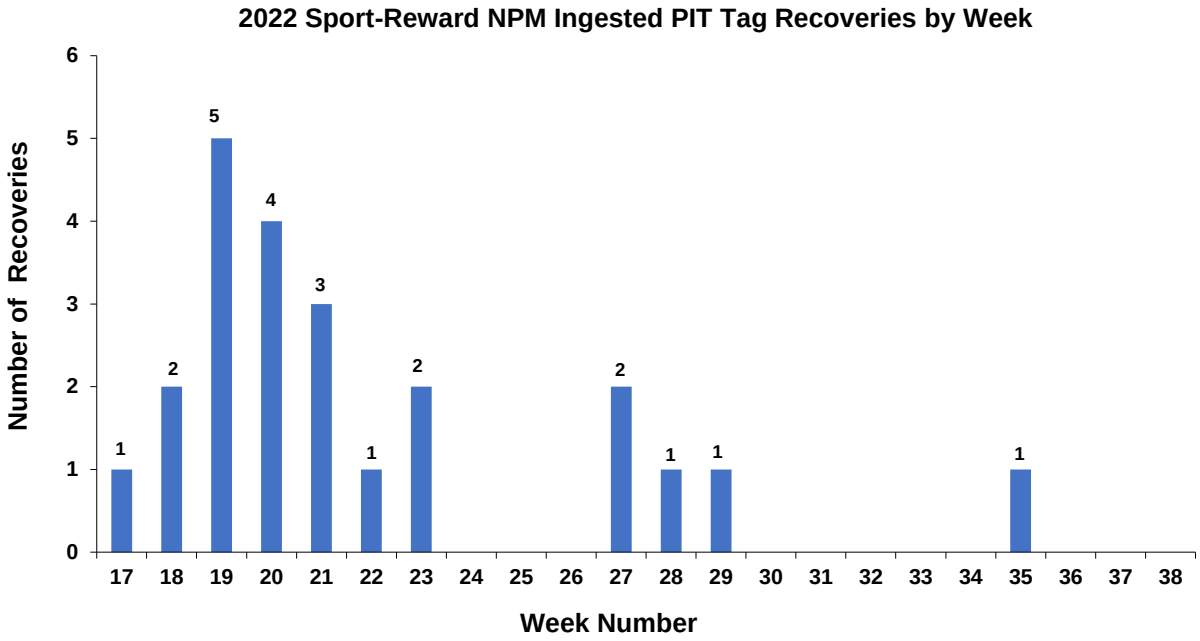


Figure 26. 2022 NPSRF ingested PIT Tag recoveries by week

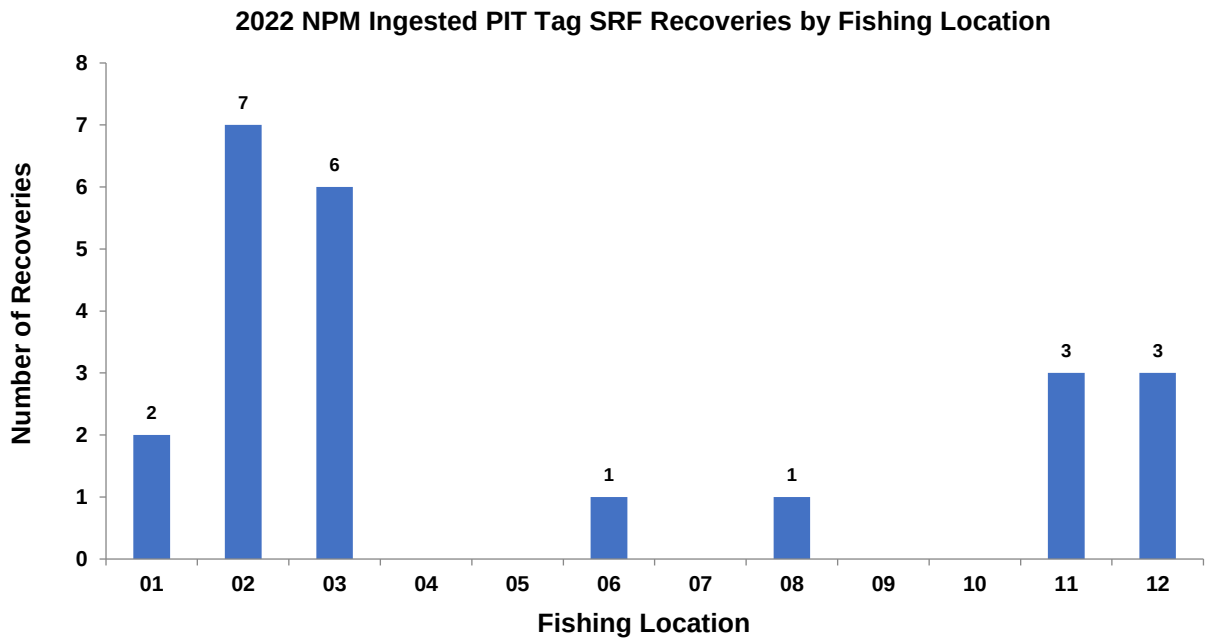


Figure 27. 2022 NPSRF ingested PIT Tag recoveries by fishing location*

*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 2022 NPSRF was obtained from PTAGIS and showed that most recoveries occurred in May and that 19 of the 23 ingested PIT tag recoveries (82.6%) were from Chinook smolts (Figure 28). Of the Chinook smolts, 18 of the 19 PIT tags (90.0%) indicated that the smolts were of hatchery origin, one wild of unknown run origin. PTAGIS queries further revealed that the hatchery Chinook PIT tag recoveries consisted of 7 Fall Chinook, 8 Spring Chinook, 3 Summer Chinook. Finally, PTAGIS queries revealed that the other 4 ingested PIT tag recoveries consisted of 1 hatchery summer Sockeye, 1 hatchery summer Steelhead, 1 hatchery Coho, and 1 unknown PIT tag recovery (not found in PTAGIS and generally referred to as “orphan”).

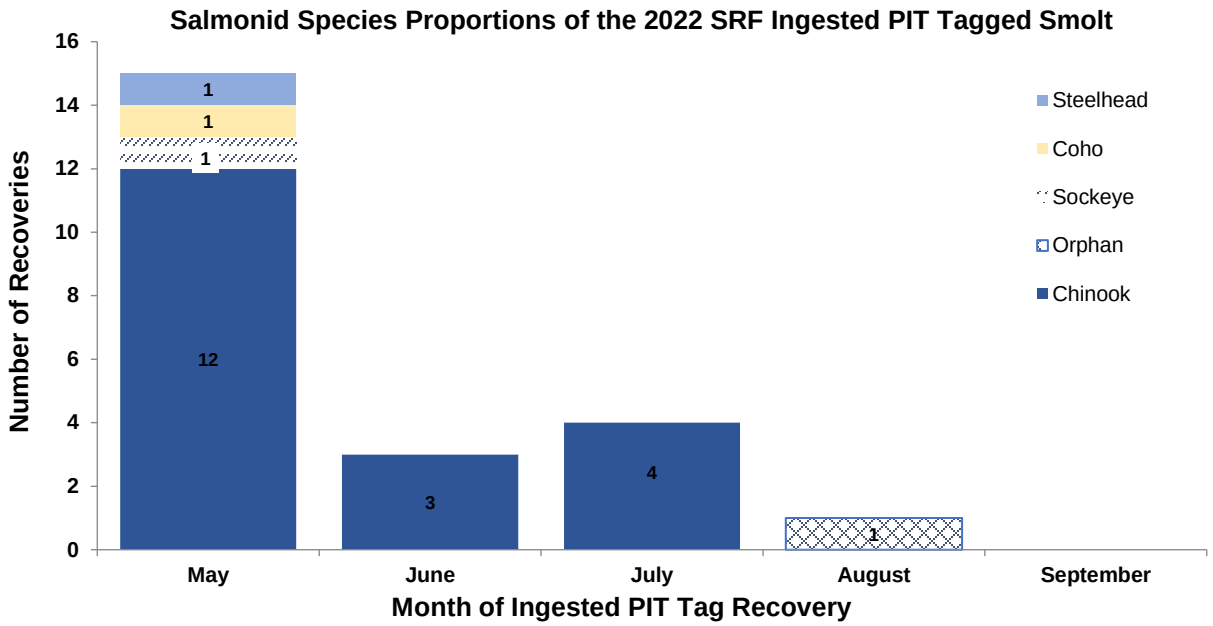


Figure 28. Recoveries of ingested Salmonid PIT Tags from the 2022 NPSRF

Analysis of PIT tag recovery data from the 2022 NPSRF continues to document actual Northern Pikeminnow predation on downstream migrating juvenile salmonids and identify 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 2022 NPSRF season resulted in a significant improvement in harvest from the previous two seasons which had marked the lowest harvest points in the program's 30+ year history. It also continued to be challenging, from an angler effort point of view since angler effort declined despite favorable river conditions which improved 2022 angler success. CPUE was the highest in NPSRF history, where angler CPUE at all three tier levels increased (from 2021), but since there was a decline in the number of individual anglers at each tier level, the 2022 NPSRF was unable to take full advantage of the conditions.

While total 2022 NPSRF harvest was still below 1991-2021 average annual harvest (165,488), the 2022 NPSRF once again succeeded in achieving the NPMP's 10-20% exploitation goal as it has for every year (since 1997), with 2022 exploitation estimated to be 14.9% for the year. NPSRF harvest in 2022 reversed the downward trend of the past two years and was 50,000 more fish higher than 2021 harvest (which was the lowest in NPSRF history).

Annual angler effort in 2022 decreased by 972 angler days from 2021 while the number of individual anglers decreased by 433 anglers (359 of which were unsuccessful anglers).

CPUE increased from 7.75 in 2021 to 13.27 in 2022 (Winther et al. 2022). For the first time in NPSRF history, peak weekly harvest occurred during week 36 (Sept 5th-11th), rather than during the peak of the spawn which is typically in week 26. Peak weekly effort occurred during week 21 of the 2022 season, and nearly matched again in week 26. The Boyer Park registration station was the NPSRF's top station for harvest in 2022 (21,862 fish) and The Dalles registration station accounted for the station with the most angler effort with 2,278 angler days of effort spent.

We recovered only 37 Northern Pikeminnow with external spaghetti or Floy tags in 2022 as ODFW discontinued use of external tags in favor of exclusively using PIT tags in order to conduct the NPMP's biological evaluation. We recovered an additional 140 Northern Pikeminnow which had no external tags but did retain ODFW PIT tags (formerly "tag-loss"). Mean fork length for Northern Pikeminnow harvested in the 2022 NPSRF was 263 mm, down from 278 mm in 2021 (Winther et al. 2022). Incidental catch consisted primarily of Peamouth, Smallmouth Bass, and Sculpin, reflecting a similar pattern seen in past NPSRF seasons.

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 decreased to 1:6,092 4902 in 2022 versus 1:1,990 in 2021, and species composition of the 23 ingested PIT tags recovered from harvested Northern Pikeminnow indicated 19 were from Chinook smolts, 18 being of hatchery origin and 1 of wild origin. There were also 1 hatchery Steelhead, 1 hatchery Sockeye and 1 hatchery coho recorded according to PTAGIS.

RECOMMENDATIONS

1.) Continue to evaluate the use of "standardized season dates (May 1st-Sept 30th) for implementation of the 2023 NPSRF in order to identify feasibility of opening a limited number of stations where high harvest may be typically available during the first weeks of the season, prior to May 1st. Early opening stations (as the NPSRF did in the 1990's) may enhance Northern Pikeminnow harvest opportunities, increase program efficiency, and improve exploitation estimates for some areas by operating the SRF during earlier dates when exploitable numbers of predatory Northern Pikeminnow may be more available to anglers.

2.) Continue to implement and evaluate angler incentives such as the $6 base reward level used in 2022 as an incentive designed to recruit new anglers to the 2023 NPSRF. Continue to utilize the standard Tier levels used in 2022 which were designed to incentivize current, proficient, knowledgeable anglers to expend additional effort participating in the 2023 NPSRF.

   a) Review NPSRF station times and routes for efficiencies which may allow adding additional stations (or increased station hours) and provide additional angler opportunities for participation. Consider reinstituting and evaluating use of the

"satellite" station concept first used in the 1994 SRF for limited times and durations as a means to increase SRF efficiency and angler outreach.

b) Continue use of angler clinics, coupons, and sport shows as tools to recruit new anglers and promote NPSRF awareness.

c) Continue to develop video content for use in improving angler education, NPMP awareness through the use of Facebook, Instagram and other online/ social media as a means to maintain or increase NPM harvest.

3.) Review NPSRF Rules of participation as needed, adjusting to the dynamics of the fishery (especially related to new phone app angler registration) 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. Investigate the feasibility of using PIT tag scanners to communicate with Ipad type devices for data collection.

5.) Continue to evaluate the use Floy tags as external promotional tags deployed by WDFW on Northern Pikeminnow as an angler incentive (given the ODFW decision to discontinue their use of external spaghetti/floy tags as part of the NPMP's biological evaluation.

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

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REPORT B

Northern Pikeminnow Sport-Reward Payments

2022 Annual Report

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March 2023

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 2022, the tier rewards paid to anglers were increased from the previous season's $5, $6 and $8 per fish. There was not an early startup or season extension and there were no late season increases to the dollar amount paid to eligible or verified specially-tagged Northern Pikeminnow. All vouchers issued from May 1 through September 30, 2022 were paid at $6, $8 and $10 per fish for the three payment tiers (1-25 fish, 26-200 fish and 201-up). The rewards for tagged fish were $200 per fish with a PIT tag only and $500 per fish with an external tag.

A total of 139,188 fish were paid at the standard payment tiers (excluding coupon amounts, tagged fish and tag-loss bonus payments). The season total reward paid for these fish was $1,316,928.

A combined total of 37 tagged fish (having an external spaghetti or floy tag) were paid in 2022. The season total paid for tag rewards was $18,500.

A total of 141 tag-loss fish (external tag missing but still possessing a verifiable PIT tag or PIT tag only as of 2022) were paid a *bonus* reward of $200. The season total paid for tag-loss *bonus* was $28,200.

A total of 377 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 $3,770.

A total of 1,175 separate anglers registered to fish, of which 445 (38%) caught one or more fish and received payments during the season. The total value for all 139,225 Northern Pikeminnow submitted for payment in 2022 (including all coupons, tagged fish and tag-loss *bonus* payments) was $1,367,398.

INTRODUCTION

The **Northern Pikeminnow Sport Reward Program** was again administered by PSMFC in 2022. 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) and is funded by the Bonneville Power Administration (BPA). WDFW was responsible for the sport-reward registration/creel check stations throughout the river, handled all fish checked in to the program, externally tagged fish for promotional purposes 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, contractual, fiscal and administrative oversight for all segments of the Program and processed all reward vouchers for the sport-reward anglers.

THE 2022 SEASON

The 2022 Northern Pikeminnow Sport-Reward Fishery started May 1 and ran through September 30. The season was characterized by below average catch and effort and above average catch per unit effort. Of the 140,121 pikeminnow vouchered, 139,225 (99.4%) were successfully submitted for payment. Tier 1 anglers harvested 1,631 (1.2%) of the total paid. Anglers that obtained Tier 2 status by the end of the season harvested 8,875 (6.4%) of the total paid. Anglers that obtained Tier 3 status by the end of the season harvested 128,719 (92.4%) of the total paid.

Four hundred forty-five anglers successfully submitted vouchers for payment by the November 15 deadline. Out of the 231 (52.0%) Tier 1 anglers paid, 176 caught ten or less pikeminnow. One hundred fourteen (25.6%) anglers paid achieved Tier 2 status by the end of the season and 100 (22.4%) achieved Tier 3 status by the end of the season. The top 20 anglers caught 72,365 (52.0%) of all pikeminnow paid and earned $734,492 (53.7%) of the total funds disbursed.

PSMFC distributed $1,367,398 (79.8%) of the $1,714,000 Sport-Reward fund to anglers participating in the program. Of the funds distributed, $41,868 (3.1%) were paid at the Tier 1 rate ($6/fish), $188,160 (13.7%) at Tier 2 ($8/fish) and $1,086,900 (79.5%) at Tier 3 ($10/fish) for successful submission of a standard voucher. Another $50,470 (3.7%) in Sport-Reward funds were paid out for tag vouchers, tag loss fish and one-time bonus coupons.

ONE-TIME $10 BONUS COUPON

Prior to the opening of the season, “coupon” postcards were mailed to anglers in the pikeminnow database who participated in the program within the past 3 years (2019 – 2021) and to those who signed up for our mailing list at the various sportsmen’s shows. The 2022 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 377 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 $3,770.

PARTICIPATION AND PAYMENT

A total of 574 anglers who registered were successful in catching one or more fish in 2022. Of those anglers; 445 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 2022 a total of 140,121 fish were harvested in the sport-reward fishery. Of this total, 139,225 (99%) fish were submitted for payment and paid prior to the 2022 payment deadline. To obtain payment, vouchers must have been received no later than November 15, 2022. In addition, any *received* vouchers with issues preventing payment (missing information, voiding of voucher for program violations, etc.) that had not been resolved by November 15, 2022 became null and void.

TAGGED FISH AND PAYMENTS

Registered anglers caught and submitted a total of 37 tagged fish (showing an external spaghetti or floy 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 then the angler's responsibility to 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 $18,500.

TAG-LOSS BONUS PAYMENT

Prior to 2022, all tagged northern pikeminnow initially have both a spaghetti/floy 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/floy tag. 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/floy tag, the fish was considered a *standard* fish (and paid at the standard tier rate of $6, $8, and $10 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 $200 *bonus* check and congratulatory letter which included the tagging date and approximate area of release. As of 2022, ODFW began a PIT tag only protocol. These PIT tag only fish were paid at the same bonus rate as tag-loss fish. A total of 141 tag-loss fish qualified for and were paid the *bonus* reward of $200. The season total paid for tag-loss *bonus* was $28,200.

TOTAL ACCOUNTING

Total payments for the season of regular vouchers, *$10 bonus coupons,* tag vouchers and *tag-loss bonus* payments were $1,367,398.

All IRS Form 1099-NEC Statements were sent to the qualifying anglers for tax purposes on January 20, 2023. Appropriate reports and copies were provided to the IRS on January 13, 2023.

A summary of the catch and rewards paid, including information on the "top 20" anglers, is provided in Table 1. For further information contact Allan Martin, PSMFC, Field Programs Administrator at (503) 595-3100 or email at DMartin@psmfc.org.

2022 SPORT REWARD PAYMENTS SUMMARY

The following is a summary of all vouchers received and paid in 2022

	Fish	Incentives	Reward
Fish paid @ tier 1 ($6 each):	6,978	-	$41,868
Fish paid @ tier 2 ($8 each):	23,520	-	$188,160
Fish paid @ tier 3 ($10 each):	108,690	-	$1,086,900
Tags paid (@ $500 each):	37	-	$18,500
Coupons issued (@ $10 each):	-	377	$3,770
Tag-loss issued (@ $200 each):	-	141	$28,200
Total:	139,225		$1,367,398

Anglers @ tier 1	*231*
Anglers @ tier 2	*114*
Anglers @ tier 3	*100*
Number of separate anglers	*445*

Anglers with 10 fish or less:	*176*
Anglers with 2 fish or less:	*69*

	Total Fish	$500 Tags	Tag Loss	Coup.	Total Reward
1.	6,858	1	$ 600	$ 10	$ 69,230
2.	6,328	1	$ 400	$ 10	$ 63,730
3.	5,644	0	$ 200	$ 10	$ 56,200
4.	5,379	2	$ 200	$ -	$ 54,520
5.	4,147	1	$ 1,800	$ 10	$ 43,320
6.	4,264	0	$ 400	$ 10	$ 42,600
7.	3,856	0	$ 2,400	$ 10	$ 40,520
8.	3,689	2	$ -	$ 10	$ 37,430
9.	3,497	0	$ 800	$ 10	$ 35,330
10.	3,176	0	$ 1,200	$ 10	$ 32,520
11.	2,921	3	$ 400	$ 10	$ 30,640
12.	2,916	1	$ 800	$ 10	$ 30,010
13.	2,710	2	$ 200	$ 10	$ 27,840
14.	2,642	1	$ 800	$ -	$ 27,260
15.	2,726	0	$ 200	$ 10	$ 27,020
16.	2,562	0	$ 200	$ -	$ 25,370
17.	2,346	2	$ 200	$ -	$ 24,192
18.	2,334	0	$ 400	$ 10	$ 23,300
19.	2,357	0	$ -	$ 10	$ 23,130
20.	1,997	0	$ 800	$ 10	$ 20,330
	72,349	16	$ 12,000	$ 160	$ 734,492

NORTHERN PIKEMINNOW SPORT-REWARD FISHERY VOUCHER

2022 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 | DOCUMENT # | STATION

2022

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 11/15/22.*****
[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

2022 TAG

LAST NAME | FIRST NAME | MI

ADDRESS

CITY | STATE | ZIP CODE

ANGLER TELEPHONE NUMBER – –

TAG VOUCHER #

MONTH | DAY | 2022

DOCUMENT #

STATION | FISH LOC | EXTERNAL TAG # | TAG TYPE (S/F) | FORK LENGTH

PIT TAG #

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

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 11/15/22.

[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 RULES AND REGULATIONS

Anglers participating in the Northern Pikeminnow Sport-Reward Fishery must adhere to each of the following rules:

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

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

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

4) Provide true and accurate information to authorized program representatives regarding the taking, possession, delivery, transportation, sale, transfer or any other use of fish caught while participating in the Northern Pikeminnow Sport-Reward Fishery.

5) Comply with the directions of authorized program personnel related to the collection of sampling data and angler participation in the Northern Pikeminnow Sport-Reward Fishery.

6) Mail in all reward vouchers within 30 days of the end of each year's fishery. To obtain payment, vouchers must be received no later than Nov. 15, 2022. Any issues preventing payment (missing information, voiding of voucher for program violations, etc.) must be resolved by Nov. 15, 2022 or the voucher becomes null and void.

7) Fish must have been caught in the mainstem Columbia River from the mouth up to the restricted zone below Priest Rapids Dam, or in the Snake River from the mouth up to the restricted zone below Hells Canyon Dam. The "mainstem" includes backwaters, sloughs, and up tributaries 400 feet from the tributary mouths. "Tributary mouth" is as defined by state fishing regulations.

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

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

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

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

12) Violation of any of the above rules may result in disqualification from the Northern Pikeminnow Sport-Reward Fishery.

Report C

System-wide Predator Control Program: Fisheries and Biological Evaluation

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ABSTRACT

Since 1990, the Northern Pikeminnow Management Program (NPMP) has applied targeted 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 2022, the Oregon Department of Fish and Wildlife (ODFW) evaluated the continued efficacy of the Northern Pikeminnow removal program and assessed potential outcomes of the fisheries through a combination of field activities, laboratory work, and data analyses. This report augments historical information with current data and seeks to: 1) estimate rates of targeted fisheries exploitation of Northern Pikeminnow and the concomitant reduction in juvenile salmonid predation; 2) characterize population parameters of Northern Pikeminnow, Smallmouth Bass (*Micropterus dolomieu)*, and Walleye (*Sander vitreus)* in the John Day Reservoir; and 3) assess evidence of possible intra- and inter-specific compensatory responses by Northern Pikeminnow, Smallmouth Bass, and Walleye related to the sustained removal of Northern Pikeminnow from the lower Columbia and Snake rivers. To quantify exploitation during 2022, standardized boat electrofishing was used to collect, 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 FL during 2022 was 14.9% (± 5.9%, 95% confidence interval). Based on this level of exploitation, modeled results predict that predation by Northern Pikeminnow in 2023 will be reduced by 34% (range: 11–47%), relative to pre-program levels. These metrics suggest that NPMP continues to be successful to reduce predation on juvenile salmonids by Northern Pikeminnow. Fisheries independent biological evaluation was conducted during spring in the John Day Reservoir to generate additional information about trends in the indices of abundance, consumption, and predation for Northern Pikeminnow and Smallmouth Bass. An index of abundance was also estimated for Walleye. These indices were broadly showing declines in Northern Pikeminnow and increases in Smallmouth Bass and Walleye prior to 2022. These trends were broadly supported during 2022 biological evaluation, providing evidence that the piscine predation dynamics in the John Day Reservoir may be changing. NPMP continued to effectively restructure the Northern Pikeminnow population to reduce predation on out-migrating salmonids by more than 30%. Fisheries independent data provided a means to assess long-term trends in population structure and potential compensatory responses among Northern Pikeminnow, Smallmouth Bass, and Walleye. This information provides the region with an important piscine predation reduction tool as well as fisheries management relevant information about three piscine predators to out-migrating juvenile salmonids.

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 multiple factors, including habitat degradation and overexploitation (Nehlsen et al. 1991; Wismar et al. 1994), and hydroelectric and flood control activities (Raymond 1988). Predation on out-migrating juveniles was also identified as a significant factor in adult salmon returns (Rieman et

al. 1991; Collis et al. 2002). Escalating concern in the 1980s surrounding the impacts of predation on juvenile salmon prompted researchers to further examine the degree to which predation, especially by resident fishes, may constrain juvenile salmon survival in the Columbia River Basin. 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 upper reaches of the reservoir were 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) the John Day Reservoir supported substantial populations of resident predatory fishes (Poe and Rieman 1988). Based on existing information (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 the John Day Reservoir provided evidence that the native Northern Pikeminnow was the most abundant and dominant predator on juvenile salmon, accounting for the majority of predation-related mortality observed during the study period (Beamesderfer and Rieman 1991; Poe et al. 1991; Rieman et al. 1991; Vigg et al. 1991).

While data indicated predation by Northern Pikeminnow contributed appreciably to juvenile salmon mortality in the John Day Reservoir, questions remained surrounding impacts of Northern Pikeminnow predation in other areas of the lower Columbia and Snake rivers. To answer these questions, indices were developed to allow rapid assessment of predation by Northern Pikeminnow throughout the system. From 1991 through 1993, researchers applied these indices to data collected in the lower Columbia River reservoirs (1990 and 1993), the Columbia River downstream of Bonneville Dam (1991), and lower Snake River reservoirs (1992) to characterize abundance, consumption, and predation (Ward et al. 1995). Results from these evaluations showed temporally variable predation by Northern Pikeminnow on juvenile salmonids was problematic in areas throughout the lower Columbia and Snake River reservoirs. Management strategies aimed at decreasing predation on juvenile salmonids were examined, according to the premise that persistent exploitation of Northern Pikeminnow (i.e., 10–20% per year) could lead to 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, 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. The Oregon Department of Fish and Wildlife (ODFW) is responsible for Objective 2 through standardized monitoring techniques in the Columbia and Snake rivers. This sampling has been ongoing at monitoring locations since the early 1990s. The data collected through these monitoring efforts have been used to evaluate the efficacy of targeted removals to reduce predation and assess possible compensatory consequences (e.g., intra- and inter-specific responses to management actions) that may be related to sustained removals of Northern Pikeminnow. Additionally, ODFW in collaboration with the Washington Department of Fish and Wildlife (WDFW) and the Pacific States Marine Fisheries Commission (PSMFC) has monitored the population of the native predator, Northern Pikeminnow, for signs of significant population declines related to the predation control program. There are two current Northern Pikeminnow predator removal strategies being incorporated by NPMP, both managed by WDFW. The first

involves a reward based recreational angler fishery, known as the Sport Reward Fishery (SRF). The second involves WDFW staff directly removing Northern Pikeminnow from areas with high concentrations of these predators below the powerhouse turbine outflows in the tailrace of The Dalles Dam and the John Day Dam, known as the Dam Angling Fishery (DAF). More details on SRF and DAF removal fisheries can be found in reports A and D, respectively.

ODFW evaluates the efficacy of the predator removal efforts and fish population parameters through a combination of field and laboratory studies incorporating data obtained throughout the Columbia and Snake rivers in the states of Oregon, Washington, and Idaho (Fig. 1). Broadly, ODFW estimates Northern Pikeminnow exploitation from SRF and DAF, salmonid predation reduction, and curation of long-term data to assess predator population trends. ODFW relies on data collected through independent activities within the Agency as well as biological samples acquired through SRF and DAF. ODFW field activities span two field studies. The first field study was designed to tag Northern Pikeminnow to incentivize the SRF and inform a mark/recapture-based estimate of exploitation from SRF and DAF (fisheries evaluation). The second field study was designed to obtain fisheries independent assessments of abundance and provide predator digestive material used to estimate prey consumption for Northern Pikeminnow, Smallmouth Bass, and Walleye (biological evaluation). Laboratory techniques were applied to quantify gut contents used to inform indices of consumption and predation as well as to address the question of predator compensation due to continued exploitation of Northern Pikeminnow.

ODFW biological monitoring efforts deviated from the historical pattern during the 2022 season. Specifically, The Dalles Reservoir was not sampled to allow ODFW to double the spring biological evaluation efforts in the John Day Reservoir. This approach was implemented to generate a larger data set from the John Day Reservoir which has shown patterns in declining Northern Pikeminnow indices of abundance, consumption, and predation with concurrent increases in Smallmouth Bass indices of abundance, consumption, and predation, as well as increases in the Walleye index of abundance. Given the history of the John Day Reservoir as the 'model' reservoir used to guide the establishment of NPMP, it was determined that additional sampling could elucidate whether these trends were more likely due to previously small sample sizes or representative of accurate trends in interspecies patterns in abundance, consumption, and predation.

This report augments historical information with data collected in 2022 from areas of the Columbia and Snake rivers and evaluates spatiotemporal changes of fish population parameters and their relation to reductions in juvenile salmonid predation from SRF and DAF activities where possible. Specific goals for this reporting period were to:

(1) Estimate rates of exploitation of Northern Pikeminnow and quantify potential predation reduction resulting from the targeted removal fisheries;
(2) Characterize population parameters of Northern Pikeminnow, Smallmouth Bass, and Walleye in the John Day Reservoir.
(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

Sport Reward Fishery Evaluation and Predation Reduction Estimates

Field Procedures

Boat electrofishing was used to collect and tag Northern Pikeminnow 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 158 (upper reaches of Little Goose Reservoir) to rkm 251 (near Asotin, WA) upstream of Lower Granite Dam (Fig. 1). Sampling consisted of four 900 s electrofishing transects within each 1.61 river kilometer. ODFW researchers conducted sampling during 2022 using Smith-Root™ 18-EH model electrofishing boats equipped with a 5.0 or 7.5 generator powered pulsator electrofisher powered by a Kohler Power Systems™ gas generator and one Smith-Root electrofishing boat equipped with an Apex™ electrofisher powered by an air-cooled Honda generator. When engaged, the electrofishing unit applies pulsed direct current at a rate of 60 pulses/s to maximize capture efficiency with minimal injury to fishes. Two boom arms extend forward from the bow of each boat, each supporting an array of six electrodes that functions as an anode. Electrodes hanging from the boat and the hull itself, function as the cathodes. Electrofishing controls were set according to federal guidelines for waters containing ESA listed salmonids where peak output does not exceed 800 V at water conductivity 100 to 300 µS/cm (NMFS 2000). The targeted average electrical current during all electrofishing events was 3–4 A. All controls were standardized across boats with minor adjustments to the duty cycle and/or voltage to achieve the targeted output. Electrofishing protocols were followed to minimize fish exposure to electric current yet induce uncontrolled swimming toward the anode (electrotaxis) and avoid intense muscle contraction to the point of becoming stiff (tetany). Additionally, protocols were developed and implemented to reduce interactions with species listed under the U.S. Endangered Species Act to guide sampling efforts. These protocols included, but were not limited to, discontinuing electric current when encountering listed species, or terminating sampling transects when encountering 500 or more out-migrating juvenile salmonids or 50 adult salmonids.

Sampling occurred along shallow shoreline areas as the effective range of boat electrofishing was limited to an approximate maximum depth of 3 m. The timing of sampling ranged from 17 March to 9 June 2022 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 daytime sampling was necessary to navigate safely. ODFW preponed the 2022 sampling season in an effort to reduce interactions with out-migrating juvenile salmonids. Three rkm in the area below Bonneville Dam; 43.5 rkm in McNary Reservoir; 45 rkm in Little Goose Reservoir; and 27 rkm in Lower Granite Reservoir were dropped from sampling due to equipment malfunction or weather-related constraints. When weather or other reasons required, sampling was strategically adjusted to eliminate sampling areas with historically low rates of tag deployment. Ideally, all tagging activities would have concluded before the SRF and DAF began. However, that was unachievable due to time constraints and the extent of the sampling area. All fish captured in the Bonneville Reservoir were tagged prior to the start of the fisheries (1 May 2022). ODFW discontinued tagging efforts in John Day Reservoir following the 2019 season and in The Dalles Reservoir following the 2021 season due to continued declines in electrofishing catch. These declines made it infeasible to continue fishery evaluation tagging because of time and budget constraints. Due to inclement weather, Northern Pikeminnow were tagged concurrent with the fisheries in upper

reaches of the area below Bonneville Dam (historically tagged prior to SRF), in addition to all areas above McNary Dam on both the Columbia and Snake rivers.

Northern Pikeminnow ≥ 200 mm fork length (FL) were tagged with an internal 134.2 MHz passive integrated transponder (PIT) tag injected into the dorsal sinus cavity (Fig. 2). In 2022, ODFW initiated a PIT tag only marking strategy in which Northern Pikeminnow were not tagged externally. This strategy was deployed in an effort to increase survival of marked fish and increase our recapture rate through increased tag retention and fish survival. During Northern Pikeminnow tagging operations, Walleye were also captured, measured, and weighed in these areas to gain better understanding of their populations by assessing size distributions (PSD, PSD-P) and condition (relative weight) and to supplement data collected during biological evaluation activities (see below).

Working with WDFW, tag recovery information was obtained from the SRF and DAF (Report D). The SRF occurred daily from 1 May to 2 October 2022 (Report A). Participating anglers received payment for all harvested Northern Pikeminnow ≥230 mm (9 in) total length (TL). This size criterion for TL corresponds to the minimum FL (200 mm) of Northern Pikeminnow marked during tagging operations. The 2022 reward payment schedule consisted of three tiers (see Report B for details). Further, anglers were eligible for a $500 reward for each externally tagged fish returned to a check station and a $200 reward for each "tag-loss" fish (i.e., 2022 PIT tag only fish or fish tagged prior to 2022 for which an external tag had been lost in the environment but retained a functioning PIT tag). It was assumed 100% of the Northern Pikeminnow marked with an external and/or an internal PIT tag harvested by participating anglers were submitted to a check station for reward payment during the season.

The DAF operated from 23 May to 23 September 2022 (Report D) in the powerhouse tailraces of The Dalles and John Day dams and used a team of anglers with hook-and-line fishing gear to remove Northern Pikeminnow. WDFW personnel examined all fish for the presence of external tags (loop and T-bar) and PIT tags. Tagged Northern Pikeminnow removed in the DAF were accounted for when estimating exploitation rates for the SRF.

Data Analysis

Sport Reward Fishery Exploitation

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 inches TL (≥ 278 mm TL; ≥ 250 mm FL) to 9 inches TL (≥ 230 mm TL; ≥ 200 mm FL) beginning in the year 2000, rates of exploitation were calculated for three size-classes: 1) ≥ 200 mm FL (all 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 a known bias into area-specific estimates of annual exploitation, two different models were applied; 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 concurrent with the fishery (Styer 2003). Under each of these scenarios, estimated rates of

exploitation were calculated 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, the rate of exploitation (u) of the population was calculated using the Petersen estimator (Ricker 1975) as:

$$u_j = \frac{R_j}{M_j}, \quad (1)$$

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 with a cash reward, and since that time a correction for tag retention has not been applied to exploitation estimates.

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

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

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 were concurrent, each week was treated as a separate sampling period according to the function:

$$u_{weekly_j} = \frac{R_{ij}}{M_{ij}}, \quad (3)$$

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 SRF.

To account for the positive bias associated with insufficient mixing, fish that anglers recaptured during the same week they were tagged were excluded 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, a multiple sample approach was applied as follows:

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

where

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

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

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

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.

Predation Reduction

Indirect measures of predation reduction were used to evaluate the efficacy of Northern Pikeminnow removals (Beamesderfer et al. 1996) due to numerous confounding factors that limit the ability to measure success in terms of increased number of juvenile salmonids reaching the estuary or returning as adults. A model based on Friesen and Ward (1999) was implemented to estimate changes in predation on juvenile salmon that have occurred since before the onset of the program. The model was designed to estimate the effects of the NPMP on predation of juvenile salmonids if all other factors were held constant (e.g., river and ocean conditions, number of migrating juvenile salmonids, passage conditions/mortality at dams). The model also assumed no compensation by non-native predators and remaining Northern Pikeminnow. That assumption was assessed through the biological evaluation. The model estimated 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 and recruitment, (4) area- and size-specific abundance estimates, and (5) area- and size-specific estimates of seasonal consumption of juvenile salmon by Northern Pikeminnow (Friesen and Ward 1999). The details for these components were:

1. Northern Pikeminnow population size (length) structure before SRF and DAF removals were simulated using length-frequency distributions in each reservoir (Parker et al. 1995; Knutsen and Ward 1999).

2. Area specific exploitation rates were calculated as described above for the area below Bonneville Reservoir, the pooled Columbia River reservoirs and the pooled Snake River reservoirs. Relationships between exploitation and length of Northern Pikeminnow were used to estimate age-specific exploitation rates (Friesen and Ward 1999). Age increments

were changed to 15 mm FL increments based on measured annual growth from mark recapture information (Weaver et. al 2008).

3. A linear regression on a growth curve, constructed from adjusted age frequencies (Ricker 1975), was used to estimate natural mortality (0.611 for area below Bonneville Reservoir, 0.62 for impounded Columbia and Snake River reservoirs) and mean index of recruitment to age five or 240 mm FL (Friesen and Ward 1999).

4. Area specific size structure was adjusted over time for exploitation and natural mortality using equation 6:

$$A_{h+j} = A_{h-1,j-1}\left(1 - E_{(h-1,j-1)}(1 - M)\right), \quad (6)$$

where

A_{h+j} = abundance index for size-h fish in year j,

$A_{h-1,j-1}$ = abundance index of fish size h -1 in year j –1,

$E_{h-1,j-1}$ = exploitation rate of fish size h –1 in year j –1, and

M = annual natural mortality rate.

5. Consumption information from 1990 to 1996 was collected and the consumption index as calculated below in equation (7) was converted to consumption rates:

$$C = -0.077 + 0.618(CI) \quad (7)$$

where

C = number of juvenile salmonids per Northern Pikeminnow per day

CI = consumption index

Separate size and area specific consumption rates were calculated for the area below Bonneville Dam, the combined Columbia River reservoirs, and the combined Snake River reservoirs.

Using these five model components, consumption rates for each size class were multiplied by the abundance index and the number of days in each season (Spring 91, Summer 62) to get a loss index by season and area. Summing loss by season and area estimated the total loss for the year for all areas contained within the NPMP. Relative predation was calculated by subtracting the overall loss index in the current year and divide it by the 1990 overall loss index and multiply by 100.

PSD, Fishery Evaluation and DAF

Rates of exploitation of Northern Pikeminnow increase with increasing fish size (Zimmerman et al. 1995). A model describing proportional size distribution (PSD; Anderson 1980; Guy et al. 2007) was fit to characterize variation in size structure for Northern Pikeminnow to three groups; those sampled during fishery evaluation, biological evaluation, and from the DAF. Models describing PSD for Walleye populations sampled during both fishery and biological evaluation; and Smallmouth Bass sampled during biological evaluation were applied using the equation 8:

$$PSD_i = 100 \times \frac{FQ_i}{FS_i}, \quad (8)$$

where

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

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

Proportional Size Distribution, preferred length (PSD-P), Fishery Evaluation and DAF

Proportional size distribution of preferred-length fish (PSD-P) was calculated for Smallmouth Bass and Walleye (Gabelhouse 1984; Guy et al. 2007) sampled during fishery and biological evaluation using equation 9:

$$PSD - P_i = 100 \times \frac{FP_i}{FS_i}, \quad (9)$$

where

FP_i = number of fish ≥ preferred-length for species *I*, and

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

Stock and quality minimum length categories used for Northern Pikeminnow were 250 and 380 mm FL, respectively (Beamesderfer and Rieman 1988; Parker et al. 1995). Stock, quality, and preferred minimum length categories were collected from the literature (Anderson 1980; Gabelhouse 1984) and converted them to FL measurements using a species-specific model for Smallmouth Bass ($FL_{SMB} = TL_{SMB} / 1.040$). The published stock-length measurement is smaller than our target size (200 mm FL) for Smallmouth Bass. To remove any bias in our data from variation in sampling procedures among years, our target size was used as the minimum stock-length for PSD and PSD – P analyses. Thus, stock, quality, and preferred minimum FL categories

for Smallmouth Bass were 200, 269, and 337 mm, respectively. Similarly, using published categories (Anderson 1980; Gabelhouse 1984) and the species-specific model for Walleye (FL_{WAL}= TL_{WAL}/1.060), these categories were calculated as 236, 358, 481 mm FL, respectively. 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, a non-parametric bootstrap approach using the 'boot' package (Fox and Weisberg 2011) in the R programming environment (R Core Team 2021) was used to calculate 95% confidence intervals. Temporal monotonic trends were calculated for PSD of Northern Pikeminnow and PSD and PSD-P of Walleye by applying a non-parametric Mann-Kendall test (Mann 1945). 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. Significant differences were assessed at $\alpha \leq 0.05$.

Relative Weight (W_r), DAF

Relative weight (W_r) (Wege and Anderson 1978) was calculated to compare the condition of Northern Pikeminnow over time. Length-specific standard weights predicted by a length-mass regression model ($\log_{10}[W_s]=a'+b\cdot\log_{10}[L]$) were used for Northern Pikeminnow (Parker et al. 1995) to calculate W_r according to equation (10):

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

where

W = the mass of an individual fish, and
W_s = predicted standard weight.

To account for sexual dimorphism, male and female W_r values were calculated separately for Northern Pikeminnow. Additionally, these analyses only included fishes that met minimum target sizes, 250 mm FL for Northern Pikeminnow. Annual median W_r values were calculated only when sample sizes exceeded four target sized fish in a given reservoir and by sex for Northern Pikeminnow. 95% confidence intervals were estimated for median W_r values using a non-parametric bootstrap approach (Fox and Weisberg 2011; R Core Team 2021).

Temporal monotonic trends in median W_r were assessed for Northern Pikeminnow by applying a non-parametric Mann-Kendall test (Mann 1945). Spline interpolation was used to account for data gaps, when present. Last, to help visualize trends, locally weighted scatterplot smoothing (LOWESS) curves were fit 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. Significant differences were assessed at $\alpha \leq 0.05$.

DAF Consumption Index (DAF-CI)

Consumption indices provide a proxy of the number of juvenile salmon eaten per day by an average predator. Previous work has demonstrated that the output values are correlated with consumption rates for Northern Pikeminnow (Ward et al. 1995). An index of consumption for DAF fish (DAF-

CI) was calculated for each week of DAF using the model of Ward et al. (1995) for Northern Pikeminnow (CI_{NPM}) using the equation 11:

$$\boldsymbol{CI_{NPM} = 0.0209 \times T^{1.60} \times W^{0.27} \times (S \times GW^{-0.61})}, \quad (11)$$

where

T = mean water temperature per week stratum (^{o}C),

W = mean predator mass (g),

S = mean number of juvenile salmon per predator, and

GW = mean diet mass (g) per predator.

Water temperature data were downloaded from the Columbia River Operational Hydrometeorological Management System. CI-DAF was calculated when sample sizes exceeded five fish, per week, per dam.

Biological Evaluation

Field Procedures

Standardized boat electrofishing techniques were used to evaluate Northern Pikeminnow, Smallmouth Bass, and Walleye population parameters in the John Day Reservoir during 2022 (Ward et al. 1995; Zimmerman and Ward 1999). Sampling was conducted in the early morning (0200–1000 hours) during Spring (10 May–27 May 2022 in the forebay (rkm 347 – 354); mid-reservoir (rkm 387 – 394) and tailrace (rkm 461 – 469) of the John Day Reservoir. The objective was to analyze predatory fish diets, focusing on salmonid consumption. In order to account for low catch rates of Northern Pikeminnow in recent years, ODFW concentrated all 2022 biological monitoring efforts within the John Day Reservoir. The timing of this work was selected to correspond with peak smolt outmigration. Sampling locations were randomly selected fixed-site transects, approximately 500-m long, in each area along all shorelines of the river. Effort at each transect consisted of a 900-second boat electrofishing period with continuous output of approximately 3-4 A. Temperature (nearest 0.1°C) and minimum/maximum observed depth were recorded for each transect (nearest 0.1').

Species, FL (nearest mm), and mass (nearest 10 g) were recorded for all Northern Pikeminnow, Smallmouth Bass, and Walleye ≥200 mm. Target-sized Northern Pikeminnow that were not previously tagged were euthanized and the digestive tract was extracted for digestive tract content analysis in the laboratory. To remove NPM digestive tracts, an incision was made along the ventral midline from the pectoral fins to the vent. The digestive tract was removed by securing both ends with hemostats, removing extra tissue, and placing the complete digestive tract into individual Whirl-Pak bags. Digestive tracts were squeezed with forceps from one end to the other to extract the contents and water was added to reduce post-collection digestion. Sex and stage of maturity

were assessed by examining the gonads and scoring maturity from 0-4 with '0' representing a juvenile fish and '4' representing a mature fish that had recently spawned (spawned-out). Diet samples were collected from target-sized Smallmouth Bass and Walleye by a non-lethal gastric lavage method using a modified Seaburg sampler (Seaburg 1957). Gut contents were flushed from the foregut of each fish into a 425 µm sieve and then transferred into individual sample bags. For all species, diet samples were stored on ice while in the field and transferred to a freezer until processing.

Using the protocol described above, diet samples were also collected from Northern Pikeminnow captured during the 2022 DAF in Bonneville and The Dalles reservoirs. Diets were collected from a representative subsample of catches at each dam weekly from 23 May– 29 September, 2022, generally two days per week with a target of 20 fish per day at each dam. In addition, FL, mass, sex, and stage of maturity were recorded for each fish sampled.

Laboratory Procedures

Contents of diets from Northern Pikeminnow, Smallmouth Bass, and Walleye collected during biological evaluation field activities, and Northern Pikeminnow collected from the DAF were examined to quantify relative consumption of juvenile salmonids. Due to the large number of Smallmouth Bass diets collected, a random subsample of diets was selected and analyzed for each sampling area in the John Day Reservoir. Gut contents were subsampled so that the proportion analyzed were based on initial catch distribution by day and area. All Northern Pikeminnow and Walleye gut contents collected in the field during 2022 were processed in the laboratory.

Frozen field samples were thawed in the laboratory and the diet contents were sorted into general prey categories (i.e., fish, crayfish, other crustaceans, insects, other invertebrates, vegetation, miscellaneous). Parasitic invertebrates (e.g., tapeworms, nematodes, parasitic copepods) found in the diet samples were noted in our dataset comments, but they were not weighed, categorized as prey items, or included in the prey consumption calculations. Diet items were blotted with a paper towel to remove excess moisture and weighed to the nearest 0.01 g according to prey category. For Smallmouth Bass and Walleye, portions of diet samples containing fish were returned to the original sample bags for chemical digestion. To ensure complete recovery of diagnostic structures from Northern Pikeminnow diet samples, the entire digestive tract was chemically digested along with possible fish tissue. To chemically digest soft tissues, a 20 ml of solution of pancreatin (20 g/L) and sodium sulfide nonahydrate (Na_2O_9S; 10 g/L) in tap water was added to each sample. Next, sample bags were 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 dissolve remaining fatty materials and the sample was agitated. Contents of each sample bag were then poured into a 425 µm sieve and rinsed with tap water. In rare cases, the presence of fish was recorded during the initial sorting and weighing but no bones were found after chemical digestion. When this occurred, those bones were assumed lost, and therefore one unidentified fish was counted present in the sample (unless the taxon was identified during the preprocessing stage). Diet samples of fishes that did not contain any diet items (empty) were included in all statistical analyses.

Bones from prey items, post chemical digestion, were identified to the lowest possible taxon (typically family) using stereoscopic dissecting microscopes at 6.1x-55x magnification with 10x

eyepieces and standard keys (Hansel et al. 1988, Frost 2000, and Parrish et al. 2006). Paired structures were enumerated to arrive at minimum counts of a given prey taxon in a diet sample, but only presence/absence could be determined for certain prey items. For example, if ventral scutes of American Shad (*Alosa sapidissima*) were the only diet item present in a sample, it was assumed that one American Shad had been consumed because the total number of scutes associated with an individual fish is ambiguous. A similar assumption was made for instances where lamina of lampreys (family Petromyzontidae) were present in diet samples. Diet samples containing large numbers of juvenile shad bones were sampled to estimate the total number of shad using a subset of the diagnostic bones. The dentaries and parasphenoid bones were used as rapid identification diagnostic bones, allowing staff to process these samples in a fraction of the time needed for full diagnostic bone enumeration. Shad quantified in this way were identified in our database and the complete sample of bones was stored for future enumeration, should the need arise.

For samples where fish vertebrae were observed, it was possible to distinguish between salmonid and other fish prey; however, it was impossible to determine the exact number of juvenile salmon consumed. In these cases, it was assumed that one juvenile salmon was consumed to avoid artificially inflating the count. Given these constraints, diet data represent a conservative enumeration of prey fish within diet samples. Lastly, to calibrate identification accuracy among analysts, 10% of all samples were re-analyzed at random by a second reviewer.

Data Analysis

Biological Evaluation Abundance Index (AI)

Catch per unit effort (CPUE) was found to be the strongest index of abundance to correlate with mark recapture population estimates (Ward et al, 1995). Following the methods of Ward et al. (1995), seasonal abundance index values were calculated for each predator species using the mean CPUE of boat electrofishing by season and area, the surface area (ha) of the specific sampling locations in each river area, divided by 1,000 for scale using the equation 12:

$$AI_i = \frac{(D_i \times S_i)}{1{,}000}, \qquad (12)$$

where:

AI_i = abundance index for area *i*

D_i = density in area *i* as determined by mean CPUE and

S_i = surface size (hectares of area *i*)

Biological Evaluation Consumption Index (CI)

Consumption indices provide a proxy of the number of juvenile salmon eaten per day by an average predator and previous work has demonstrated that the output values are correlated with

consumption rates for Northern Pikeminnow (Ward et al. 1995) and Smallmouth Bass (Ward and Zimmerman 1999). An index of consumption (CI) was calculated using the models of Ward et al. (1995) and Ward and Zimmerman (1999) for Northern Pikeminnow (CI_{NPM}) and Smallmouth Bass (CI_{SMB}) using the equations 11 and 13:

$$CI_{\mathrm{SMB}} = 0.0407 \times e^{(0.15)(T)} \times W^{0.23} \times (S \times GW^{-0.29}), \qquad (13)$$

where

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

Water temperature data were either collected in the field (boat electrofishing) or downloaded from the Columbia River Operational Hydrometeorological Management System (DAF collected fish). CI was calculated when sample sizes exceeded five fish for a given species, season, and sampling area.

Biological Evaluation Predation Index (PI)

To quantify compensatory responses to removals, a predation index (PI) was developed to describe changes in the relative magnitude of predation on juvenile salmonids by Northern Pikeminnow (Ward et al, 1995) and Smallmouth Bass (Ward and Zimmerman, 1999). Currently, no comparable model exists to evaluate Walleye consumption and predation. Seasonal-and location-specific PI estimates were generated for Northern Pikeminnow and Smallmouth Bass using the product of seasonal AI and CI values (Ward et al. 1995) using equation 14:

$$PI_i = AI_i \times CI_i, \qquad (14)$$

where

PI_i = predation index for area *i*.

AI_i = abundance index in area *i*,

CI_i = consumption index in area *i*.

Proportional Size Distribution (PSD)

PSD was calculated for Northern Pikeminnow, Smallmouth Bass, and Walleye caught during biological evaluation using equation 8.

Proportional Size Distribution, preferred length (PSD-P)

PSD-P was calculated for Smallmouth Bass and Walleye (Gabelhouse 1984; Guy et al. 2007) sampled during biological evaluation using equation 9.

Stock and quality minimum length categories used for Northern Pikeminnow were 250- and 380-mm FL, respectively (Beamesderfer and Rieman 1988; Parker et al. 1995). Stock, quality, and preferred minimum length categories were collected from the literature (Anderson 1980; Gabelhouse 1984) and converted them to FL measurements using a species-specific model for Smallmouth Bass ($FL_{SMB} = TL_{SMB}$ /1.040). The published stock-length measurement was smaller than the target size (200 mm FL) for Smallmouth Bass from this study and to remove any bias in these data from variation in sampling procedures among years, the target size was used as the minimum stock-length for PSD and PSD – P analyses. Thus, stock, quality, and preferred minimum FL categories for Smallmouth Bass were 200, 269, and 337 mm, respectively. Similarly, using published categories (Anderson 1980; Gabelhouse 1984) and the species-specific model for Walleye ($FL_{WAL}= TL_{WAL}$/1.060), these categories were calculated as 236, 358, 481 mm FL, respectively. 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, a non-parametric bootstrap approach using the 'boot' package (Fox and Weisberg 2011) in the R programming environment (R Core Team 2021, Canty et al. 2021) was used to calculate 95% confidence intervals.

Relative Weight (W_r)

Relative weight (W_r; Wege and Anderson 1978) was calculated to compare the condition (within species) of Northern Pikeminnow, Smallmouth Bass, and Walleye over time. Length-specific standard weights predicted by a length-mass regression model ($\log_{10}[W_s]=a'+b\cdot\log_{10}[L]$) were used for Northern Pikeminnow (Parker et al. 1995), Smallmouth Bass (Kolander et al. 1993), and Walleye (Murphy et al. 1990) to calculate W_r according to equation (10).

To account for sexual dimorphism, male and female W_r values were calculated separately for Northern Pikeminnow. However, field sampling methodologies precluded diagnosis of sex for Smallmouth Bass and Walleye as they were not sacrificed. Therefore, calculations of W_r for Smallmouth Bass and Walleye were for both sexes combined. Additionally, these analyses only included fishes that met minimum target sizes (250 mm FL for Northern Pikeminnow and 200 mm FL for Smallmouth Bass and Walleye). Annual median W_r values were calculated only when sample sizes exceeded four target sized fish in a given reservoir and by sex for Northern Pikeminnow. 95% confidence intervals were estimated for median W_r values using a non-parametric bootstrap approach (Fox and Weisberg 2011; R Core Team 2021).

Temporal monotonic trends in PSD were assessed for Northern Pikeminnow and Walleye and median W_r for Northern Pikeminnow, Smallmouth Bass, and Walleye by applying a non-parametric Mann-Kendall test (Mann 1945). Similarly, PSD – P was also analyzed with this method for Walleye. Spline interpolation was used to account for data gaps, when present. Due to a large gap in length data for Northern Pikeminnow in the DAF (1997–2005 in Bonneville Reservoir and 1996–2006 in The Dalles Reservoir), data for this large data gap were not interpolated. Instead, the two periods were treated as separate time series; data collected before

1997 as "early" and data collected after 2005 as "late". A non-parametric Mann-Whitney U test was used to compare PSD values between early and late years for each reservoir. Last, to help visualize trends, locally weighted scatterplot smoothing (LOWESS) curves were fit 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. Significant differences were assessed at $\alpha \leq 0.05$.

RESULTS

Sport Reward Fishery Evaluation and Predation Reduction Estimates

A total of 436 Northern Pikeminnow ≥ 200 mm FL were marked or recaptured throughout the Columbia and lower Snake rivers during 2022, of which 300 were ≥ 250 mm FL (Table 1). While boat electrofishing for tagging purposes, two Northern Pikeminnow ≥ 200 mm FL that were tagged in previous years were recaptured. These previously tagged fish were accounted for in annual exploitation calculations and were included as in-year marked or handled fish for 2022 estimates. Overall, 70 of the fish marked in 2022 were recovered in SRF and none in DAF. One fish that was tagged below Bonneville Dam was recovered in Bonneville Reservoir and was excluded from calculations of exploitation. One fish was tagged below Bonneville Dam without a recorded FL and was only counted as a mark for ≥200 mm FL size class. Another fish tagged in Lower Granite Reservoir and returned to the SRF with a large discrepancy in FLs was also only included in the ≥ 200 mm FL size class for exploitation purposes. Fish tagged in 2022 and subsequently recaptured in the SRF were at large from 7 to 166 days (mean = 72.8 d; SE = 7.2). Sport Reward Fishery recaptures greater than or equal to 250 mm FL accounted for 58.6% of all 2022 tag recoveries (Table 1).

Sport Reward Fishery Exploitation

The system-wide exploitation rate for Northern Pikeminnow ≥ 250 mm FL during the Sport Reward Fishery was estimated at 14.9% (±5.9; 95% confidence interval; Table 2). This estimate was within the targeted exploitation range of 10-20% (Fig. 3). Tag returns were sufficient ($n \geq 4$) to calculate area-specific exploitation rates of fish ≥ 250 mm FL for the Columbia River downstream of Bonneville Dam (17.6%, Table 2). This was the first year of NPMP that insufficient numbers of tagged Northern Pikeminnow were recaptured by SRF to calculate an exploitation rate in Bonneville Reservoir. System-wide exploitation of Northern Pikeminnow ≥ 200 mm FL was 18.2% (±4.8; 95% confidence interval) and tag returns were sufficient to calculate area-specific exploitation estimates for the Columbia River downstream of Bonneville Dam, and in Lower Granite Reservoir on the Snake River (Table 3). This was the first year of NPMP that insufficient numbers of tagged Northern Pikeminnow were recaptured by SRF to calculate an exploitation rate in Bonneville Reservoir. For Northern Pikeminnow within the 200–249 mm FL size class, system-wide exploitation was estimated to be 24.6% (±12.5; 95% confidence interval) (Table 4). Area-specific rates of exploitation for this size class was estimated for the area downstream of Bonneville Dam and Lower Granite Reservoir (Table 4).

Sport Reward Fishery Predation Reduction

The model-estimated median reduction of predation on juvenile salmonids by Northern Pikeminnow relative to pre-program levels for 2022 was 31% (range: 10–44%) and for 2023 will

be 34% (range: 11–47%; Fig. 4). 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 suppressed levels through 2026 with an estimated median reduction near 32% (Fig. 4).

PSD, Northern Pikeminnow

Northern Pikeminnow PSD significantly decreased over time in McNary reservoir (Mann-Kendall $\tau = -0.34$, $P = 0.02$; Fig. 5). There was not a significant monotonic trend in PSD below Bonneville Dam or in Bonneville Reservoir. Sufficient data were not collected in Snake River reservoirs and The Dalles Reservoir to calculate PSD for 2022 ($n < 20$).

PSD/PSD-P, Walleye

There was not a significant monotonic trend in Walleye PSD in the McNary reservoir. There was not a significant monotonic trend in Walleye PSD-P in McNary reservoir.

Dam Angling Fishery

During the 2022 DAF season, 382 Northern Pikeminnow diet samples were collected from fish harvested at the angler accessible areas in the powerhouse tailraces of Bonneville reservoir (fishing from the Dalles Dam) and The Dalles reservoir (fishing from the John Day Dam). These fish ranged in size from 238-570 mm FL. In both reservoirs, large proportions of the diets of target sized Northern Pikeminnow contained food and the most prevalent diet item was fish (Table 5). In Bonneville Reservoir, salmonid proportions were 0.09 for 2022 DAF fish, which was below the long-term average of 0.13. In The Dalles Reservoir, the proportion of salmonids increased (0.27) from the mean proportion of the time series (0.15). The proportions of "other fishes" for both Bonneville Reservoir (0.11) and The Dalles Reservoir (0.06) consisted of sculpin (*Cottidae* spp.), unknown Centrarchidae, unknown Cyprinidae, catfish (*Ictaluridae* spp.), and unknown species (non-salmonid and unidentified). American Shad (*Alosa sapidissima*) were the second most abundant prey item in the Bonneville Reservoir (0.31). Other invertebrates not identified as crayfish were the second most abundant diet item in The Dalles Reservoir (0.37).

In Bonneville Reservoir, the proportion of lampreys (*Petromyzontidae* spp.) encountered in the 2022 DAF diet samples peaked at week 21 (0.83) and then decreased over the rest of the sampling time series (Fig. 8). Salmon and steelhead were encountered in the greatest proportion (0.50) of diet samples in week 21 and decreased over the rest of the DAF season. American Shad were first encountered in the diet samples in week 30 and increased sharply to 0.91 in week 38.

In The Dalles Reservoir, lampreys were encountered in the greatest proportion of DAF diet samples (0.67) in week 22 and then decreased throughout the rest of the sampling time series. Salmon and steelhead proportions increased and reached a peak in week 26 (0.53) and then steadily declined. American Shad proportions peaked in week 32 appearing in 43% of samples. After week 32, we did not obtain enough samples for analysis in The Dalles Reservoir.

The 2022 weekly juvenile salmonid consumption index for Northern Pikeminnow removed during DAF at Bonneville and The Dalles reservoirs was the greatest during weeks 28 and 31 respectively

(Fig. 9). CI was also high in The Dalles reservoir in week 26 which was associated with an increase in yearling salmon (Fig. 9).

PSD of Northern Pikeminnow in Bonneville Reservoir during the DAF was significantly greater during the early years (1990-1996) of sampling than during the later years (2006-2022) ($F=21.94$, $P < 0.01$; Fig. 10). There was no significant difference in PSD at The Dalles Reservoir during the early years relative to the later years. PSD for DAF caught fish in both reservoirs has followed an upward trend since 2018. There was no significant monotonic trend for W_r for either female or male DAF Northern Pikeminnow captured in either Bonneville of The Dalles reservoirs (Figs. 11 and 12).

Biological Evaluation

Field staff conducted 159 electrofishing runs during spring 2022 in the John Day Reservoir to collect fishes for biological evaluation. Due to time, budget, and ESA species constraints, total effort had been reduced to only include a spring index season. Sampling was optimized for logistical efficiency by distributing effort between sampling areas based on the number of diet samples needed to meet minimum sample sizes in an attempt to fill data gaps where sample sizes have not historically been met. Of the 159 runs, 64 (40%) were in the tailrace area, 58 (36%) were in the mid reservoir, and 37 (23%) were in the forebay area. During the 2022, ODFW sampled 790 (64.8% of total catch) Smallmouth Bass, 415 (34%) Walleye, and 15 (1.2%) Northern Pikeminnow. The timing of our annual biological evaluation field work was planned to coincide with predicted peak juvenile salmon out migrations. Spring sampling in 2022 overlapped with peak yearling salmon outmigration at McNary Dam (Fig. 13).

Diet Composition

Detailed results of the diet assessments are found in Table 6 but relevant trends are listed here. Diets were examined from 15 Northern Pikeminnow, 480 Smallmouth Bass, and 404 Walleye at three sites in John Day Reservoir. Food items were present in the majority of digestive tracts assessed during biological evaluation (60% - 97%, Table 6). Fish were not found in any diet samples for Northern Pikeminnow and were found more frequently in Walleye (57%) than in Smallmouth Bass (35%). Walleye had the greatest average proportion of salmonids (0.15) followed by Smallmouth Bass (0.05). Lampreys were found in a low proportion of diets for Smallmouth Bass (0.01) and Walleye (0.01). Insects were the most common item found in diets of Northern Pikeminnow (0.33).

AI, Northern Pikeminnow

Northern Pikeminnow AI was zero in the John Day Reservoir Forebay and Mid-reservoir biological evaluation sites in 2022 because there were no Northern Pikeminnow caught in these sites. Previous years without Northern Pikeminnow AI were 2015 and 2004 in these sites (Table 7). Northern Pikeminnow AI from the John Day Reservoir Tailrace (0.22) trended lower than the time series mean (0.76, Table 7).

AI, Smallmouth Bass

Smallmouth Bass AI trended above the mean of the time series for all areas and were among some of the highest AI values from this time series (Table 8). Since the last spring evaluation in 2018, Smallmouth Bass AI increased in the John Day Reservoir Forebay but was lower in the Mid-reservoir and Tailrace sites (Table 8).

AI, Walleye

Walleye AI from John Day Reservoir in 2022 was the highest of the 30 year timeseries in all sites (Table 9).

CI, Northern Pikeminnow

Northern Pikeminnow CI from John Day Reservoir in 2022 could not be calculated in the Forebay or Mid-reservoir sites because no Northern Pikeminnow were caught in these sites. Northern Pikeminnow CI was zero in the Tailrace because none of the sampled fish had salmonids in their digestive contents (Table 10).

CI, Smallmouth Bass

Smallmouth Bass CI from John Day Reservoir in 2022 was comparable to the mean of the time series and lower than the highest CI year, 2015 (Table 11).

PI, Northern Pikeminnow

Northern Pikeminnow PI from John Day Reservoir in 2022 could not be calculated in the Forebay or Mid-reservoir sites because no Northern Pikeminnow were caught in these sites. Northern Pikeminnow PI was zero in the Tailrace because none of the sampled fish had salmonids in their digestive contents (Table 12).

PI, Smallmouth Bass

Smallmouth Bass PI trended above the mean of the time series for all areas and were among some of the highest PI values from this time series (Table 13). Since the last spring evaluation in 2018, Smallmouth Bass PI decreased in all John Day Reservoir biological evaluation sites with the largest decreases in the Forebay (Table 13).

PSD, Northern Pikeminnow

Northern Pikeminnow PSD could not be calculated in John Day Reservoir in 2022 due to insufficient sample size (n = 7, minimum for PSD n = 20).

PSD/PSD-P, Smallmouth Bass

Smallmouth Bass PSD in John Day Reservoir in 2022 was 41.6% (Fig. 14). There was not a significant monotonic trend in Smallmouth PSD (Mann-Kendall $\tau = 0.28$, $P = 0.17$). Smallmouth

Bass PSD-P was 9.2% (Fig. 15). There was not a significant monotonic trend in Smallmouth Bass PSD-P (Mann-Kendall τ = -0.16, P = 0.43).

PSD/PSD-P, Walleye

Walleye PSD in John Day Reservoir in 2022 was 35.0% (Fig. 16). There was not a significant monotonic trend in Walleye PSD (Mann-Kendall τ = -0.28, P = 0.11). Walleye PSD-P was 10.2% (Fig. 17). There was a significant monotonic trend in Walleye PSD-P (Mann-Kendall τ = -0.44, P = 0.01).

W_r, Northern Pikeminnow

There were insufficient numbers of Northern Pikeminnow to calculate relative weight or test for monotonic trends in relative weight over time in the John Day Reservoir in 2022.

W_r, Smallmouth Bass

Smallmouth Bass relative weight in John Day Reservoir in 2022 was 91.0% (Fig. 18). There was not a significant monotonic trend in Smallmouth Bass relative weight (Mann-Kendall τ = -0.18, P = 0.37).

W_r, Walleye

Walleye relative weight in John Day Reservoir in 2022 was 89.6% (Fig. 19). There was not a significant monotonic trend in Walleye relative weight (Mann-Kendall τ = -0.07, P = 0.77).

DISCUSSION

Overview

NPMP was tasked with reducing the predation on juvenile salmonids, by Northern Pikeminnow, as they migrate through the hydropower systems of the Columbia and Snake rivers. NPMP was a multi-agency collaboration incorporating sport reward and dam fisheries managed by WDFW which promoted focused removals of Northern Pikeminnow. These removal efforts were paired with requisite biological monitoring of the Northern Pikeminnow targeted by these removal activities as well as evaluation into the efficacy of the Northern Pikeminnow removal efforts on the reduction in predation to juvenile salmonids conducted by ODFW. NPMP program administration and contract management was led by PSMFC.

Sport Reward Fishery Exploitation

The 2022 Sport Reward Fishery system wide exploitation rate of Northern Pikeminnow ≥ 250 mm FL was 14.9% (±5.9; 95% C.I) which marked the 25th consecutive year that the target of 10 – 20% exploitation was achieved. The point estimate was in the mid-range of the exploitation management goal and was comparable to the mean of the exploitation time series. Despite reaching this goal system-wide, there were insufficient tag returns in 2022 to calculate area-specific estimates of exploitation in Bonneville, McNary, Little Goose, and Lower Granite reservoirs. Due

to the lack of sufficient data and time and budget constraints, ODFW discontinued tagging efforts in John Day Reservoir following the 2019 season and in The Dalles Reservoir in 2022. Reasons for low recaptures resulting in a subsequent inability to estimate exploitation included but were not limited to; an inability to place sufficient initial marks in a reservoir, a lack of angler effort, a lack of angler success in an area, or other unaccounted for processes. 249 mm FL size class, system-wide exploitation was the highest recorded since the NPMP changed the regulations to allow angler retention of that size class. This increase was more than double any previous year, except for 2019, when a less invasive T-bar tag was introduced, resulting in increased exploitation (19.4%) but skewed by high tag loss (65%) due to improper training and tag placement (Carpenter et al. 2019). This increase in exploitation was likely due to lower post-release mortality of these marked fish resulting from discontinuing the use of external tags to a PIT tag only sampling technique incorporated in 2022. Continued use of this sampling technique could help determine if external tagging has contributed to post-release mortality and an underestimation of exploitation, particularly in smaller fish. Going forward, NPMP will continue to adapt and make project management decisions to optimize resources to meet project objectives within a constrained budget.

Predation Reduction

The target predation reduction was met in 2022 at a median, system wide reduction of 31%. The variability associated with this predation reduction estimate was indicative of uncertainty associated with the numerous indices that were integrated into the predation reduction model. Despite this uncertainty, the predation reduction estimates were comparable to previous years and as expected with the measured level of exploitation. The exploitation estimate coupled with the estimated predation reduction value suggest that the removal program continued to be successful. These findings were designed to be presented in conjunction with biological evaluation of additional fisheries metrics, allowing NPMP to further assess whether long-term exploitation of Northern Pikeminnow contributed to predatory compensation with non-native piscivores and native Northern Pikeminnow. The biological evaluation metrics also provide a means to monitor for a chronic decline in the Northern Pikeminnow population.

Fishery Evaluation Trends

Aside from some initial research in 1990 and 1993, there were no recent biological evaluations in McNary Reservoir, despite ESA listed salmonids present above the dam and populations of predator fish in the reservoir. Therefore, fisheries dependent data were utilized for McNary Reservoir in lieu of the biological evaluation used in other areas monitored by the NPMP. Fisheries evaluation sampling techniques were less standardized than fisheries independent biological evaluation data. The fishery evaluation data continued to show a significant monotonic decrease for Northern Pikeminnow PSD in McNary Reservoir. Walleye also demonstrated non-significant decreasing trends in PSD and PSD-P in McNary Reservoir. Declining trends in PSD for Northern Pikeminnow and PSD/PSD-P for Walleye may be cause for concern potentially indicating a truncation in the larger end of the size frequency distribution for these fish. These trends could be related to fishing, interspecific competition, and/or recruitment events. Additional biological evaluation data would be necessary to further understand the processes affecting Northern

Pikeminnow and Walleye populations in this area. As McNary reservoir continues to be the only area showing a significant decline in Northern Pikeminnow PSD, consideration for additional resources and focus are warranted to initiate a biological evaluation in McNary Reservoir to characterize population parameters for all predators and monitor for evidence of a compensatory response to SRF removals.

DAF

Northern Pikeminnow removed in the DAF appeared to be feeding regularly in the powerhouse tailrace areas of Bonneville and The Dalles reservoirs. Additionally, around 16% of the diet composition of DAF caught Northern Pikeminnow was salmonids. These proportions were calculated from Northern Pikeminnow collected from 23 May– 29 September 2022. During this time, there were documented pulses of out-migrating juvenile salmonids associated with increases in the proportions of juvenile salmonids in the diet of Northern Pikeminnow. There was intra-annual variation in the diet composition. Salmonids and lamprey were primarily preyed upon during the early weeks of DAF (20-31), with diet composition largely consisting of American Shad in later weeks (32-38). These data suggest that Northern Pikeminnow feeding in the powerhouse tailrace areas may be influenced by prey availability. Though previous years of data indicate Northern Pikeminnow feeding on pulses of out-migrating salmonids (Carpenter et al. 2019), diet data from DAF 2022 showed salmon consumption early in the season followed by diets consisting largely of American Shad. One possible explanation is that a particularly large outmigration of shad beginning week 32 provided ample prey for Northern Pikeminnow in the powerhouse tailraces of The Dalles and Bonneville reservoirs and salmonids became a much smaller proportion of the available prey.

Due to sampling, location, and timing differences, a comparison between the diets of DAF caught Northern Pikeminnow and diets sampled during biological evaluation was not possible. Though it was notable that the only Northern Pikeminnow diets containing salmonids came from the DAF; there were very few Northern Pikeminnow sampled during the biological evaluation portion of the study. The continuation of diet composition analyses from DAF caught Northern Pikeminnow may be valuable to track trends in the predation of numerous taxa traveling through the powerhouse tailraces, several of which may be threatened or endangered. The significance of this work is elevated in the context of high proportions of salmonids in digestive tracts of Northern Pikeminnow caught in the boat restricted zones in previous years. Sampling in these areas, through the biological evaluation component, have since been eliminated from the study design due to budget cuts, safety and logistical concerns, and restrictions to access. Therefore, DAF diet composition data provide one mechanism to fill data gaps surrounding potentially important Northern Pikeminnow feeding areas adjacent to the powerhouse tailrace areas. These data were useful in augmenting the understanding of the predator/prey dynamics between Northern Pikeminnow, juvenile salmonids, lampreys, American Shad, and numerous other prey taxa. In addition, the removal of Northern Pikeminnow from the powerhouse tailrace areas via DAF mitigates for the direct impact of the Federal Columbia River Power System through a means that is inaccessible to anglers participating in the SRF. PSD for Northern Pikeminnow in the Bonneville Reservoir powerhouse tailrace (The Dalles Dam), caught through DAF, was significantly lower during the more recent sampling time period (2006 – 2022) relative to the older time period (1990

– 1995). This may indicate a fishing signal from DAF, which began actively removing Northern Pikeminnow in 1990. The Dalles Reservoir tailrace (John Day Dam) did not have a significant difference in PSD for late relative to early time periods. While DAF may have initially depressed PSD in these powerhouse tailrace areas, increasing PSD since 2018 suggest Northern Pikeminnow population dynamics have changed recently. The abundance of larger Northern Pikeminnow were increasing relative to smaller Northern Pikeminnow. Particularly, PSD for Northern Pikeminnow in The Dalles Reservoir powerhouse tailrace has increased to comparable levels similar to the older time sampling period (1990-1995), while PSD has increased in recent years in Bonneville Reservoir, it is not nearly at historical levels. The mechanism for this difference remains unknown. Potential explanations include a shift in SRF effort and or catch between the two reservoirs (Winther et al. 2021) or differential population responses to abiotic and/or biotic factors (e.g., Jackson 2001). Future biological evaluation of Bonneville and The Dalles Reservoirs will be conducted through 2025 and may help to further elucidate trends in PSD across the sub-areas of each reservoir and between Northern Pikeminnow and Smallmouth Bass.

Northern Pikeminnow relative weight was not different in either powerhouse tailrace for males or females. This result would suggest that while the proportion of larger Northern Pikeminnow has increased in these areas (e.g., PSD) the condition of individual Northern Pikeminnow has not significantly changed. This result may not be surprising given that several hundred to thousands of Northern Pikeminnow were removed from the powerhouse tailrace areas each year through DAF thereby possibly reducing the intraspecies competition from, presumably, food rich areas of these hydropower reservoirs. However, if these powerhouse tailrace areas were prime feeding areas, increasing competition from other predators may change the present predator/prey dynamics potentially impacting when or how much food Northern Pikeminnow were able to access from the powerhouse tailrace areas. Monitoring of these areas should continue as it provides important insight into shifts in predator dynamics that other sampling cannot address.

Biological Evaluation

In addition to modeling the predation reduction due to the NPMP SRF and DAF, fishery metrics were measured for three predatory species: Northern Pikeminnow, Smallmouth Bass, and Walleye. These data were collected independently of the SRF and DAF; and were designed to test for indications of a compensatory predatory response among these three species due to focused Northern Pikeminnow removals and monitor for signs of Northern Pikeminnow overfishing. The primary indicator of a compensatory response was whether the level of predation changed within Northern Pikeminnow populations and how it compared with other piscine predators of salmon and steelhead, particularly non-native Smallmouth Bass and Walleye. Changes in the abundance of the predators or trends in the consumption of juvenile salmonids can provide additional evidence of a compensatory response to Northern Pikeminnow removals. During the 2022 field season, ODFW doubled the spring biological evaluation effort in the John Day Reservoir in an attempt to expand the sample size of Northern Pikeminnow used to calculate indices of abundance, consumption, and predation. This reservoir was central to the establishment of NPMP, generating much of the early work used to guide the monitoring and evaluation framework of NPMP (e.g., Vigg et al. 1991), but has been showing long-term decreasing trends in Northern Pikeminnow AI, CI, and PI. NPMP prioritized the 2022 biological evaluation in this single reservoir to further

explore if additional sampling effort could help clarify whether the declining trends of these indices were due to the amount of sampling or indicative of declining index values.

Doubling the spring biological evaluation sampling effort in the John Day Reservoir did not increase the sample size of Northern Pikeminnow relative to previous years despite keeping the sampling methods the same. This would support that the trends in index values were reflective of changes in these indices, relative to previous years. Northern Pikeminnow AI was zero in the Forebay or Mid-reservoir biological evaluation sites. There were enough Northern Pikeminnow to calculate AI in the Tailrace but those fish did not have any salmonids in their digestive tract so CI and PI equaled zero. These data support previous biological evaluation data showing trends of decreasing AI in the Tailrace since the mid 1990s.

In contrast, the overall trend in the index of abundance was increasing for Smallmouth Bass and Walleye and were the second highest and highest, respectively, during the 30 year time series for the John Day Reservoir. Smallmouth Bass CI in 2022 was comparable to the long-term mean while PI was among the highest of the time series. Therefore, the elevated PI for Smallmouth Bass was principally driven by the increase in AI as opposed to an increase, relative to the long term mean, in salmonid consumption. NPMP did not incorporate PI for Walleye due to a lack of a model for prey consumption needed to develop a CI.

These results suggest that Northern Pikeminnow abundance has been depressed in the John Day Reservoir to the point that it was difficult to track indices of consumption and predation to juvenile salmonids in two of the three biological evaluation sites. For the third biological evaluation site, there were enough Northern Pikeminnow captured to calculate an index of abundance but those individuals did not have any salmonids in their digestive tracts. Therefore, CI and subsequently PI were zero. At the same time Smallmouth Bass were more abundant but were consuming comparable proportions of salmonids to the long-term mean. When considered together, predation on salmonids by Smallmouth Bass has increased primarily due to their increased abundance. Walleye have also demonstrated increases of abundance that would presumably lead to increased predation on juvenile salmonids, though this study does not explicitly track indices of consumption and predation for Walleye. Walleye AI in the tailrace area increased twofold from 2018, which was double the previous high of the time series. The tailrace areas have been identified as predation hotspots throughout the Columbia River Basin and in John Day Reservoir (Poe et al. 1991). Additionally, the upper reaches of John Day Reservoir are known to be important rearing areas for subyearling Chinook (Tiffan et al. 2006), additionally increasing their vulnerability to predation in this reservoir. This further supports the importance of adaptive management strategies when there are indications of changing piscine predation dynamics in the mainstem Colombia River.

The interpretations from these indices were complicated by the fact that the Columbia and Snake River reservoirs were assessed on a multi-year rotating schedule that has varied spatially and temporally throughout the history of the project. This schedule rotation left gaps in the data leading to a coarser temporal scale used to assess trends in AI, CI, and PI. The coarser temporal scale of data could miss important high or low index years leading to misinterpretations of the long-term trends present in the data. The low Northern Pikeminnow and high Smallmouth Bass AI, CI, and

PI, as well as the high Walleye AI, observed in 2022 were broadly consistent over this timeframe and not from a single anomalously low or high year in a series of relatively constant years. The rotating index scheduling was driven by the incorporation of rapid assessment methods necessary to generate management actionable data through chronic flat funding for this program. The results presented here demonstrate the difficulty in assessing fish predator populations with limited data and means for assessment.

Two additional fisheries metrics were calculated for these three species, independent of SRF and DAF, for the John Day Reservoir. These metrics were PSD and W_r which provided additional information about the size frequency distribution and body condition of these species. These metrics can be used to assess for further signs of compensation among predator species, potentially related to Northern Pikeminnow removal, as well as to monitor for signs of overfishing of Northern Pikeminnow. Neither of these metrics could be calculated for Northern Pikeminnow due to insufficient sample sizes. Furthermore, there were not significant monotonic trends in PSD, PSD-P, or W_r for Smallmouth Bass or Walleye. These results suggest stable size structure for Smallmouth Bass and Walleye populations over time, which is supported through the cyclical trends apparent in the data during the 30 year time series (Figs. 14 – 19).

Taken in aggregate, the fisheries independent indices of abundance, consumption, and predation suggest a long-term decline in Northern Pikeminnow populations and a reduction in their predatory impact on juvenile salmonids in the John Day Reservoir. Of note, no Northern Pikeminnow were captured in the Forebay or Mid-reservoir biological evaluation sites despite doubling the effort. While this was not the first year without Northern Pikeminnow captured in those sites, it has only occurred twice before and compliments the steady decreasing trends of these indices over time. Additionally, while there were enough Norther Pikeminnow captured in the tailrace to calculate AI, there were not many captured (n = 7) and none of those individuals had salmonids in their digestive tracts. This sample size was also too low to calculate PSD, PSD-P, and W_r. Concurrently, there have been substantial increases in Smallmouth Bass and Walleye AI and Smallmouth Bass PI, particularly in the last 10 – 15 years (Tables 8 and 9). While it was not possible to say for certain that the patterns between declining metrics for Northern Pikeminnow and some increasing metrics for Smallmouth Bass and Walleye were indicative of a compensatory response, there was evidence that both species were more abundant in John Day Reservoir than they were at the start of NPMP in 1990. This also suggests that predation of juvenile out-migrating salmonids by Northern Pikeminnow has been reduced while it has increased by Smallmouth Bass. Additionally, while NPMP doesn't have consumption or predation index values for Walleye, the proportion of salmonids in their diets would suggest that the increase in the index of abundance would lead to an increase in predation of out-migrating juvenile salmonids by Walleye (Table 6).

Continued evidence of compensatory responses to removals could justify a need to augment the current study design to include investigations into the predator/prey dynamics occurring in areas where compensation is suspected. In the absence of long-term, scientifically rigorous data, state and federal resource managers will not be able to accurately assess the effects of long-term fishing pressure, subsequent reduction in predation on juvenile salmonids, and changes to the multi-species predator/prey dynamics in this highly modified river system. It is important that NPMP

adapts and continues to monitor these areas through biological evaluation to assure a viable population of the native predator.

The rapid assessment methods incorporated into this report provided cost effective methods to biologically monitor and evaluate the effect of recreational sport reward fishing for Northern Pikeminnow. While these methods were not spatially or temporally exhaustive, they did provide an additional year of scientifically robust data that was used to augment the existing 31 years of historical data. In doing so, NPMP was able to address the efficacy of the sport reward fishery to exploit 10 – 20% of the Northern Pikeminnow population, estimate the concomitant juvenile salmonid predation reduction, monitor for predator compensation, and provide a safeguard against overexploiting a native fish predator. These methods provided evidence that there may be a compensatory response in Smallmouth Bass and Walleye, potentially due to the removal of Northern Pikeminnow in the John Day Reservoir. This potential compensatory response needs to be monitored carefully as continuing to remove one predator, only to have the reductions to juvenile salmonid predation negated by predation from another predator, counteracts the essence of the efforts of NPMP. There were many factors that influenced the predatory impact of piscivorous fishes on ESA listed salmonids. In the effort to elucidate the relationships among these factors, NPMP will continue adapting the research methods to provide management actionable information about the predation of juvenile salmonids in the Columbia and Snake rivers.

Future Perspectives

NPMP is based on an adaptive management framework which implicitly calls for updates to project operation as data inform management strategies (NMFS 2020) and based on input from an independent scientific review panel (ISRP 2019). To continually improve the relevance and utility of the data collected by NPMP, there are several priority project areas that will be evaluated for potential modification for the 2023 season and beyond. These priority areas nest within a broader plan to address recommendations presented by ISRP in 2019.

First, to address concerns about incidental electrofishing interactions with juvenile salmonids during Northern Pikeminnow sampling activities, the 2023 field season will assess longline gear in tandem with electrofishing gear. Concurrent with this alternative gear testing will be a pilot program to evaluate the utility of a hybrid sportfishing/biological evaluation study design. Second, the exploitation and predation reduction analytical methods employed here will be assessed using mark/recapture population estimates and incorporating models like the Brownie model (Brownie et al. 1987). Paired with this will be an assessment of the utility of an R based mark/recapture analytical interface, RMark (Laake 2013) with NPMP mark/recapture data. Third, NPMP will assess the functionality of a bioenergetics R based analytical tool to be used with the biological and diet data collected from Northern Pikeminnow, Smallmouth Bass, and Walleye; Fish Bioenergetics 4.0 (Deslauriers et al. 2017). Should this tool be a cost effective and functional tool to model bioenergetics using NPMP data, it could provide a mechanism to update the bioenergetics models used in the index of consumption for Northern Pikeminnow and Smallmouth Bass as well as a possible tool to develop an index of consumption for Walleye. Fourth, NPMP has been involved in a regional group developing action items intended to improve populations of salmonids in the Columbia River Basin by integrating recommendations from technical experts and other stakeholders involved with avian, pinniped, and piscine predation. These interactions will help the

region better coordinate monitoring and mitigation measures across three broad taxa that have been shown to predate upon salmonids but lack a consistent, coordinated management approach.

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TABLES

Table 1. Numbers of Northern Pikeminnow marked and recaptured[a] in the Sport Reward Fishery and Dam Angling Fisheries during 2022 by location and size class.

	200–249 mm FL		≥ 250 mm FL		≥ 200 mm FL	
Reach/Reservoir	Marked	Recaptured	Marked	Recaptured	Marked	Recaptured
Below Bonneville	70	14	222*	35*	293*	49
Bonneville	8	2	46	1	54	3
The Dalles	—	—	—	—	—	—
John Day	—	—	—	—	—	—
McNary	3	0	24	3	27	3
Little Goose	7	2	1	0	8	2
Lower Granite	46***	10	9	2	56***	13***
All areas	134	28	302	41	438	70

[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). '≥ 200 mm' includes fish that don't fit within either the '200 – 249 mm' category or the '≥ 250 mm' category. Summing across '200 – 249 mm' and '≥ 250 mm' does not sum to the value used in the '≥ 200 mm' fields. See the following explanations for details. * One fish was tagged below Bonneville Dam but recaptured in the Sport Reward in Bonneville Reservoir. ** One fish was tagged Below Bonneville Dam without a Fork Length recorded and therefor only counts as ≥ 200 FL. ***One fish tagged in LGR at 206 mm FL was recapped at 312 mm FL so was only counted as ≥ 200FL

Table 2. 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	Little Goose	Lower Granite	All areas
1991	7.6	10.9	23.6	2.8	5.3	2.4	20.0	8.5
1992	11.4	4.0	6.2	3.4	5.6	11.9	15.0	9.3
1993	6.0	2.1	7.0	2.4	15.9	3.3	12.5	6.8
1994	13.6	2.2	9.8	3.2	14.0	6.1	8.7	10.9
1995	16.1	3.5	14.9	*a*	22.4	2.9	6.4	13.4
1996	12.7	6.1	15.5	*a*	18.2	8.9	11.7	12.1
1997	7.8	8.0	5.8	*a*	16.5	*a*	15.5	8.9
1998	8.2	7.8	12.8	*a*	13.6	*a*	12.1	11.1
1999	9.6	13.9	16.1	3.7	15.9	*a*	6.1	12.5
2000	10.0	16.3	*a*	*a*	9.7	*a*	8.7	11.9
2001	16.2	8.5	*a*	*a*	26.0	—	*a*	16.2
2002	12.6	6.0	*a*	*a*	7.7	—	14.3	12.3
2003	13.6	16.7	*a*	*a*	8.2	—	*a*	13.0
2004	20.1	9.3	*a*	*a*	*a*	—	23.8	18.5
2005	23.1	8.2	18.0	*a*	13.0	—	*a*	19.0
2006	15.6	13.7	25.3	*a*	11.2	26.3	*a*	17.1
2007	19.4	11.1	*a*	*a*	7.5	*a*	17.3	17.8
2008	22.2	10.5	15.0	*a*	16.8	21.7	9.2	19.5
2009	11.3	15.9	*a*	*a*	11.6	25.8	*a*	12.8
2010	19.8	13.1	*a*	*a*	*a*	*a*	*a*	18.8
2011	14.5	10.4	*a*	*a*	17.8	*a*	*a*	15.6
2012	17.4	13.5	*a*	*a*	17.6	*a*	*a*	15.9
2013	9.6	11.2	*a*	*a*	26.5	*a*	11.4	10.8
2014	9.2	6.9	*a*	*a*	17.9	*a*	11.3	11.5
2015	16.7	14.3	*a*	*a*	*a*	*a*	24.4	17.2
2016	11.6	8.9	*a*	*a*	4.6	24.8	14.4	12.1
2017	16.3	14.8	*a*	*a*	28.1	*a*	*a*	17.4
2018	13.8	18.3	*a*	*a*	18.1	*a*	16.9	16.8
2019	14.7	7.8	*a*	*a*	16.5	*a*	19.7	15.4
2020	19.0	10.1	—	—	*a*	*a*	*a*	17.8
2021	11.8	5.6	*a*	—	19.7	*a*	*a*	12.9
2022	17.6	*a*	—	—	*a*	*a*	*a*	14.9
mean (SE)	14 (0.8)	10 (0.8)	14.2 (1.8)	3.1 (0.2)	15 (1.2)	13.4 (3.2)	14 (1.2)	14 (0.6)

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

Table 3. 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	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	13.6	*a*	15.0
2018	10.1	16.8	*a*	*a*	18.3	5.5	5.5	12.6
2019	13.6	9.5	*a*	*a*	15.9	30.4	13.2	17.3
2020	16.3	8.7	—	—	*a*	15.0	5.3	15.2
2021	11.1	7.8	*a*	—	18.1	*a*	*a*	12.3
2022	18.6	*a*	—	—	*a*	*a*	25.7	18.2
mean (SE)	14 (0.9)	10.2 (0.6)	14.2 (3.5)	*b*	12.1 (1.3)	14.8 (2.7)	13.9 (4)	13.2 (0.6)

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 (200–249 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	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	10.6	*a*	8.7
2018	3.5	*a*	*a*	*a*	10.6	*a*	*a*	4.5
2019	11.7	21.1	*a*	*a*	13.0	29.9	9.9	19.4
2020	*a*	7.9	—	—	*a*	*a*	*a*	8.4
2021	*a*	10.5	*a*	—	15.4	*a*	*a*	10.9
2022	22.0	*a*	—	—	*a*	*a*	23.5	24.6
mean (SE)	8.4 (1.8)	9.1 (1.5)	*b*	*b*	8.9 (1.3)	12 (3.4)	9.6 (4.4)	8.5 (1.2)

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 5. Number (n) of Northern Pikeminnow diets examined from Dam Angling Fishery catch from Bonneville (tailrace of The Dalles Dam) and The Dalles (tailrace of John Day Dam) reservoirs and proportions containing specific prey items (cray =crayfish, other invert = all invertebrates not identified as crayfish, sal = salmon or steelhead, lam = lamprey, ash = American Shad).

Reservoir, Year	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{other\ invert}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$	$\hat{p}_{ash}$	$\hat{p}_{other\ fishes}$
Bonneville,									
2006	129	0.36	0.21	0.08	0.04	0.04	0.17	0.00	0.05
2007	340	0.61	0.40	0.04	0.22	0.13	0.31	0.00	0.06
2008	209	0.63	0.44	0.04	0.33	0.11	0.31	0.00	0.12
2009	223	0.70	0.64	0.06	0.19	0.09	0.50	0.01	0.14
2010	395	0.62	0.49	0.06	0.14	0.16	0.18	0.15	0.18
2011	329	0.66	0.44	0.07	0.19	0.36	0.09	0.00	0.08
2012	275	0.77	0.57	0.09	0.19	0.15	0.18	0.00	0.00
2013	216	0.77	0.43	0.12	0.34	0.17	0.22	0.04	0.06
2014	489	0.58	0.46	0.07	0.13	0.19	0.47	0.19	0.42
2015	474	0.75	0.53	0.13	0.29	0.07	0.53	0.21	0.15
2016	463	0.73	0.37	0.03	0.44	0.07	0.14	0.13	0.08
2017	415	0.76	0.53	0.03	0.35	0.14	0.18	0.17	0.14
2018	346	0.72	0.46	0.04	0.36	0.06	0.05	0.29	0.15
2019	383	0.82	0.49	0.03	0.50	0.07	0.24	0.13	0.12
2020	336	0.69	0.49	0.03	0.26	0.16	0.26	0.07	0.13
2021	327	0.78	0.55	0.04	0.34	0.18	0.23	0.03	0.19
2022	221	0.71	0.54	0.04	0.20	0.09	0.14	0.31	0.11
The Dalles,									
2007	453	0.58	0.37	0.02	0.27	0.13	0.08	0.11	0.21
2008	64	0.81	0.36	0.03	0.69	0.09	0.23	0.00	0.08
2009	224	0.61	0.56	0.08	0.31	0.11	0.40	0.00	0.14
2010	382	0.55	0.29	0.07	0.34	0.16	0.10	0.02	0.07
2011	283	0.70	0.22	0.06	0.56	0.15	0.07	0.00	0.02
2012	479	0.77	0.39	0.13	0.48	0.15	0.12	0.04	0.00
2013	447	0.78	0.47	0.22	0.34	0.23	0.16	0.09	0.05
2014	363	0.72	0.44	0.31	0.27	0.18	0.46	0.14	0.36
2015	337	0.79	0.45	0.24	0.37	0.14	0.45	0.12	0.16
2016	426	0.73	0.31	0.04	0.57	0.14	0.04	0.06	0.07
2017	329	0.61	0.30	0.05	0.48	0.11	0.07	0.09	0.08
2018	473	0.75	0.30	0.04	0.57	0.13	0.09	0.06	0.04
2019	410	0.77	0.38	0.06	0.54	0.14	0.16	0.06	0.06
2020	549	0.70	0.48	0.04	0.39	0.13	0.19	0.19	0.03
2021	317	0.67	0.45	0.06	0.40	0.20	0.20	0.08	0.07
2022	161	0.70	0.48	0.06	0.37	0.27	0.21	0.06	0.06

Table 6. Number (*n*) of Northern Pikeminnow, Smallmouth Bass, and Walleye (≥ 200 mm FL) diets examined during biological evaluation in the John Day Reservoir during spring 2022 and proportion of samples containing specific prey items (cray = crayfish, crust = all crustacea not identified as crayfish, sal = salmon or steelhead, lam = lamprey).

Spring 2022	John Day Reservoir							
Species	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{crust}$	$\hat{p}_{insect}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$
Northern Pikeminnow	15	0.60	0.00	0.13	0.07	0.33	0.00	0.00
Smallmouth Bass	480	0.97	0.35	0.54	0.41	0.46	0.05	0.01
Walleye	404	0.94	0.57	0.03	0.53	0.20	0.15	0.01

Table 7. Spring abundance index values (mean catch per 900-s boat electrofishing scaled to surface area [ha] divided by 1,000; and SE) for Northern Pikeminnow (≥ 250 mm FL) in John Day Reservoir, 1990–2022. FB = forebay, Mid = mid-reservoir, and TR = tailrace. Note: dashes (—) = no sampling conducted.

	John Day Reservoir		
Year	FB	Mid	TR
1990	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	1.63 (0.67)	1.78 (1.78)	1.55 (0.66)
1994	0.39 (0.16)	2.56 (1.41)	0.68 (0.22)
1995	0.41 (0.17)	0.41 (0.41)	0.61 (0.27)
1996	0.39 (0.23)	2.67 (2.67)	0.92 (0.26)
1999	0.57 (0.30)	—	0.34 (0.14)
2004	0.00 (0.00)	0.00 (0.00)	0.33 (0.15)
2006	0.11 (0.07)	1.15 (0.80)	0.32 (0.12)
2009	0.05 (0.05)	0.41 (0.41)	0.20 (0.12)
2012	0.07 (0.07)	1.84 (1.03)	0.00 (0.00)
2015	0.00 (0.00)	0.00 (0.00)	0.05 (0.05)
2018	0.07 (0.07)	0.81 (0.81)	0.36 (0.18)
2022	0.00(0.00)	0.00 (0.00)	0.22 (0.11)
mean (SE)	0.35 (0.11)	1.68 (0.42)	0.76 (0.21)

Table 8. Spring abundance index values (mean catch per 900-s boat electrofishing scaled to surface area [ha] divided by 1,000; and SE) for Smallmouth Bass (≥ 200 mm FL) in John Day Reservoir, 1990–2022. FB = forebay, Mid = mid-reservoir, and TR = tailrace. Note: dashes (—) = no sampling conducted.

	John Day Reservoir		
Year	FB	Mid	TR
1990	3.00 (0.58)	23.67 (4.79)	0.56 (0.33)
1991	3.12 (0.55)	44.27 (7.06)	1.03 (0.29)
1992	4.69 (0.92)	24.66 (3.90)	1.25 (0.60)
1993	4.18 (0.74)	53.32 (8.18)	1.26 (0.38)
1994	4.77 (0.65)	31.91 (7.12)	1.20 (0.25)
1995	4.65 (0.64)	64.31 (6.58)	0.80 (0.23)
1996	2.29 (0.37)	55.74 (7.83)	0.37 (0.10)
1999	2.44 (0.46)	—	0.46 (0.14)
2004	20.03 (2.25)	59.04 (9.71)	3.16 (0.73)
2006	5.03 (0.71)	127.71 (13.05)	3.98 (0.55)
2009	4.96 (0.89)	72.99 (7.67)	1.02 (0.23)
2012	8.13 (0.88)	124.55 (11.32)	1.74 (0.38)
2015	4.44 (0.70)	48.44 (8.60)	0.66 (0.25)
2018	8.61 (0.97)	181.62 (18.87)	7.06 (1.07)
2022	12.56 (2.5)	136.23 (19.59)	5.05 (1.33)
mean (SE)	6.74 (1.4)	77.14 (12.22)	1.48 (0.55)

Table 9. Spring abundance index values (mean catch per 900-s boat electrofishing scaled to surface area [ha] divided by 1,000; and SE) for Walleye (≥ 200 mm FL) in John Day Reservoir, 1990–2022. FB = forebay, Mid = mid-reservoir, and TR = tailrace. Note: dashes (—) = no sampling conducted.

	John Day Reservoir		
Year	FB	Mid	TR
1990	0.00 (0.00)	0.00 (0.00)	0.51 (0.25)
1991	0.00 (0.00)	0.68 (0.68)	0.52 (0.25)
1992	0.00 (0.00)	0.00 (0.00)	0.20 (0.10)
1993	0.00 (0.00)	0.46 (0.46)	0.57 (0.20)
1994	0.00 (0.00)	0.00 (0.00)	1.39 (0.50)
1995	0.03 (0.03)	1.04 (0.86)	1.09 (0.27)
1996	0.00 (0.00)	0.75 (0.75)	1.52 (0.33)
1999	0.00 (0.00)	—	0.82 (0.19)
2004	0.08 (0.08)	5.73 (4.02)	1.59 (0.25)
2006	0.00 (0.00)	0.74 (0.55)	2.89 (0.69)
2009	0.00 (0.00)	1.03 (1.03)	0.95 (0.24)
2012	0.00 (0.00)	1.78 (1.01)	2.13 (0.37)
2015	0.00 (0.00)	0.00 (0.00)	0.81 (0.26)
2018	0.00 (0.00)	1.27 (0.94)	5.75 (1.25)
2022	0.35 (0.23)	7.65 (2.05)	12.13 (1.85)
mean (SE)	0.03 (0.02)	1.67 (0.63)	2.70 (0.90)

Table 10. Annual spring consumption index values for Northern Pikeminnow (≥ 250 mm FL) captured during biological evaluation in John Day Reservoir, 1990–2022. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

	John Day Reservoir		
Year	FB	Mid	TR
1990	*a*	0.00	1.56
1991	*a*	*a*	*a*
1992	*a*	0.00	0.00
1993	*a*	*a*	*a*
1994	1.86	*a*	0.34
1995	*a*	*a*	1.06
1996	*a*	*a*	0.50
1999	1.35	—	1.66
2004	*a*	*a*	0.00
2006	*a*	*a*	0.32
2009	*a*	*a*	*a*
2012	*a*	*a*	*a*
2015	*a*	*a*	*a*
2018	*a*	*a*	*a*
2022	*a*	*a*	0.00
mean (SE)	1.54 (0.16)	0.18 (0.18)	0.63 (0.2)

Note: *a* = no consumption index calculated ($n < 6$), dashes (—) = no sampling conducted.

Table 11. Annual spring consumption index values for Smallmouth Bass (≥ 200 mm FL) captured during biological evaluation in John Day Reservoir, 1990–2022. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

	John Day Reservoir		
Year	FB	Mid	TR
1990	*a*	0.00	*a*
1991	*a*	*a*	*a*
1992	0.08	0.00	*a*
1993	*a*	*a*	*a*
1994	0.07	0.00	0.00
1995	0.00	0.00	0.00
1996	0.00	0.00	0.00
1999	0.04	—	0.00
2004	0.07	0.04	*a*
2006	0.00	0.01	0.02
2009	0.00	0.00	0.00
2012	0.03	0.01	0.04
2015	0.09	0.12	0.23
2018	0.10	0.08	0.07
2022	0.06	0.04	0.04
mean	0.05	0.03	0.04
(SE)	(0.01)	(0.01)	(0.02)

Note: *a* = no consumption index calculated ($n < 6$), dashes (—) = no sampling conducted, b = no mean calculated (n< 3).

Table 12. Annual spring predation index values for Northern Pikeminnow (≥ 250 mm FL) captured during biological evaluation in John Day Reservoir, 1990–2022. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

	John Day Reservoir		
Year	FB	Mid	TR
1990	*a*	0.00	4.42
1991	*a*	*a*	*a*
1992	*a*	0.00	0.00
1993	*a*	*a*	*a*
1994	0.73	*a*	0.23
1995	*a*	*a*	0.65
1996	*a*	*a*	0.46
1999	0.77	—	0.57
2004	*a*	*a*	0.00
2006	*a*	*a*	0.10
2009	*a*	*a*	*a*
2012	*a*	*a*	*a*
2015	*a*	*a*	*a*
2018	*a*	*a*	*a*
2022	*a*	*a*	0.00
mean (SE)	0.75 (0.02)	0 (0)	0.71 (0.47)

Note: *a* = no predation index calculated ($n_{fish} < 6$ or $n_{runs} < 3$), dashes (—) = no sampling conducted.

Table 13. Annual spring predation index values for Smallmouth Bass (≥ 200 mm FL) captured during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2022. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

	John Day Reservoir		
Year	FB	Mid	TR
1990	*a*	0.00	*a*
1991	*a*	*a*	*a*
1992	0.49	0.00	*a*
1993	*a*	*a*	*a*
1994	0.22	0.00	0.00
1995	0.00	0.00	0.00
1996	0.00	0.00	0.00
1999	0.05	—	0.00
2004	1.66	2.36	*a*
2006	0.00	1.11	0.07
2009	0.00	0.27	0.00
2012	0.22	1.43	0.03
2015	0.40	5.88	0.15
2018	0.83	14.20	0.53
2022	0.79	4.99	0.23
mean (SE)	0.39 (0.14)	2.52 (1.21)	0.1 (0.05)

Note: *a* = no predation index calculated ($n_{fish} < 6$ or $n_{runs} < 3$), dashes (—) = no sampling conducted.

FIGURES

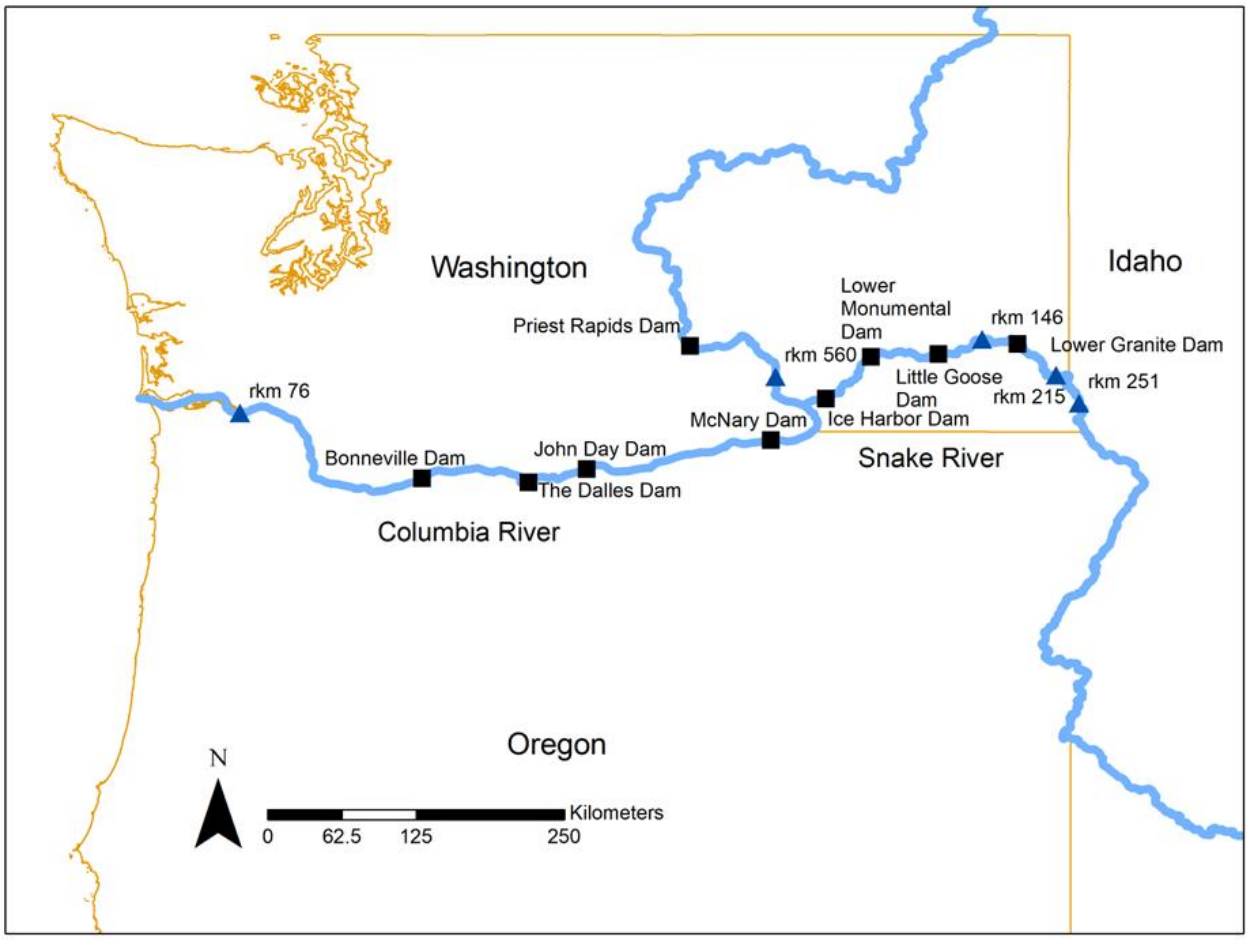

Figure 1. Study area in the Columbia and Snake rivers.

Figure 2. Tag placement areas for 134.2 MHz passive integrated transponder (PIT) tags for marked Northern Pikeminnow.

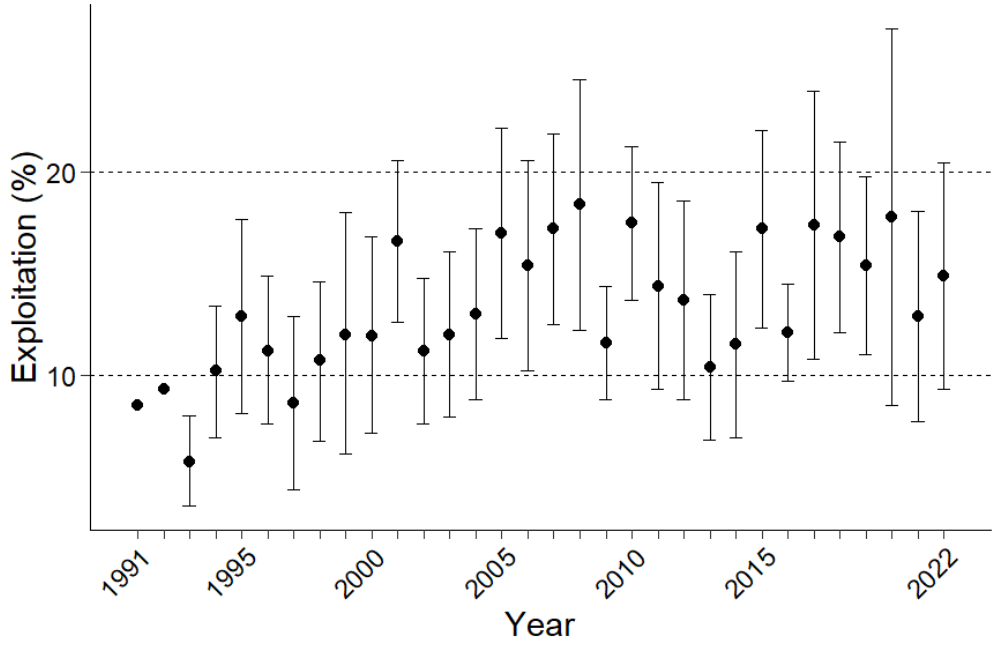

Figure 3. System-wide exploitation rates of Northern Pikeminnow (≥ 250 mm FL) in the Sport Reward Fishery, 1991–2022. Error bars represent 95% confidence intervals, though variation was not estimated for the years 1991–1992. Target exploitation is 10–20% (dashed lines).

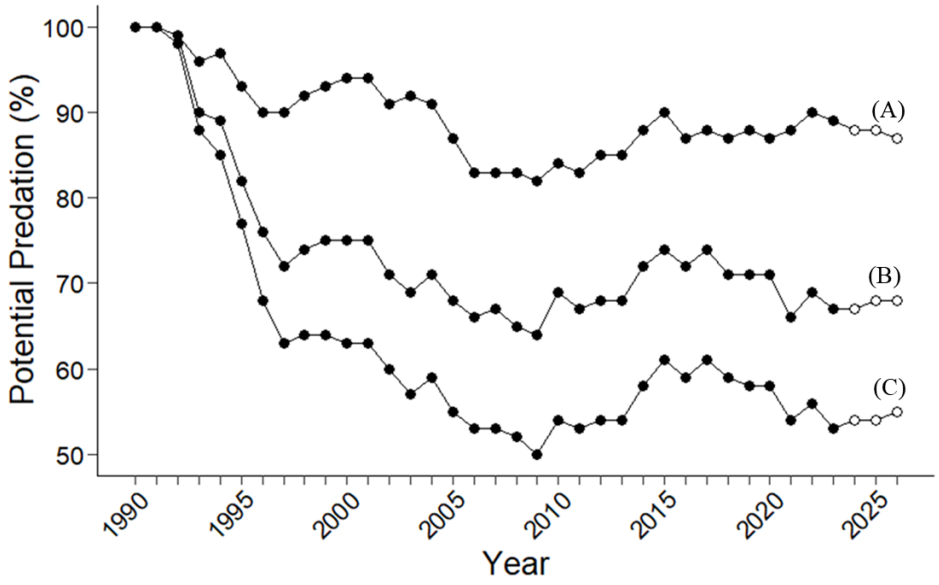

Figure 4. Estimates of (A) maximum, (B) median, and (C) minimum annual levels of potential predation by Northern Pikeminnow on juvenile salmon relative to predation levels before implementation of the Northern Pikeminnow Management Program. For the years 1991–2022, model estimates (filled circles) are based on exploitation rates from the previous year. Model forecast predictions after 2023 (open circles) are based on average exploitation estimates from years with similar fishery structure (2001, 2004–2022).

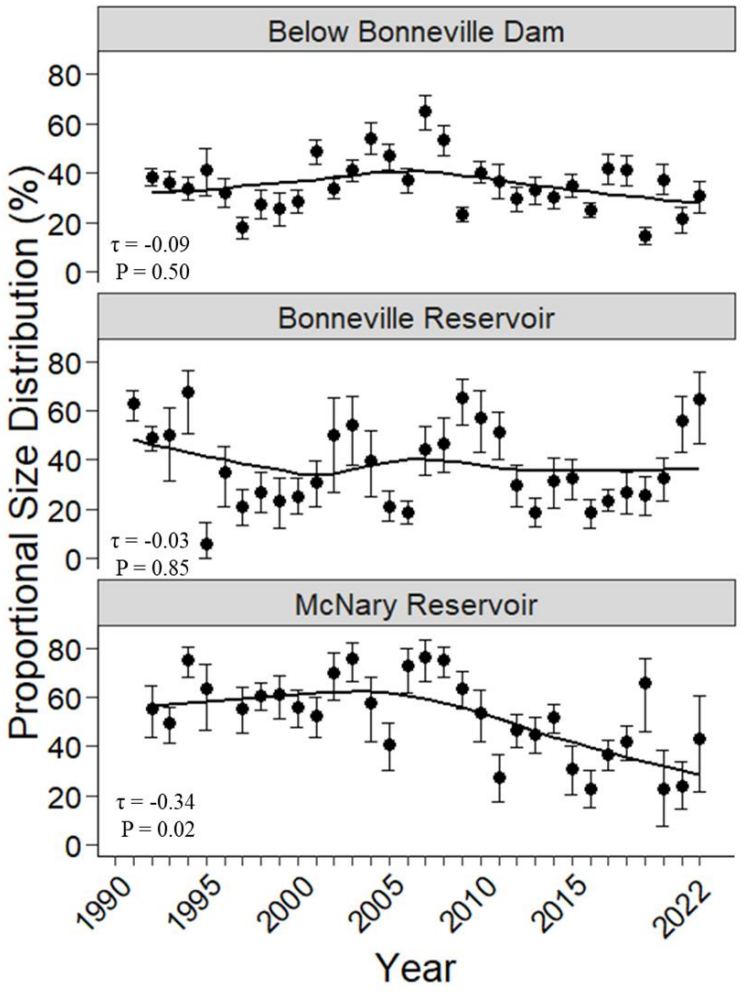

Figure 5. Estimates of proportional size distribution (PSD, %) for Northern Pikeminnow collected during fishery evaluation in the Columbia River, 1991–2022. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years without data indicate sample sizes were insufficient for analysis (n_s < 20).

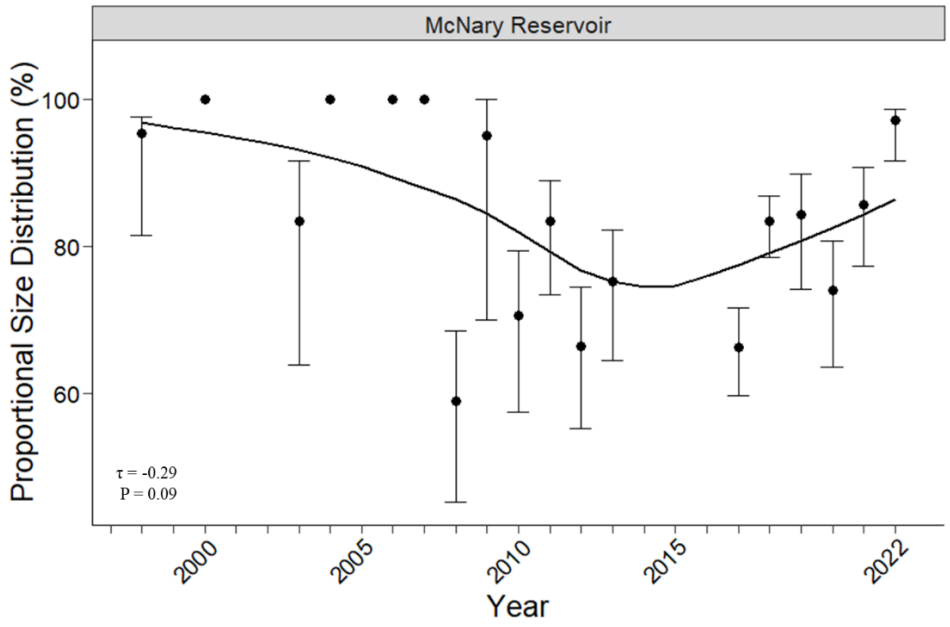

Figure 6. Estimates of proportional size distribution (PSD, %) of Walleye collected during fishery evaluation in McNary Reservoir, 1997–2022. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years without data indicate no sampling or sample sizes were insufficient for analysis (n_s < 20).

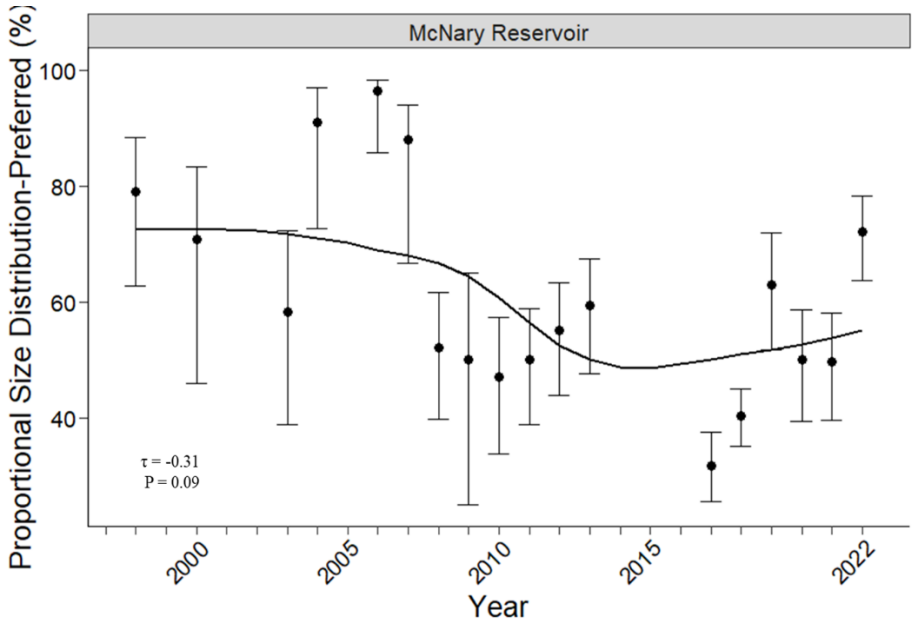

Figure 7. Estimates of proportional size distribution of preferred-length (PSD-P, %) Walleye collected during fishery evaluation in McNary Reservoir, 1998–2022. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years without data indicate no sampling or sample sizes were insufficient for analysis (n_s < 20).

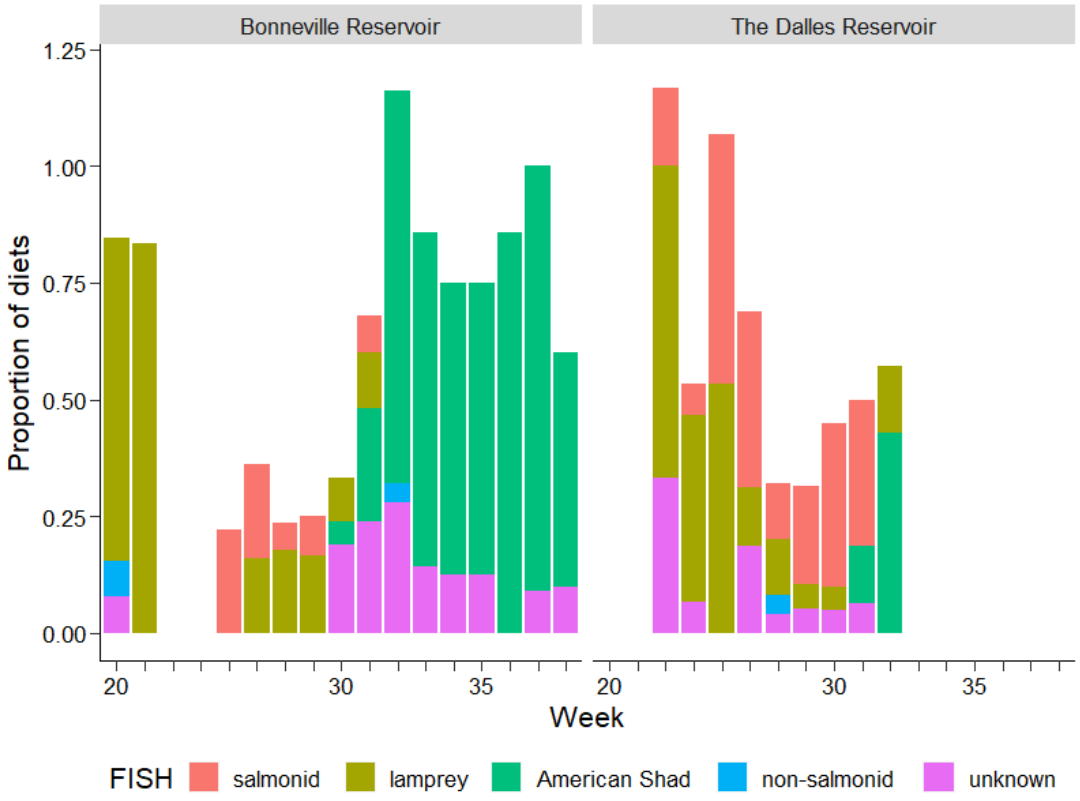

Figure 8. Proportion of all Northern Pikeminnow diet samples containing prey fish collected during the Dam Angling Fishery from the powerhouse tailraces of Bonneville (fishing from The Dalles Dam) and The Dalles (fishing from John Day Dam) reservoirs, May–September 2022. All Northern Pikeminnow diet samples collected were included in this analysis, including samples that were empty or fishless. Multiple fish groups may be represented in individual Northern Pikeminnow diets. Note: weeks without data indicate that sampling was not conducted, or sample sizes were insufficient for analyses ($n < 6$).

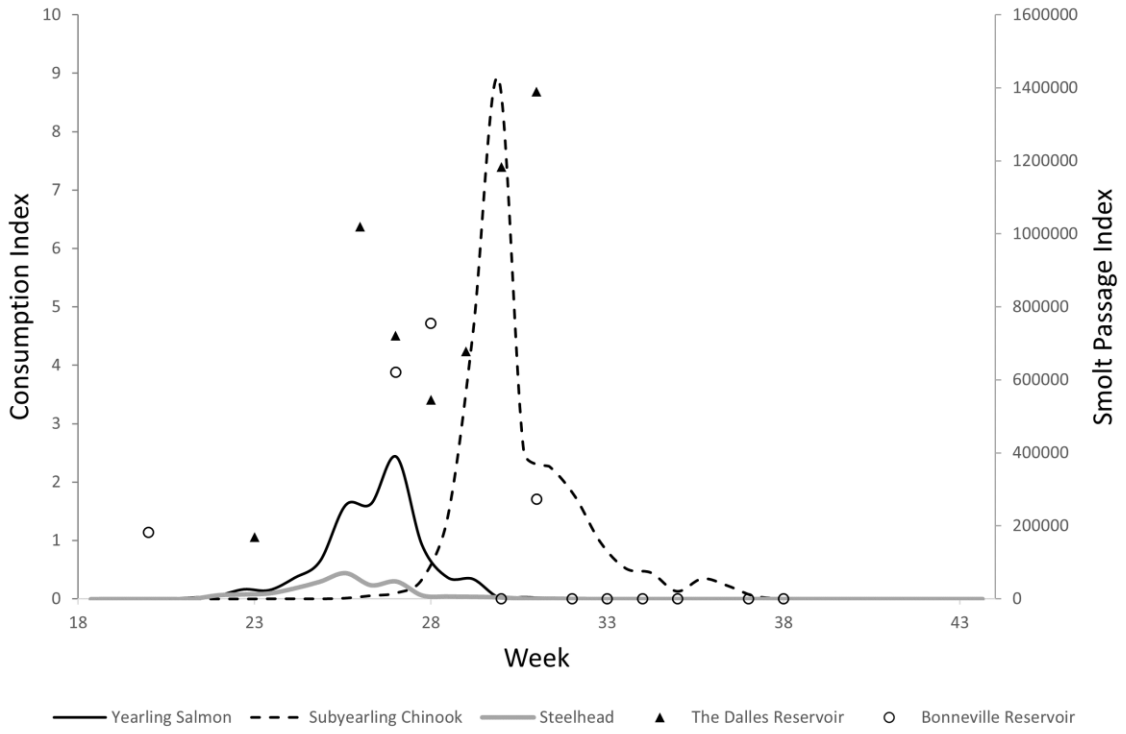

Figure 9. Mean weekly juvenile salmon consumption index for Northern Pikeminnow captured from the Dam Angling Fishery (DAF) in Bonneville (open circles) and The Dalles (filled triangles) reservoirs compared to the weekly smolt passage index at McNary Dam, 2022. Smolt passage data are summarized from Fish Passage Center (unpublished data). DAF sampling was conducted from Weeks 20-39. Weeks without data indicate that sampling was not conducted, or sample sizes were insufficient for analyses (n < 6).

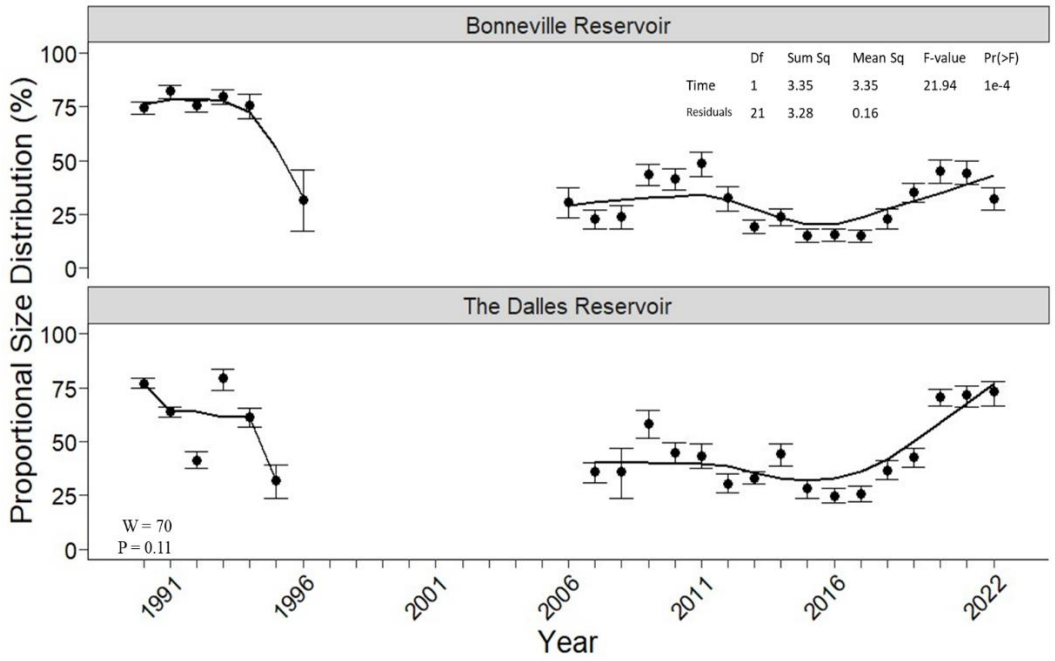

Figure 10. Estimates of proportional size distribution (PSD, %) of Northern Pikeminnow sampled in Bonneville and The Dalles reservoirs during the Dam Angling Fishery, 1990–2022. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves for two different time series: early (1990–1996) and late (2006–2022), due to the large data gap between them. Years without data indicate sampling was not conducted or sample sizes were insufficient for analyses ($n_s < 20$).

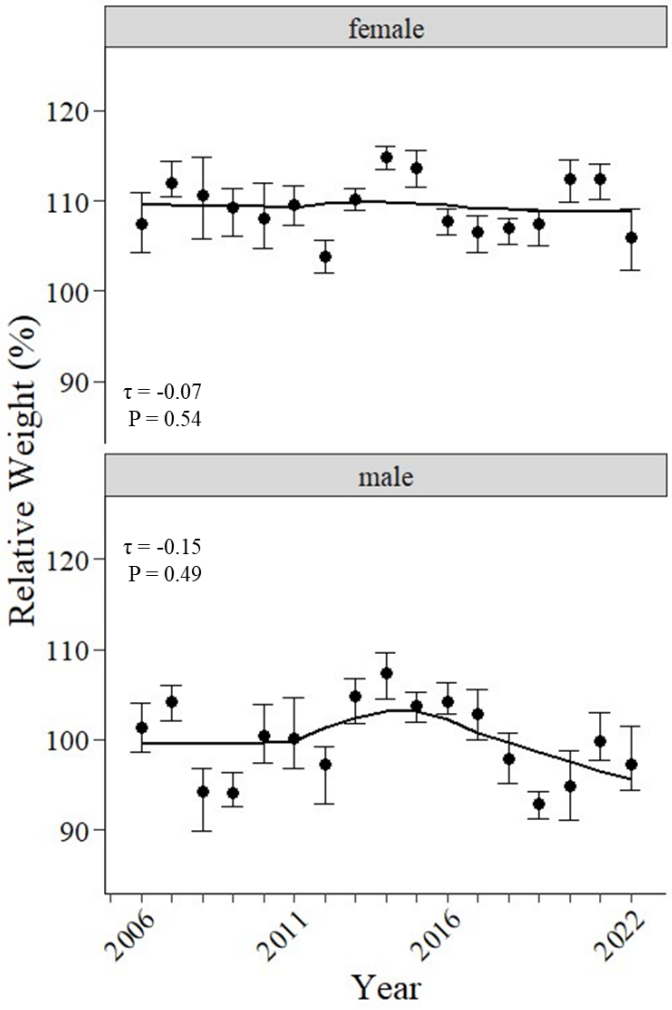

Figure 11. Median relative weight (*Wr*, %) for female and male Northern Pikeminnow collected in Bonneville Reservoir during the Dam Angling Fishery, 2006–2022. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each sex.

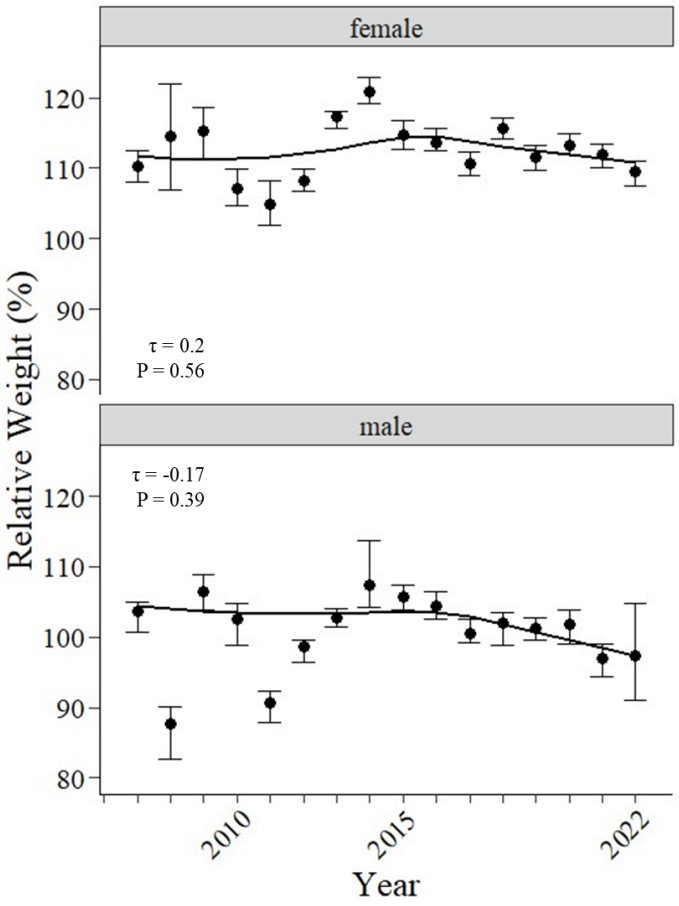

Figure 12. Median relative weight (*Wr*, %) for female and male Northern Pikeminnow collected in The Dalles Reservoir during the Dam Angling Fishery, 2007–2022. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each sex.

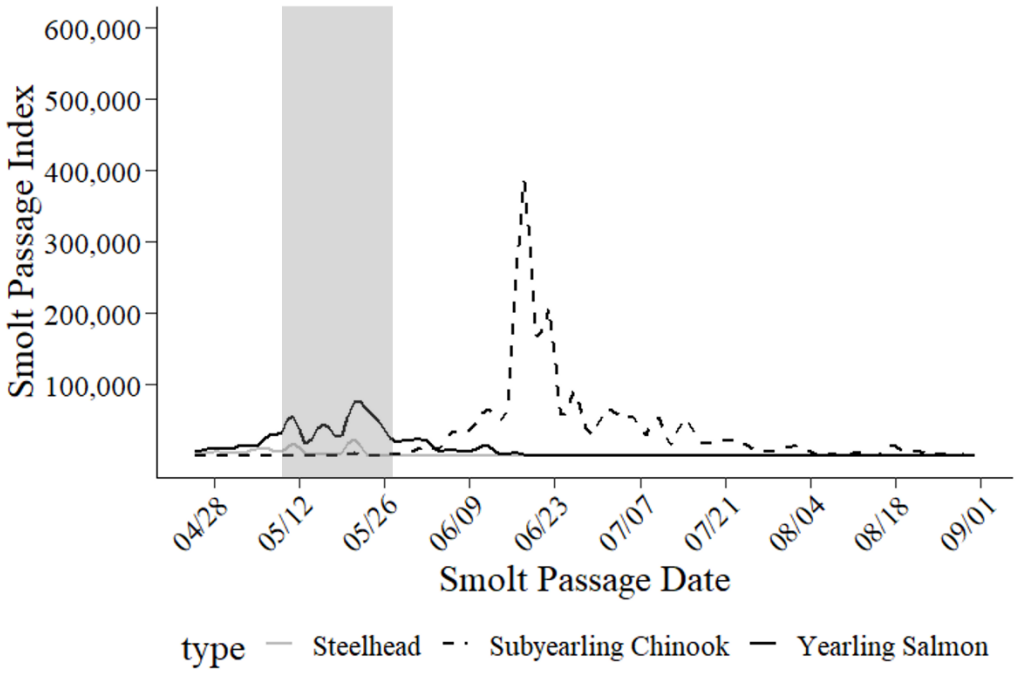

Figure 13. Period of biological evaluation (vertical bar) in John Day Reservoir and juvenile salmon and steelhead daily passage index through McNary Dam, April–September 2022 (Source: Fish Passage Center, unpublished data).

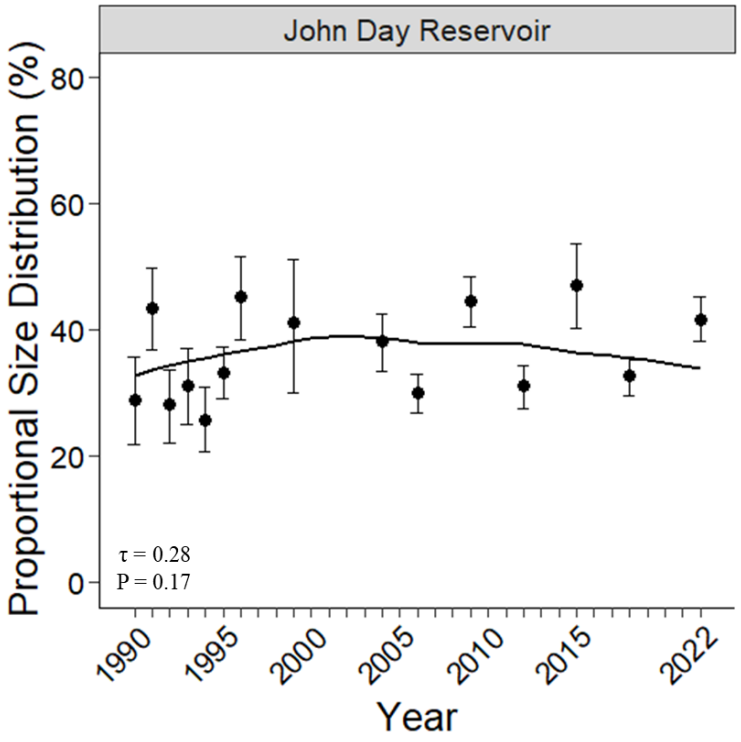

Figure 14. Estimates of proportional size distribution (PSD, %) of Smallmouth Bass collected during biological evaluation below John Day Reservoir, 1990–2022. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Years without data indicate sampling was not conducted or sample sizes were insufficient for analysis (n_s < 20).

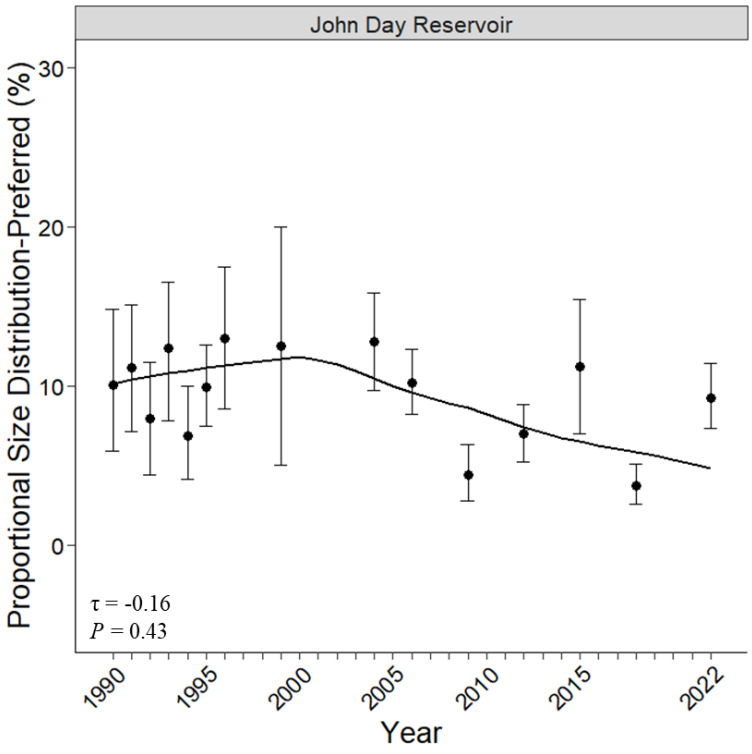

Figure 15. Estimates of proportional size distribution of preferred-length (PSD – P, %) Smallmouth Bass collected during biological evaluation in John Day Reservoir, 1990–2022. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Years without data indicate sampling was not conducted or sample sizes were insufficient for analysis ($n_s < 20$).

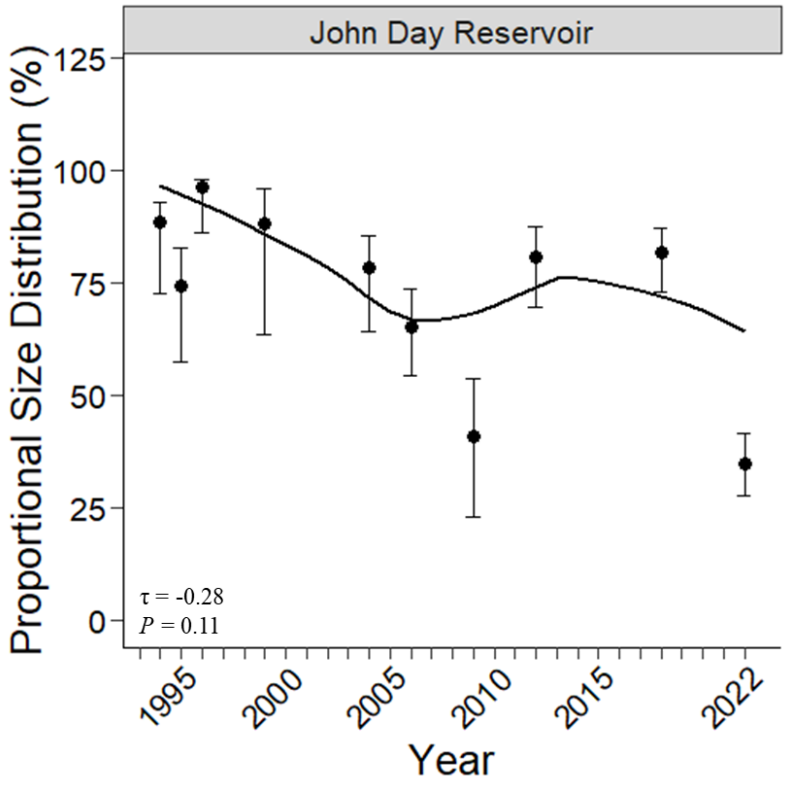

Figure 16. Estimates of proportional size distribution (PSD, %) of Walleye collected during biological evaluation below John Day Reservoir, 1990–2022. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Years without data indicate sampling was not conducted or sample sizes were insufficient for analysis ($n_s < 20$).

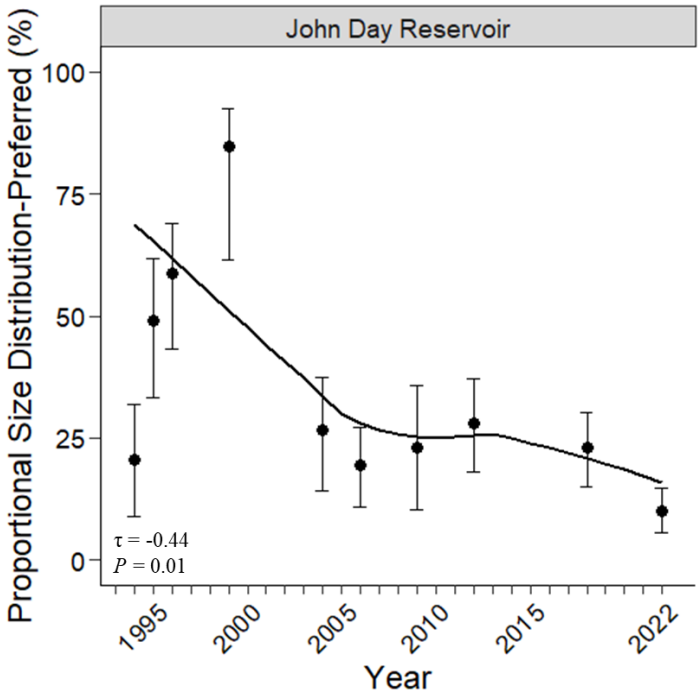

Figure 17. Estimates of proportional size distribution of preferred-length (PSD – P, %) Walleye collected during biological evaluation in John Day Reservoir, 1990–2022. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Years without data indicate sampling was not conducted or sample sizes were insufficient for analysis ($n_s < 20$).

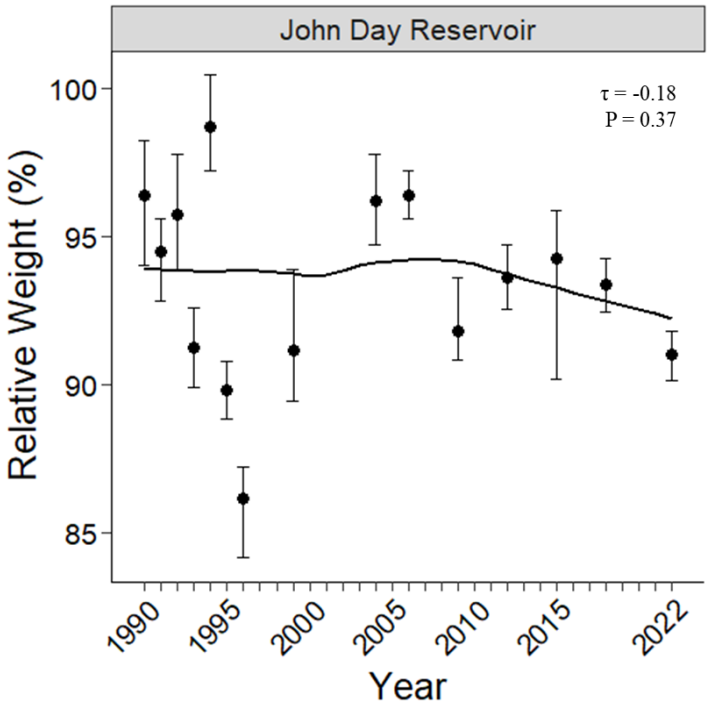

Figure 18. Median relative weight (W_r, %) of Smallmouth Bass collected during biological evaluation below John Day Reservoir, 1990–2022. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years without data indicate that sampling was not conducted, or sample sizes were insufficient for analyses ($n < 5$).

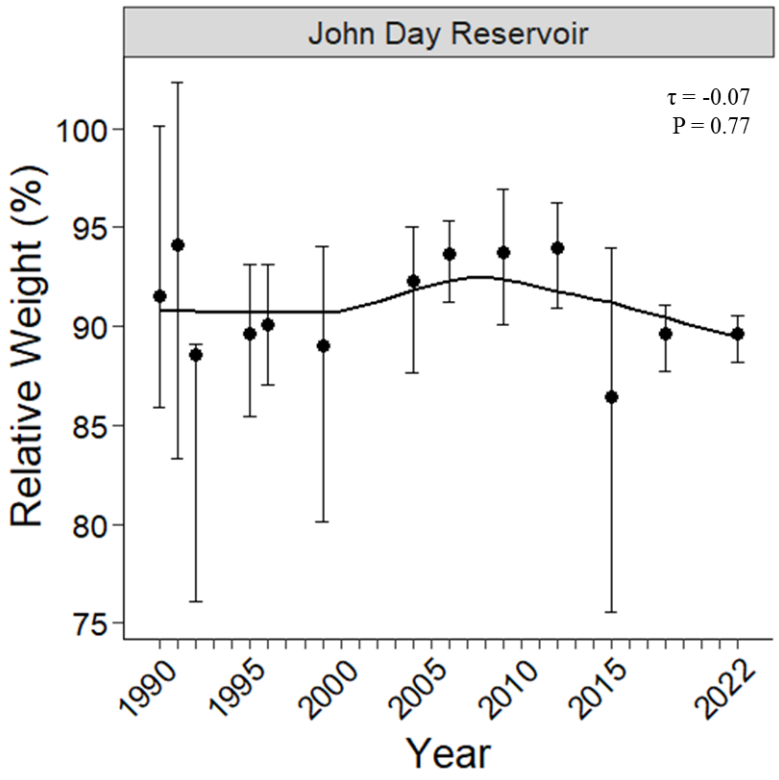

Figure 19. Median relative weight (W_r, %) of Walleye collected during biological evaluation in John Day Reservoir, 1990–2022. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time series. Years without data indicate that sampling was not conducted, or sample sizes were insufficient for analyses (n < 5).

Report D

Northern Pikeminnow Dam Angling on the Columbia River

2022 Annual Report

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We appreciate the efforts of Kyle Beckley as the Pikeminnow Dam Angling crew leader, along with Nick Makiney, Ryan Chen and Joe Xiong who served as our 2022 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 2022 season.

ABSTRACT

We are reporting on the 2022 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 19 weeks from May 23th through September 30th 2022. 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 2022 Dam Angling crew.

A Dam Angling crew of four anglers harvested a total of 1,171 Northern Pikeminnow during the 2022 season. Of those, 610 Northern Pikeminnow were harvested at The Dalles Dam and 561 were harvested at the John Day Dam. The crew fished a total of 1,050.5 hours during the 19 week fishery, averaging 62 fish per week and for a combined overall average catch per angler hour (CPUE) of 1.1 Northern Pikeminnow. At The Dalles Dam, the crew averaged 1.3 fish per angler hour, and cumulatively 10.9 Northern Pikeminnow per day. At the John Day Dam, the crew averaged 1.0 fish per angler hour with a cumulative crew total of 10.2 fish per day.

Based on the previous success of the WDFW Dam Angling Crew in implementing the Dam Angling component of the NPMP from 2010-21, the 2022 crew continued to use back bouncing soft plastic lures with rod and reel as the primary angling method for harvesting Northern Pikeminnow from the turbine decks of The Dalles and John Day dams. Incidental species most frequently caught and released by the Dam Angling crew in 2022 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 $\geq$ 275 mm FL (11 inches total length). The Northern Pikeminnow Management Program (NPMP) was created in 1990, with the goal of implementing fisheries to achieve the recommended 10-20% annual exploitation on Northern Pikeminnow $\geq$275 mm FL within the program area (Vigg and Burley 1989). The primary component of the NPMP is the Northern Pikeminnow Sport-Reward Fishery (NPSRF) implemented by the Washington Department of Fish and Wildlife (WDFW) (Burley et al. 1992). Beginning in 2010, WDFW was also contracted to conduct the Dam Angling component of the NPMP (Hone et al. 2011) and 2022 marked the 13th 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 2022.

The objectives of the 2022 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 or Floy 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 2022 Dam Angling crew.

METHODS

Project Area

In 2022, as a continuing supplemental component to the NPMP, Northern Pikeminnow hook-and-line 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 2022 were planned to occur during approximately five-month season scheduled to run from May through September. All angling activities at both The Dalles, and John Day Dams were conducted within the tailrace BRZs where no public angling was permitted. For The Dalles Dam, the Dam Angling crew fished primarily along the turbine deck (Figure 2), and at the John Day Dam, the crew fished exclusively along the turbine deck (Figure 3).

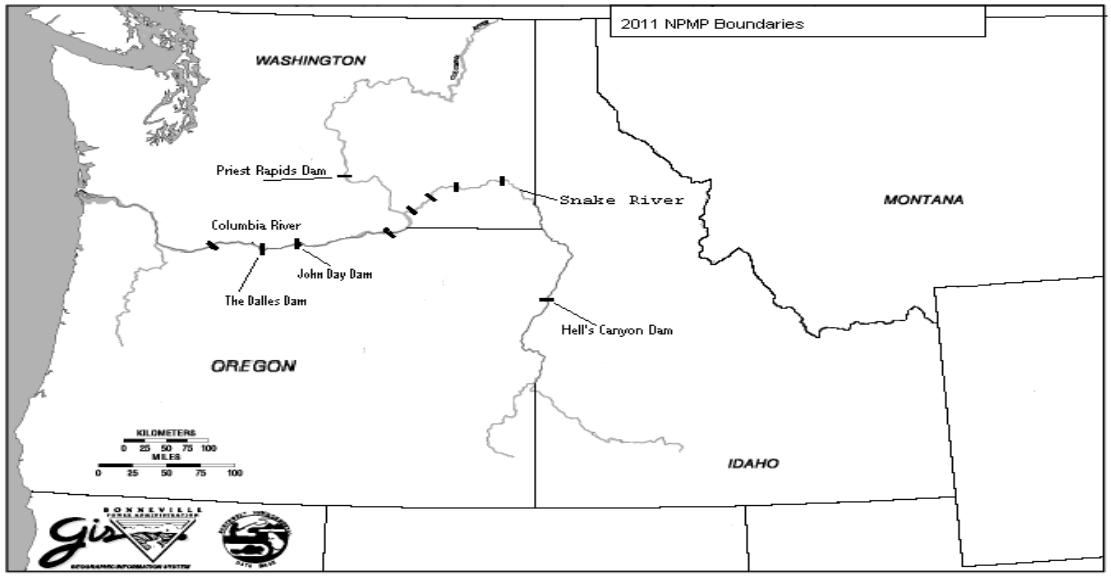

Figure 1. Northern Pikeminnow Management Program boundaries, including 2022 Dam Angling sites.

Figure 2. Angling locations for 2022 Dam Angling at The Dalles Dam

Figure 3. Angling locations for 2022 Dam Angling 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 2022, the WDFW Dam Angling crew continued to use WDFW's Dam Angling Strategy (DAS) established in 2011 (Dunlap et al. 2012), which implemented and maintained full scale angling activities when CPUE was $\geq$ 2.0 fish/angler hour, and reduced scale angling activities when CPUE fell below 2.0 fish/angler hour.

The Dam Angling Crew

The four member Dam Angling crew generally worked four ten hour days a week, (usually Tuesday - Friday) during the 2022 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 start 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 oversee angler safety and supervision, to collect, record and compile data on Northern Pikeminnow harvest, other fish species caught, and ensure that all NPMP project protocols and Corps of Engineers (USACE) rules were adhered to.

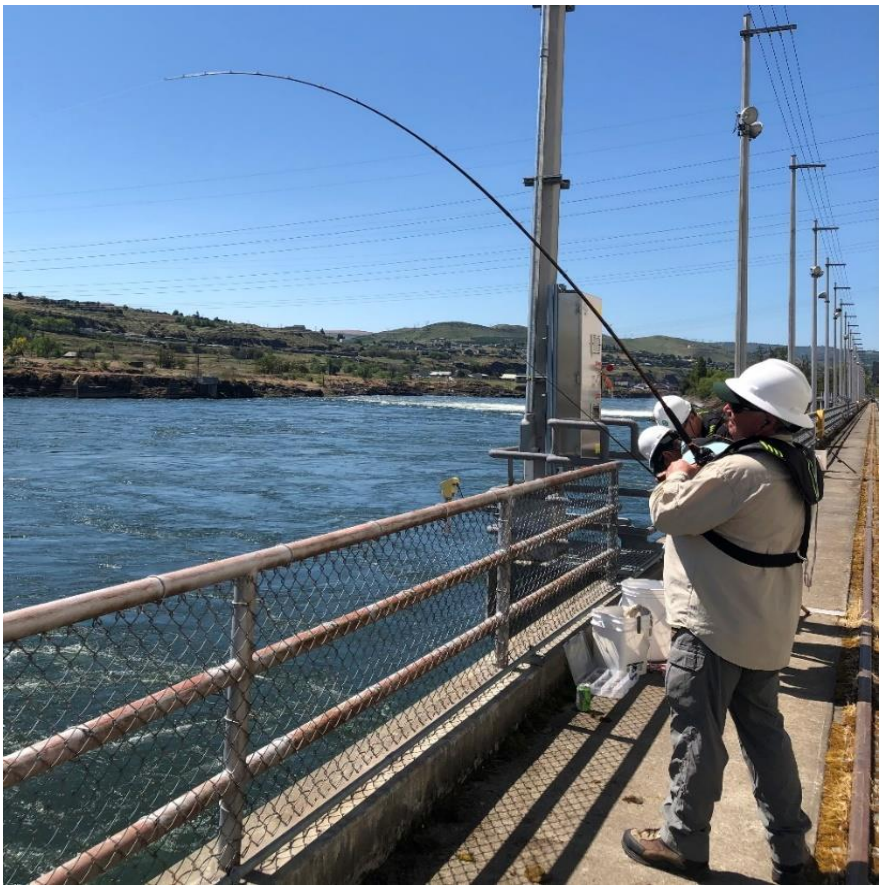

Figure 4. The Dam Angling Crew at John Day Dam

Angling Gear

Dam Anglers used Berkley Air IM8 Graphite 10'6" (2-8 oz. extra heavy casting) rods equipped with either Daiwa Lexa_HD 300 or Shimano TranX 300 series reels. Each reel was spooled with either 15# or 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 2-6 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.

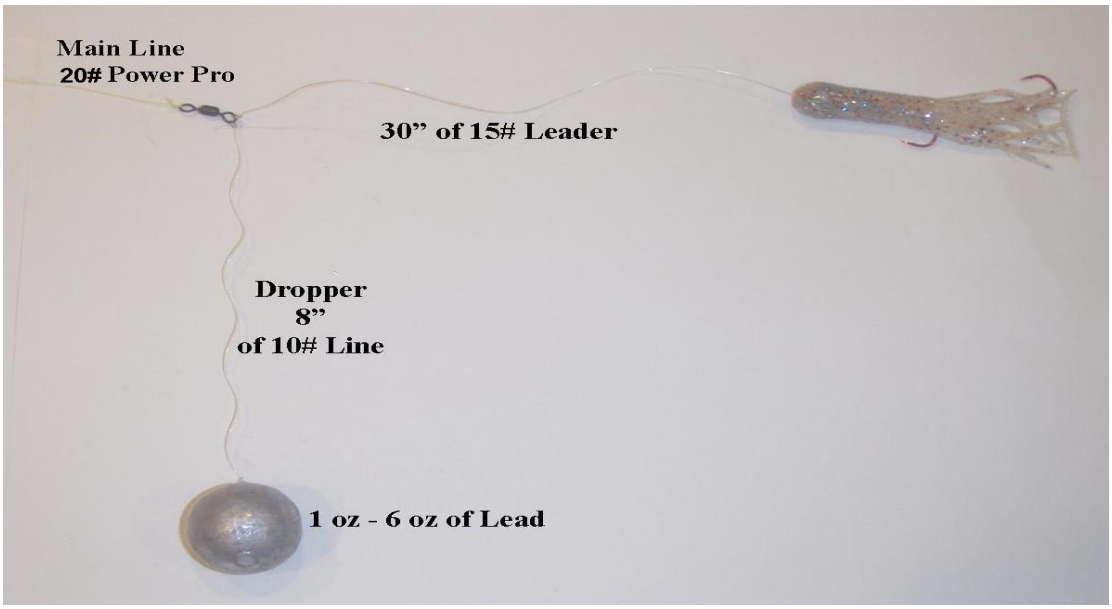

Figure 5. Example of typical rigging used by 2022 NPMP Dam Anglers

Figure 6. Examples of soft plastic tube lures used by 2022 NPMP Dam Angling Crew.

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 externally tagged Northern Pikeminnow including FL, tag number, sex (determined by evisceration), and scale samples if specified. Spaghetti or Floy tagged Northern Pikeminnow carcasses were then labeled and preserved for later data verification and/or tag recovery. External tags from harvested Northern Pikeminnow along with biological data were recorded on 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 utilization in NPMP exploitation estimates.

PIT Tag Detection

All Northern Pikeminnow collected by Dam Anglers during 2022 were also scanned for Passive Integrated Transponder (PIT) tags. PIT tags have been used by ODFW as a secondary mark in all Northern Pikeminnow fitted with external spaghetti or Floy type tags (beginning in 2003) as part of the NPMP's biological evaluation activities (Takata and Koloszar 2004), and as a primary mark beginning in 2022. Northern Pikeminnow harvested by anglers participating in the NPSRF have also been found to ingest juvenile salmonids which have been PIT tagged by other studies within the basin (Glaser et al. 2001). 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 juvenile salmonids. Scanning began on the first day of dam 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 as required.

Northern Pikeminnow Processing

During biological sampling, all Northern Pikeminnow were caudal clipped as an anti-fraud measure to reduce 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

2022 Dam Angling Season

The 2022 Dam Angling Season took place from May 23rd through September 30th. Total harvest for The Dalles and John Day dams combined was 1,171 Northern Pikeminnow in 1,050.5 angling hours, for a combined angler CPUE of 1.1 fish per angler hour. Peak weekly harvest occurred in week 29 (Figure 7), and was fairly challenging prior to week 27. The Dam Angling crew exceeded the CPUE goal of 2.0 fish/angler hour (for the first time during the 2022 season) in week 28 and results were mixed through the core harvest period ending in week 31(Figure 8). Per DAS protocol (Dunlap et al. 2012), weeks when CPUE was under the 2.0 fish/angler hour goal (outside core harvest weeks 27-31) were typically due to the Dam Angling crew deploying limited crews (< 50% effort) for "prospecting" purposes to locate and/or determine if catchable numbers of fish may be present and/or available.

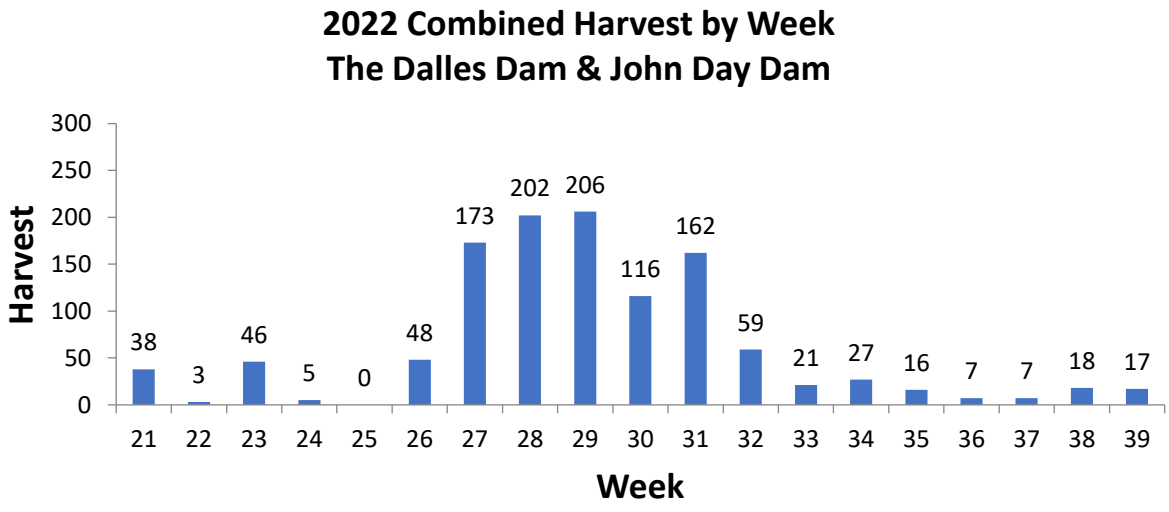

Figure 7. 2022 Weekly harvest of The Dalles (TD) and John Day (JD) Dams combined

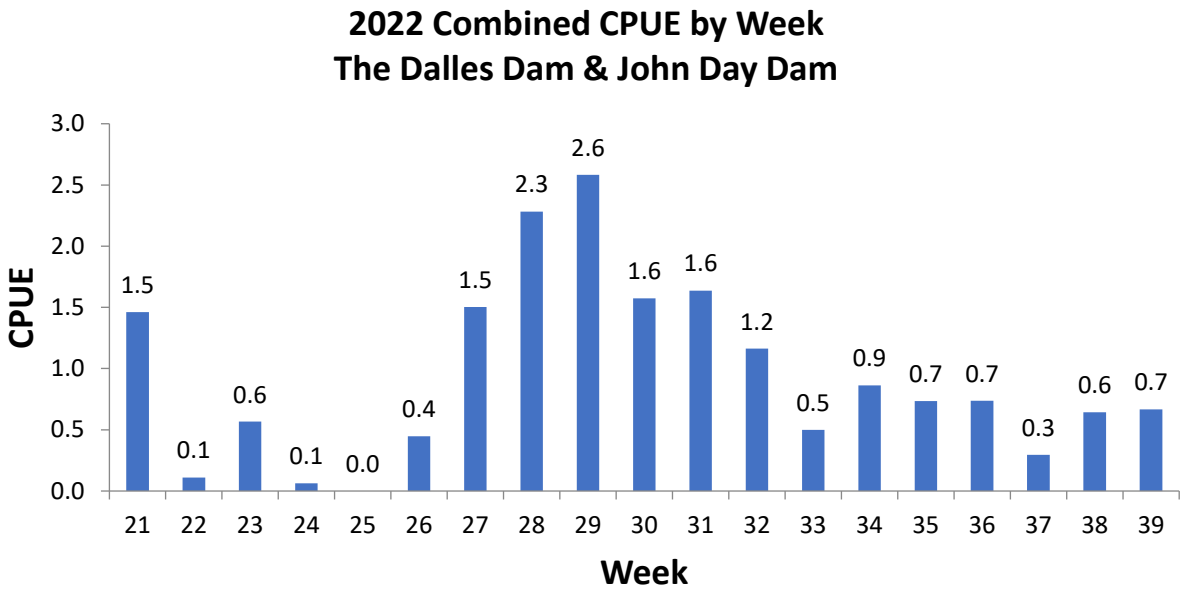

Figure 8. 2022 Weekly CPUE (fish/angler hour) of The Dalles (TD) and John Day (JD) Dams combined

Angling Gear and Technique

The 2022 Dam Angling crew primarily targeted fishing areas and fishing times at each dam that had been productive in past years. Our top producing lure in 2022 was the 3.75" Gitzit tube (a soft plastic lure) in Smoke/Black Red Glitter color.

Incidental Catch

The Dam Angling crew incidentally caught the fish species listed in Table 1 while targeting Northern Pikeminnow at The Dalles and John Day dams in 2022. All incidentally caught fish species were released in 2022. Incidental species most often caught were Walleye *Sander vitreus and* Smallmouth Bass *Micropterus dolomieue*. The Dam Angling crew continued to observe numbers of juvenile lamprey *Entosphenus* spp. and/or *Lampetra* spp. regurgitated by Northern Pikeminnow, Smallmouth Bass and Walleye caught at The Dalles Dam and John Day Dam during May and June (figure 9).

Figure 9. Juvenile lamprey regurgitated by Northern Pikeminnow.

Table 1. 2022 WDFW Dam Angler incidental catch by project

Incidental Catch

Species	The Dalles Dam	John Day Dam
Smallmouth Bass	61	457
Walleye	4	141
Sculpin	11	10
American Shad	4	8
Channel Catfish	1	7
White Sturgeon	2	5
Sucker	0	4

The Dalles Dam

Harvest

The Dam Angling crew harvested 610 Northern Pikeminnow in 19 weeks of Dam Angling at The Dalles Dam in 2022. Weekly harvest for the Dam Angling crew averaged 32 fish per week during the 2022 season (Figure 10).

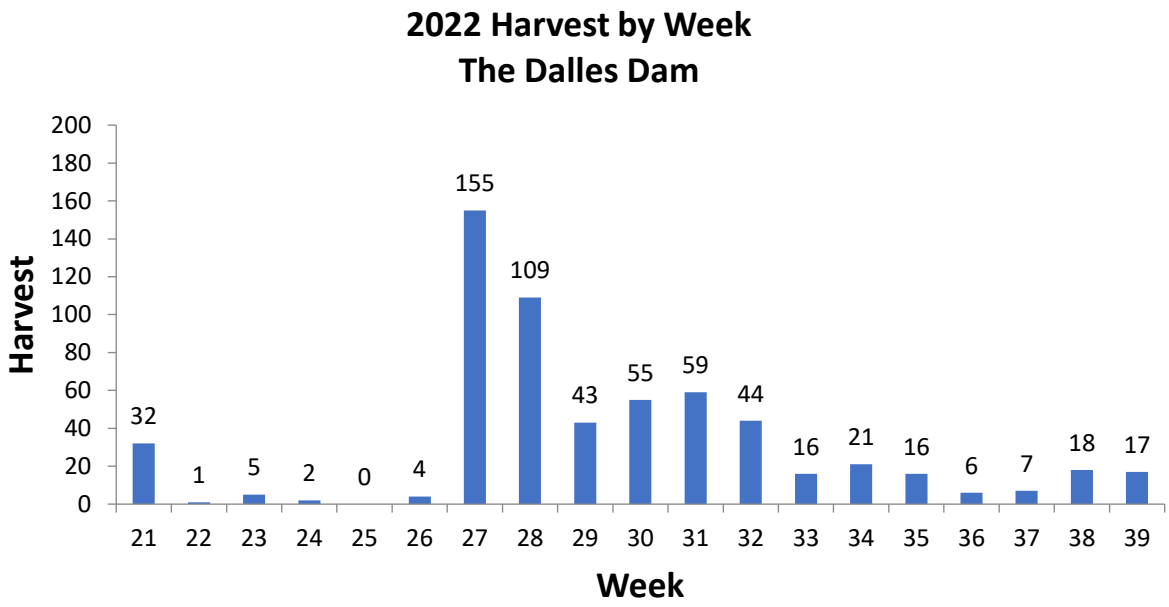

Figure 10. 2022 Weekly Dam Angler harvest of Northern Pikeminnow at The Dalles Dam

Effort

Total Dam Angler effort at The Dalles Dam was 463.25 angler hours in 2022. The Dam Angling crew fished 56 days at The Dalles Dam over 19 weeks equaling 44% of combined total Dam Angling effort (both projects) in 2022.

CPUE

The Dam Angling crew harvested 610 Northern Pikeminnow in 463.25 angler hours at The Dalles Dam in 2022 for an overall average CPUE of 1.3 fish/angler hour (Figure 11). Peak weekly CPUE at The Dalles Dam occurred during week 28.

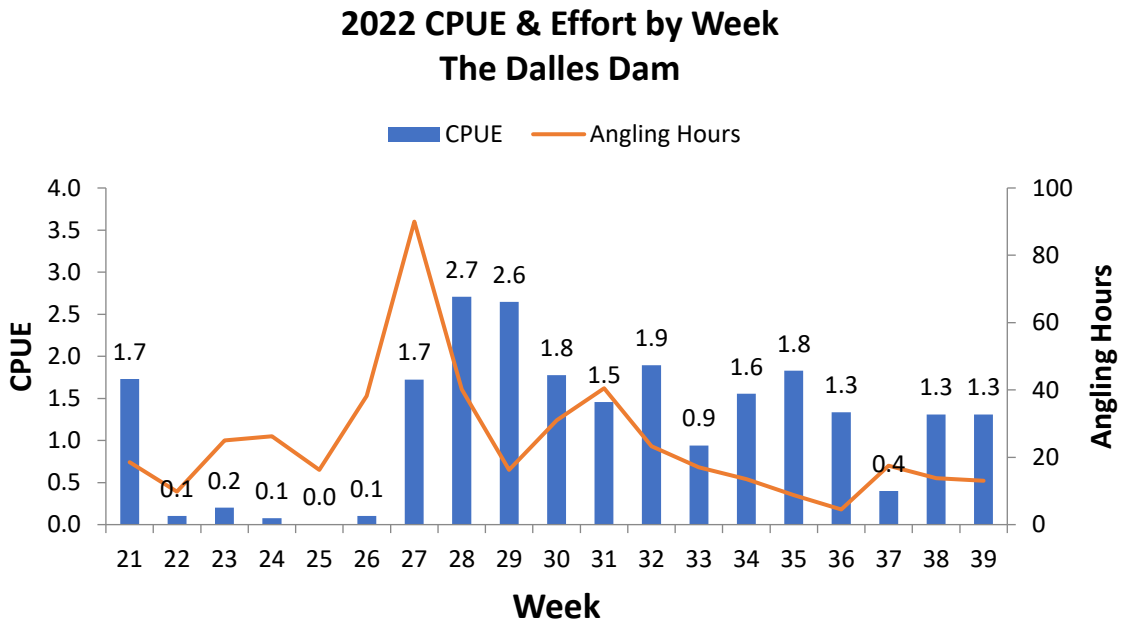

Figure 11. 2022 Weekly Dam Angler CPUE and Effort at The Dalles Dam

Fork Length Data

Fork lengths were recorded from 610 (100%) Northern Pikeminnow harvested by the Dam Angling crew at The Dalles Dam during the 2022 Season. The length frequency distribution of Northern Pikeminnow harvested at The Dalles Dam in 2022 is presented in Figure 12. Mean fork length for Northern Pikeminnow caught by the Dam Angling crew at The Dalles Dam in 2022 was 379 mm. By comparison, the mean fork length for the 2022 NPSRF was 263 mm (Werlau et al. 2023).

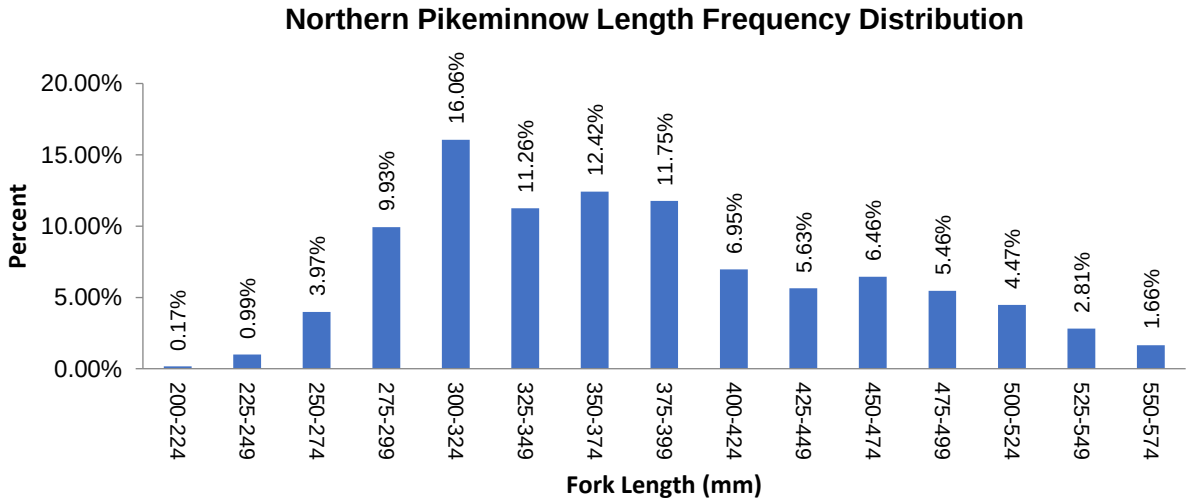

Figure 12. Northern Pikeminnow length frequency distribution at The Dalles Dam in 2022

John Day Dam

Harvest

The Dam Angling crew harvested 561 Northern Pikeminnow over 19 weeks at the John Day Dam in 2022. Peak weekly harvest at the John Day Dam occurred in week 29 and was spotty outside the core week 26-31 peak harvest period (Figure 13).

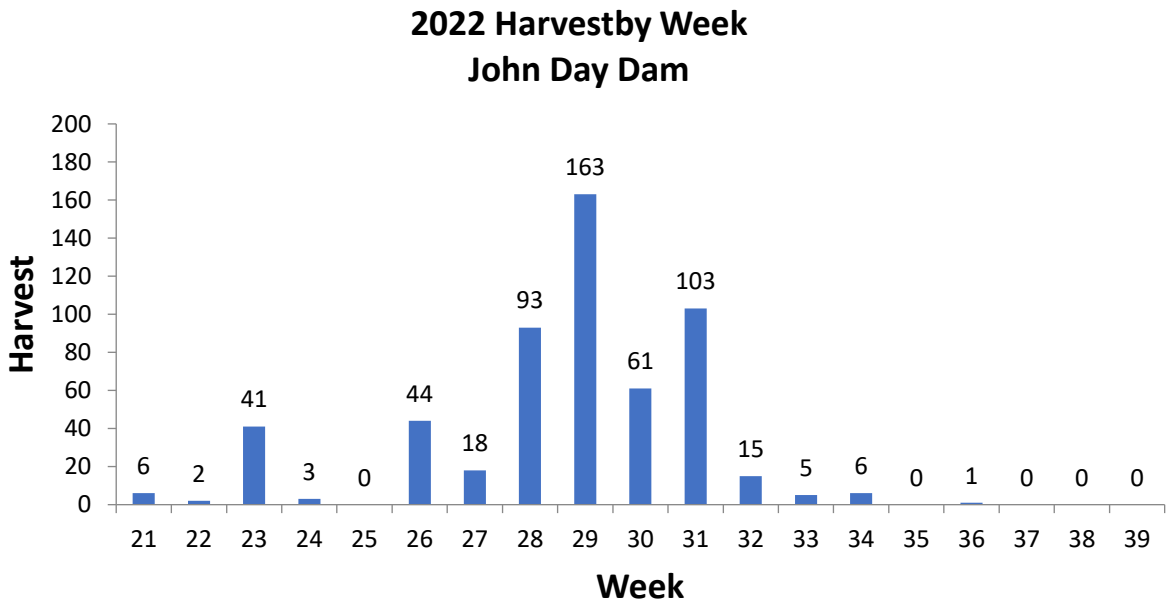

Figure 13. 2022 Weekly Dam Angler harvest of Northern Pikeminnow at the John Day Dam

Effort

Total effort at the John Day Dam was 587.25 angler hours in 2022. The Dam Angling crew fished 55 days at John Day Dam over 19 weeks equaling 56% of total combined Dam Angling effort (for both projects) in 2022.

CPUE

The Dam Angling crew harvested 561 Northern Pikeminnow in 587.25 angler hours at the John Day Dam in 2022 for an overall average CPUE of 1.0 fish/angler hour. Peak weekly CPUE at the John Day Dam occurred during week 29 (Figure 14).

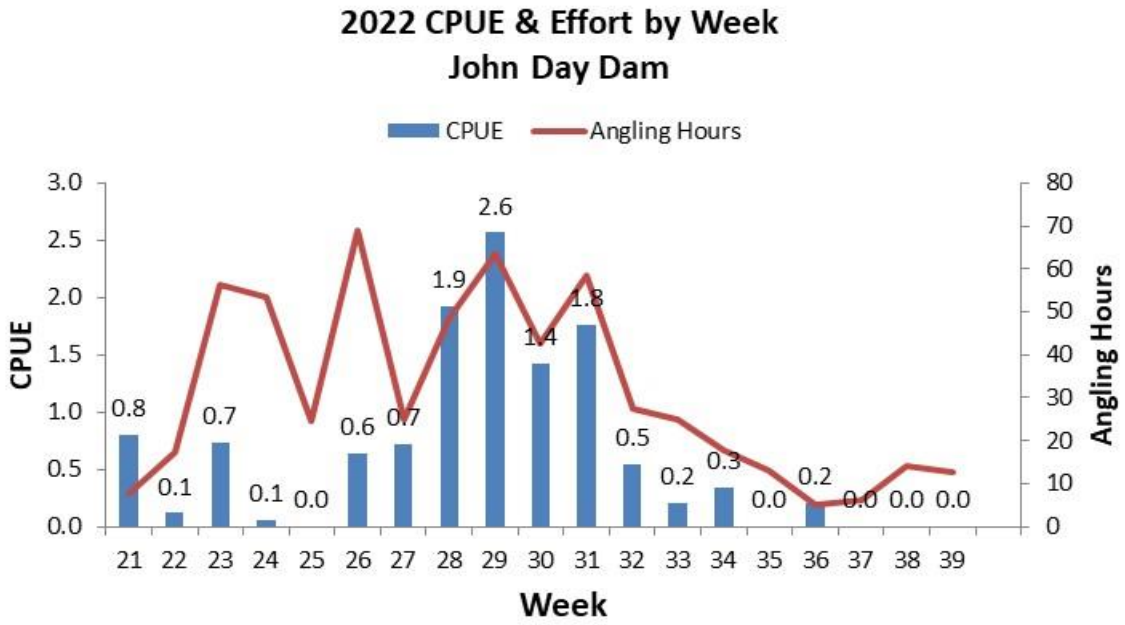

Figure 14. 2022 Weekly Dam Angling CPUE at John Day Dam

Fork Length Data

Fork lengths were recorded from 561 (100%) Northern Pikeminnow harvested by the Dam Angling crew at the John Day Dam during the 2022 Season. The length frequency distribution of harvested Northern Pikeminnow from the John Day Dam in 2022 is presented in (Figure 15). Mean fork length for Northern Pikeminnow from the John Day Dam in 2022 was 418 mm compared to 379 mm at The Dalles Dam, and 263 mm for the 2022 NPSRF (Werlau et al. 2023).

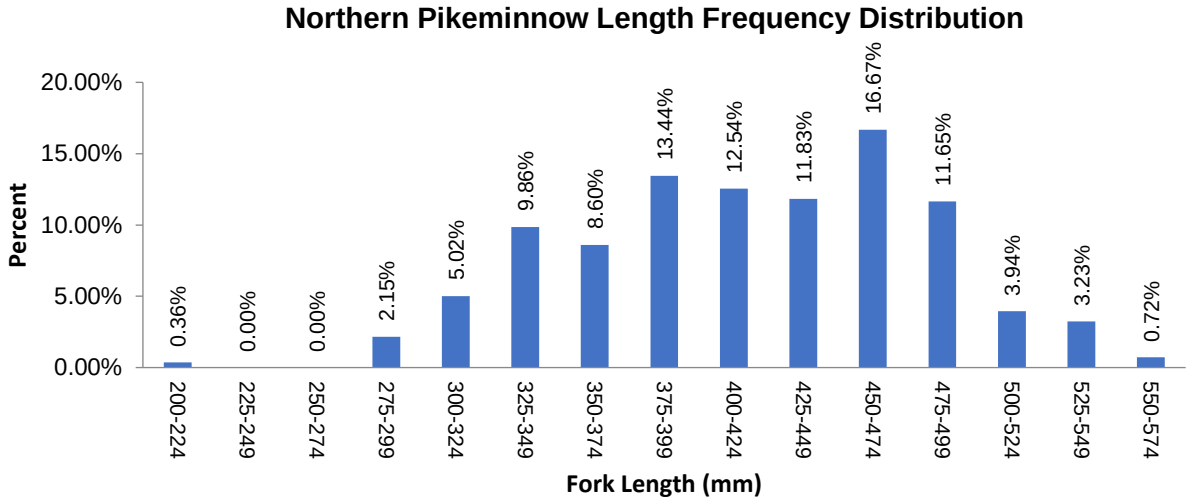

Figure 15. Northern Pikeminnow length frequency distribution at the John Day Dam in 2022

SUMMARY

During the 2022 Dam Angling season, harvest was down significantly from previous years as the angling/river conditions were especially challenging as evidenced by the relatively low angler CPUE. The Dam Angling crew spent 56% of their effort fishing at the John Day Dam and 44% of their effort at The Dalles Dam.

Mean Fork lengths for Northern Pikeminnow harvested by the 2022 Dam Angling Crew at The Dalles and John Day dams were considerably larger than the mean fork length for the NPSRF (379 mm at The Dalles Dam, 418 mm at John Day, and 263 mm from the 2022 NPSRF).

While targeting Northern Pikeminnow, the 2022 Dam Angling crew incidentally caught a combined total of 518 Smallmouth Bass, 145 Walleye, 12 American Shad, 21 Sculpin, and 8 Channel Catfish between the two projects.

RECOMMENDATIONS FOR 2023

1.) Maintain the Dam Angling component of the NPMP to remove predatory Northern Pikeminnow from the Boat Restricted Zones in the tailrace areas of The Dalles and John Day dams where Northern Pikeminnow Sport-Reward Fishery participants are not allowed.

2.) Continue to investigate conducting Pikeminnow Dam Angling at other Columbia and Snake River dams as funding and resources allow, or during non-peak times at TD and JD dams. Offer Dam Angler assistance to other research projects wishing to obtain Northern Pikeminnow and other fishes from BRZ areas to determine project feasibility and/or as a possible step to adding additional dams to the DA project.

3.) Plan for 2023 Dam Angling activities to occur during the standard May-September Dam Angling season with a focus on maximizing Dam Angler effort during peak CPUE weeks.

4.) Continue to utilize the 2.0 CPUE goal (DAS) to allocate Dam Angler effort between projects in order to maximize Dam Angler harvest of Northern Pikeminnow.

5.) 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 2023.

6.) Use HPR PIT tag scanners for scanning all incidentally caught predatory fishes.

7.) Continue to investigate and further develop Northern Pikeminnow angling techniques in 2023 such as finding additional exploitation opportunities of Northern Pikeminnow in areas not previously fished or currently fishable.

8.) Implement and investigate the feasibility of retaining carcasses of incidentally caught non-native predator fishes and recording data as done with other Columbia River research projects.

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