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

2020 ANNUAL REPORT
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2020 Executive Summary
by

Chris Wheaton

This report presents results for year twenty-eight in the basin-wide Northern Pikeminnow Sport Reward Program, designed to harvest Northern Pikeminnow[1] (Ptychocheilus oregonensis) in the Columbia and Snake Rivers. This season was unique in that the ongoing COVID-19 pandemic resulted in the start of the 2020 NPSRF being delayed. In an effort to boost exploitation and angler participation adversely affected by the pandemic, the season was later extended and temporary angler incentives implemented. Results of these efforts are provided in the detailed reports that follow.

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 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.

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[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.*

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 28-year period are subjects of this annual report.

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

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

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

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

3. **ODFW (Report C)**: Evaluate exploitation rate and size composition of Northern Pikeminnow harvested in the various fisheries conducted. Estimate reductions in predation on juvenile salmonids resulting from Northern Pikeminnow harvest and update information on year-class strength of Northern Pikeminnow.

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

Background and rationale for the Northern Pikeminnow Management Program can be found in Report A of our 1990 annual report (Vigg et al. 1990).

REPORT A

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

2020 Annual Report

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

We appreciate the efforts of Kyle Beckley, Josh Boston, Addie Donohue, Mark Flahaut, Bill Fleenor, Leif Fox, Roger Fox, Summer Henrickson, Anna Klundt, McKaden Manderbach, Mark McGowen, Eric Meyer, Jordan Miller, Brittney Salter, Amber Santangelo, Emily Splitgerber, John Paul Viviano, Robert Warrington and Dennis Werlau for operating the 2020 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 2020 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 11 through October 11, 2020. 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 102,935 Northern Pikeminnow $\geq$ 228 mm fork length (FL) and 2,583 Northern Pikeminnow < 228 mm FL were harvested during the 2020 NPSRF season. There was a total of 2,433 different individual anglers who spent 15,982 angler days of effort participating in the NPSRF during the 2020 season. Catch per unit effort for combined returning and non-returning anglers was 6.4 fish/angler day. The Oregon Department of Fish and Wildlife (ODFW) estimated that the Northern Pikeminnow harvest activities from the 2020 NPSRF resulted in an overall exploitation rate of 17.8% (Barr et al. 2021).

Anglers submitted 111 Northern Pikeminnow with external ODFW spaghetti or Floy tags, all of which had an internal ODFW PIT tag. There were also 156 Northern Pikeminnow with ODFW PIT tags, but missing spaghetti or Floy tags (tag-loss). Additionally, 21 PIT tags from ingested juvenile salmonids were recovered from Northern Pikeminnow received during the 2020 NPSRF.

Peamouth *Mylocheilus caurinus*, Smallmouth Bass *Micropterus dolomieue*, and Sculpin *Cottoidea* 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 5.2 million reward sized Northern Pikeminnow and spent over 968,000 angler days of effort to become the NPMP's most successful component for achieving the annual 10-20% exploitation rate on Northern Pikeminnow within the program boundaries (Klaybor et al. 1994, Friesen and Ward 1999).

In an effort to reverse declining angler participation seen from 2009-2014, the tiered angler reward system developed in 1995 (Hisata et al. 1996) which paid anglers higher rewards per fish based on achieving designated harvest levels was modified prior to the 2015 season (Winther et al. 2016). Reward changes raised the base reward to $5 per fish and made it easier for anglers to reach the other two higher tier levels. The goal of this action was to grow the number of proficient individual anglers (Tier 2 and Tier 3 anglers), and to incentivize these anglers to expend additional effort. At the same time, the higher base reward and more attainable 2nd and 3rd tier levels could attract and recruit additional new anglers to the NPSRF. Anglers continued to be rewarded an additional amount for returning Northern Pikeminnow with external tags (spaghetti or Floy type) 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 ongoing COVID-19 pandemic resulted in the start of the 2020 NPSRF being delayed 10 days until May 11, 2020 and the season was extended at limited stations through October 11th, 2020. A temporary, one-time angler incentive of $10 per eligible Northern Pikeminnow was implemented for the period of September 19th through October 11th in an effort to boost exploitation and angler participation adversely affected by the COVID-19 pandemic.

The objectives of the 2020 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 2020 NPSRF was started 10 days later than usual as a result of the ongoing COVID-19 pandemic in effect throughout the world. When the NPSRF opened on May 11th, it 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. Besides the delayed start date, the NPSRF was fully implemented, with all stations operating during from May 11 through September 30, 2020. The 2020 season was also extended at limited stations through October 11, 2020.

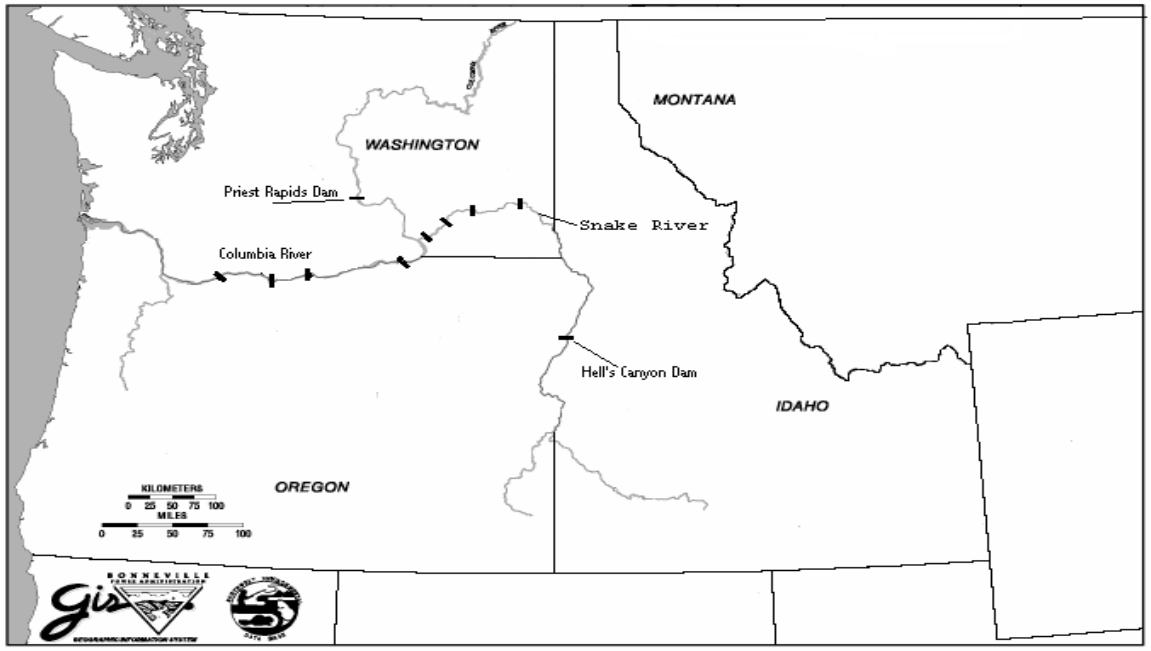


Figure 1. Northern Pikeminnow Sport-Reward Fishery Program Area

Registration Stations

Eighteen registration stations (Figure 2) were located along the Columbia and Snake Rivers within these boundaries to provide anglers with access to the Sport-Reward Fishery. WDFW technicians set up registration stations daily (seven days a week) at designated locations (normally public boat ramps or parks), which were available to anglers at specified times of between 2 and 4.5 hours per day during the season. Technicians assisted in registering anglers, and in compiling data for registered anglers participating in the NPSRF, collected angler creel

information, issued pay vouchers to anglers returning with eligible Northern Pikeminnow, recorded biological data, scanned Northern Pikeminnow for the presence of PIT tags, and provided angling advice and Sport-Reward Fishery information to the public. Self-registration boxes were also located at each station so anglers could self-register when WDFW technicians were not present.

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

Figure 2. 2020 Northern Pikeminnow Sport-Reward Fishery registration stations and hours of operation

Reward System

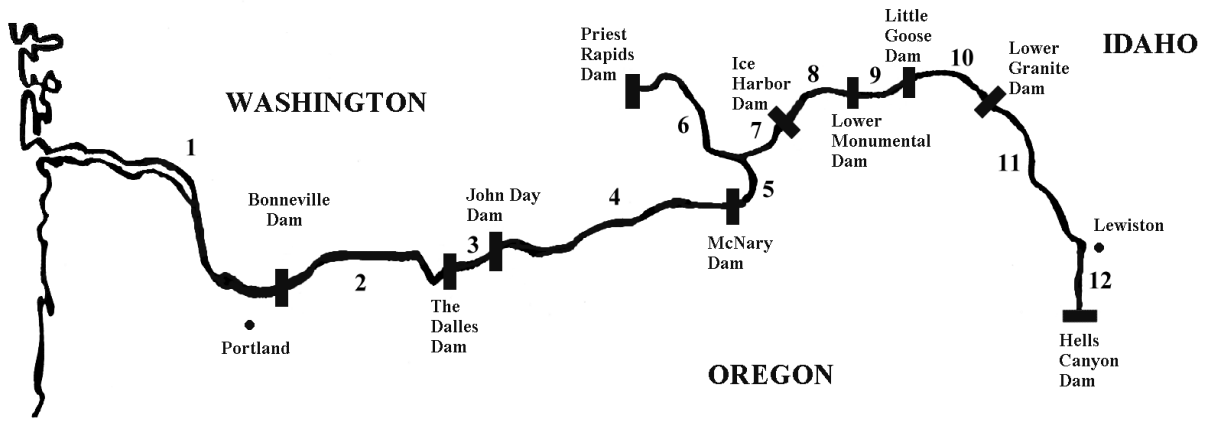
The 2020 NPSRF rewarded anglers for harvesting Northern Pikeminnow $\geq$ 228mm TL (9 inches TL) using a tiered reward system first implemented in 1995 (Hisata et al. 1996), which paid anglers a higher reward per fish once they had reached designated harvest levels over the course of the season. To receive payment, anglers returned their catch (daily) to the location where they had registered. WDFW technicians verified fish species (and that anglers had caught their fish in accordance with NPSRF Rules and Regulations) and issued them a payment voucher for the total number of eligible Northern Pikeminnow. Anglers mailed payment vouchers to the Pacific States Marine Fisheries Commission (PSMFC) for redemption. Anglers returning with Northern Pikeminnow that were spaghetti tagged by ODFW as part of the biological evaluation of the NPSRF (Vigg et al. 1990), were issued a separate tag payment voucher that was mailed to ODFW for tag verification before payment was made to the angler by PSMFC.

The tiered reward system used during the 2020 season was first developed in 1995 (Hisata et al. 1996), and reflected changes (to increase participation) that were made to the NPSRF's tiered reward system in 2015 (Winther et al. 2016). The tiered reward system paid anglers higher rewards per fish based on achieving designated harvest levels. Tier 1 paid anglers $5 each for their first 25 Northern Pikeminnow, Tier 2 paid anglers $6 each for fish numbers 26-200, and Tier 3 paid anglers $8 each for all fish over 200. As an example of adaptive management, the reward was temporarily increased to a flat $10 per eligible fish as a one-time angler incentive for the final 2+ weeks of the 2020 season (plus the extension) in an attempt to improve exploitation and boost NPSRF angler participation adversely affected by COVID-19.

Anglers continued to be paid $500 for each Northern Pikeminnow that retained a valid external tag (spaghetti or Floy) used by ODFW for the biological evaluation of the NPMP. 2020 NPSRF anglers were also paid $100 for each Northern Pikeminnow missing an external tag, but retaining the ODFW PIT tag (tag-loss). Reward values for spaghetti tagged fish were also temporarily increased to $1,000 during the end-of-year incentive period.

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 2020 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 collected in 2020 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 in 2019 and 2020. 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.

PIT Tag Detection

All Northern Pikeminnow collected during the 2020 NPSRF were 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, tags (beginning in 2003) as part of the NPMP's biological evaluation activities (Takata and Koloszar 2004). 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 $100 reward from PSMFC for "tag-loss" fish which were defined as Northern Pikeminnow missing external tags, but retaining ODFW PIT tags as part of the NPMP.

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 2020 NPSRF, anglers harvested a total of 102,935 reward size Northern Pikeminnow (≥ 228 mm TL) over the course of a 22 week field season. There was also an 11 day extension at limited stations through October 11th. Harvest was the lowest ever recorded, well below mean 1991-2019 harvest of 175,971 fish and 43,290 fish lower than 2019 harvest (Hone et al. 2020) (Figure 4). The 2020 NPSRF harvest was estimated to equal an exploitation rate of 17.8% (Barr et al. 2021). In addition to harvesting 102,935 reward size Northern Pikeminnow, anglers participating in the 2020 NPSRF also harvested 2,583 Northern Pikeminnow < 228 mm TL.

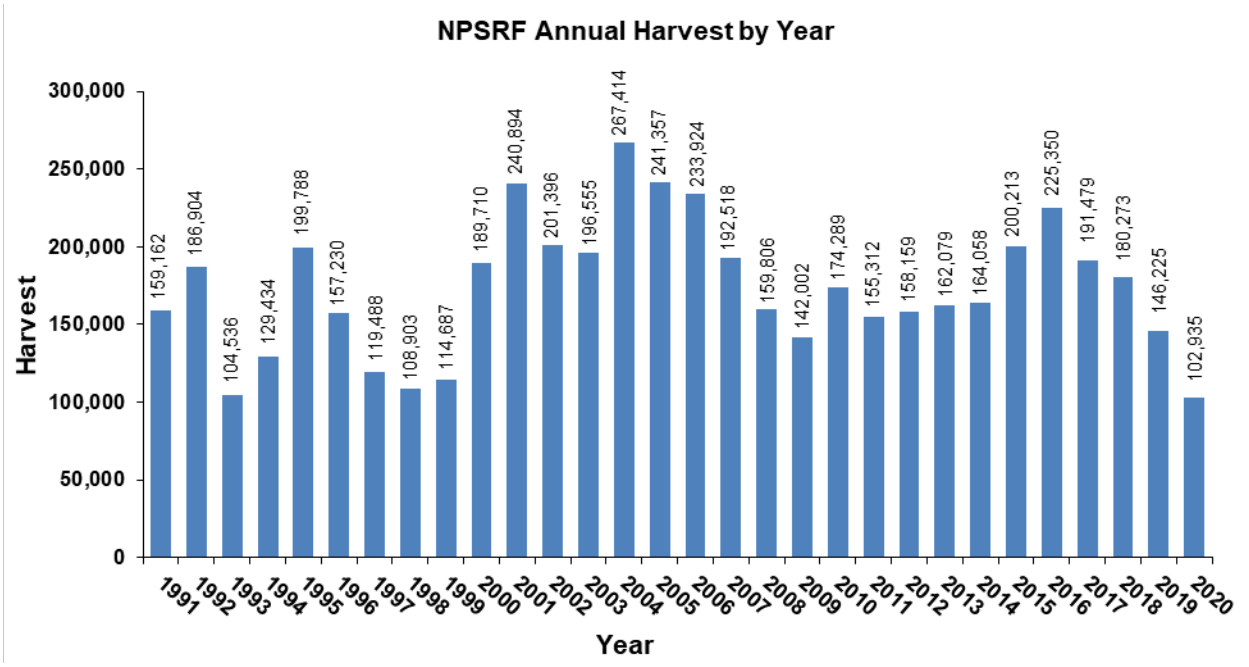


Figure 4. Annual harvest totals for the Northern Pikeminnow Sport-Reward Fishery

Harvest by Week

Peak weekly harvest was 7,667 Northern Pikeminnow and occurred in week 25, with the familiar smaller, late season peak in week 36 (Figure 5). Peak harvest for 2020 occurred one week earlier (Figure 6), and was 1,606 fish less than in 2019 (9,273), and was also one week earlier the NPSRF's historical 1991-2019 peak in week 26 (Fox et al. 2000), (Figure 7). Mean weekly harvest was lower in 2020 (4,679) than in 2019 (6,358) and total weekly harvest was below 2019 weekly harvest for 20 of the 22 weeks of the season (Hone et al. 2020). The ongoing COVID-19 pandemic caused the 2020 season start to be delayed 10 days and likely was a major factor in harvest not reaching 10,000 fish per week during the critical first 6 weeks of the season. Without high weekly harvest early in the season, 2020 NPSRF harvest total would likely be well below average.

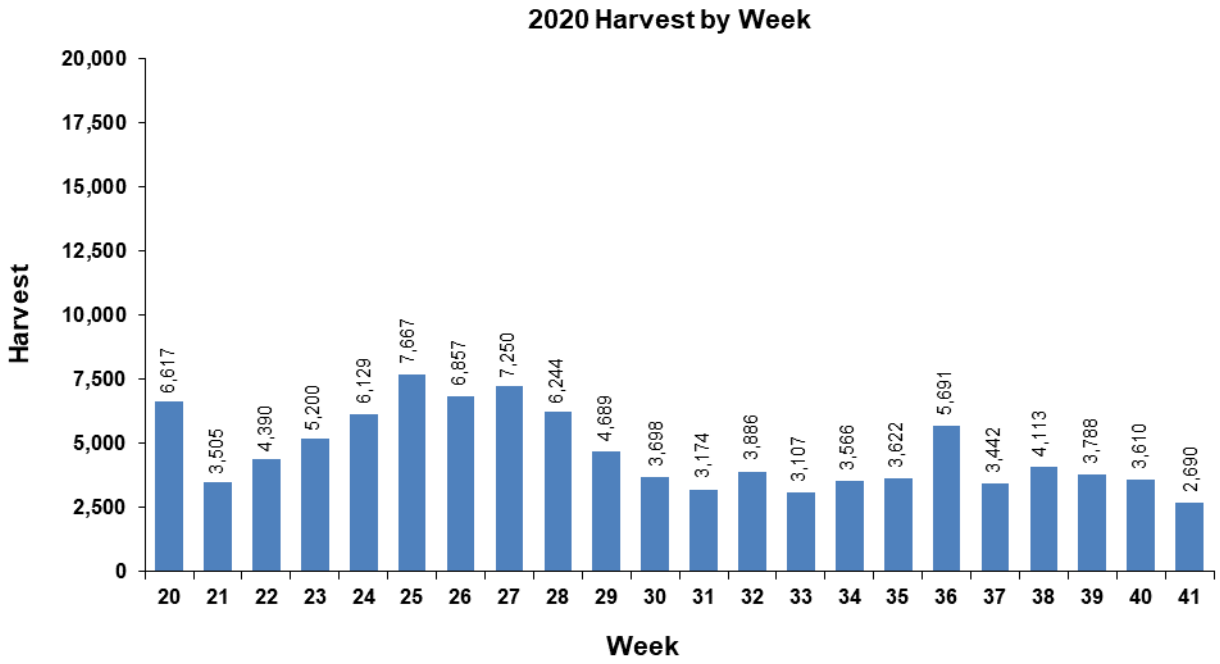


Figure 5. 2020 Weekly Northern Pikeminnow Sport-Reward Fishery harvest

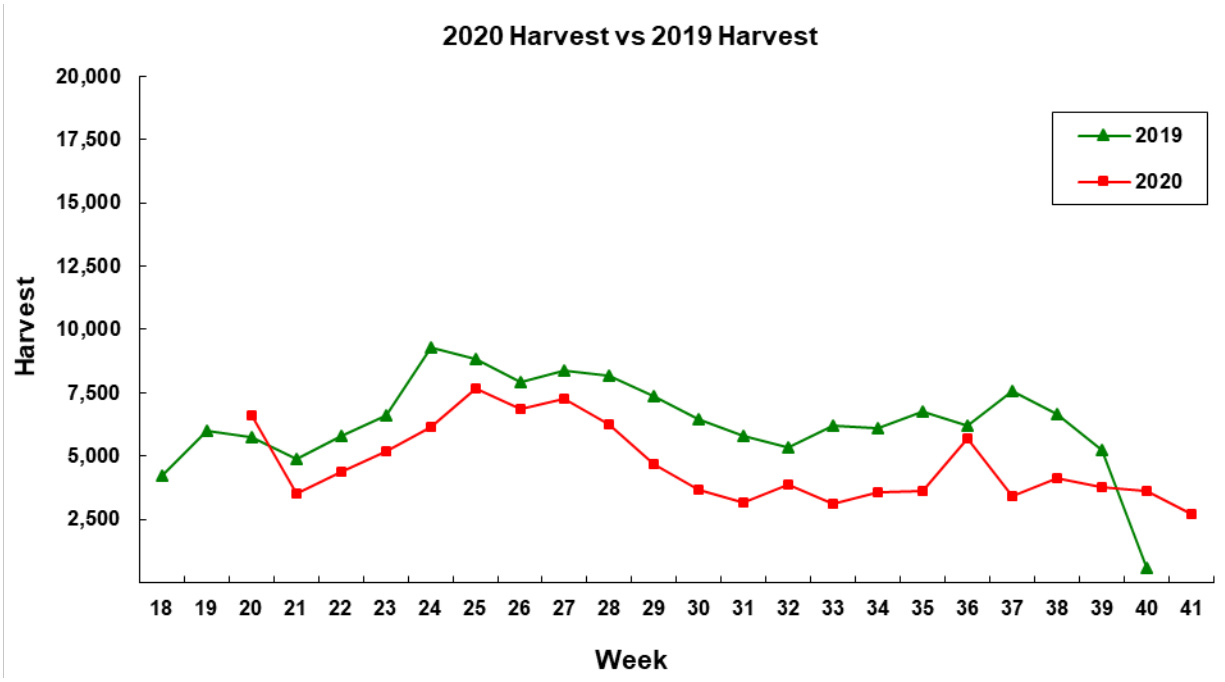


Figure 6. 2020 Weekly NPSRF harvest vs 2019 weekly harvest

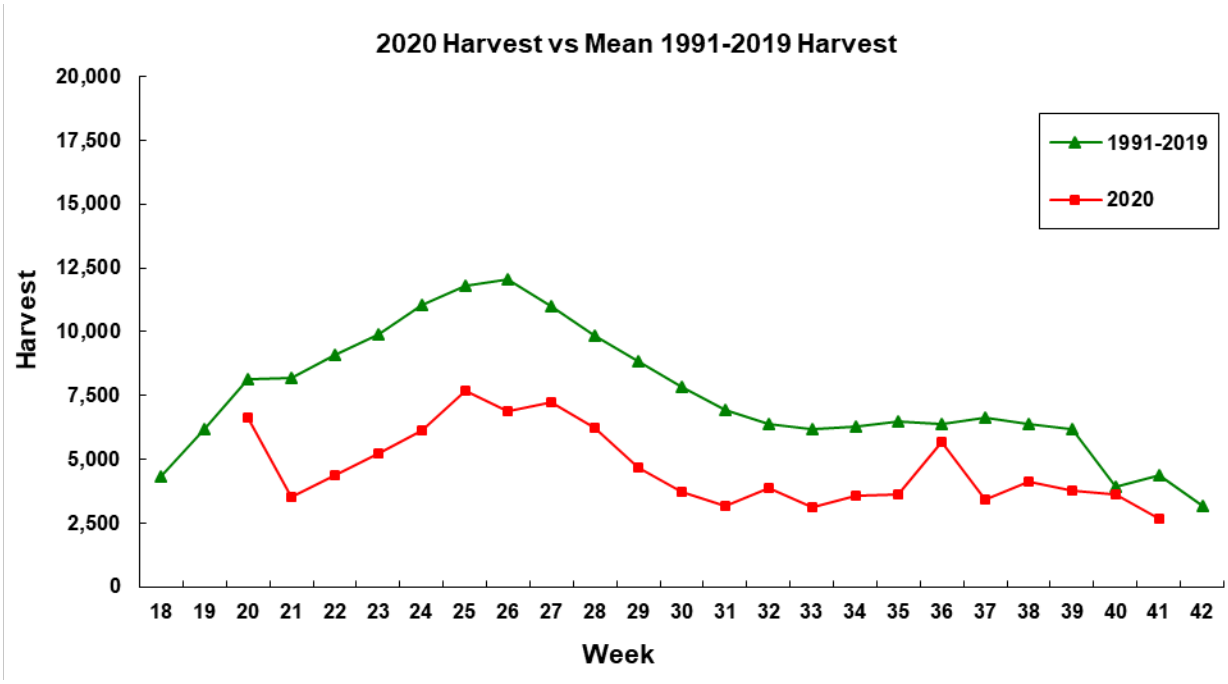


Figure 7. Comparison of 2020 NPSRF weekly harvest to 1991-2019 mean weekly harvest

Harvest by Fishing Location

The mean harvest by fishing location for the 2020 NPSRF was 8,578 Northern Pikeminnow (compared to 12,185 in 2019) and ranged from 52,581 reward size Northern Pikeminnow in fishing location 01 (Below Bonneville Dam) to only 10 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) decreased from 61.75% of total NPSRF harvest in 2019 to 51.08% of total NPSRF harvest in 2020, although it was still the highest producing location in 2020, as it has been for all but one of the preceding 29 NPSRF seasons (Hone et al. 2020). Little Goose Reservoir (Fishing Location 10) remained the second highest producing area accounting for 18.65% of total 2020 NPSRF harvest.

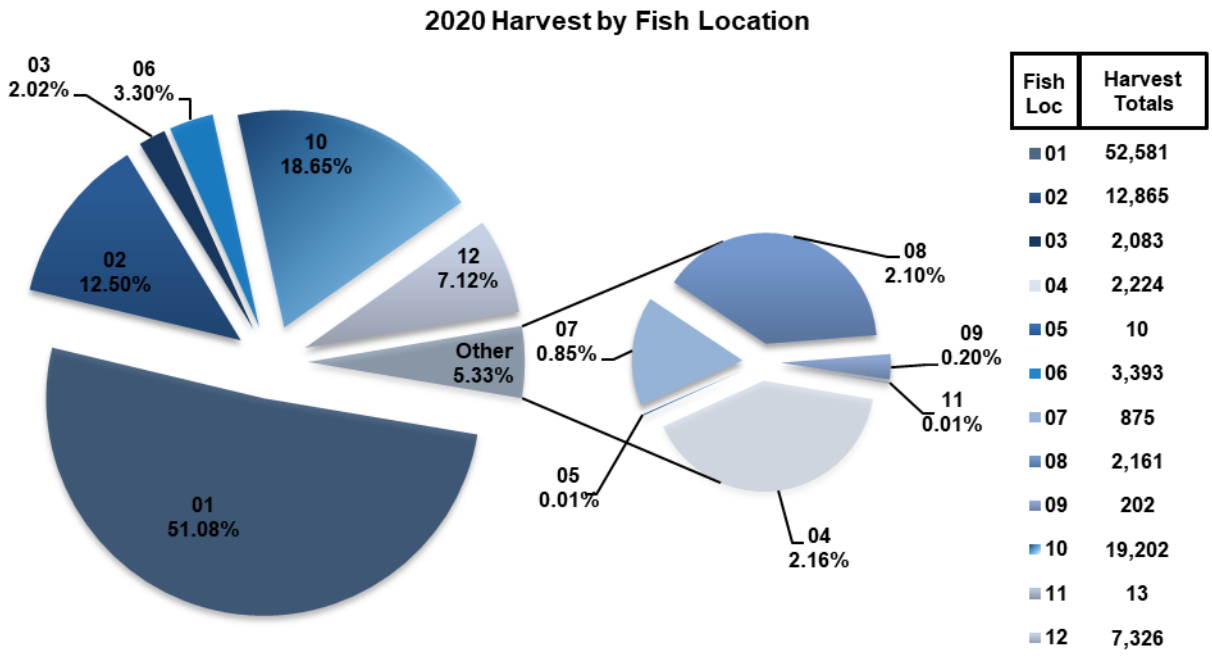


Figure 8. 2020 Northern Pikeminnow Sport-Reward Fishery harvest by fishing location*
*Fishing Location Codes for **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth of 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 2020 was down from 2019 at 15 of the 18 registration stations. The Boyer Park registration station regained the title of the NPSRF's top producing station in 2020, where anglers harvested 18,902 Northern Pikeminnow, equaling 18.4% of total NPSRF harvest (Figure 9). The Cathlamet registration station finished with the second highest total of 15,225 Northern Pikeminnow (14.8% of total) harvested in 2020. The Washougal station finished a close third behind Cathlamet with 14,892 fish. The average harvest per registration station was 5,719 reward size Northern Pikeminnow, down from 7,696 per station in 2019 (Hone et al. 2020). The registration station with the smallest harvest was Vernita where anglers harvested only 230 Northern Pikeminnow during the 2020 season. The Washougal registration station showed the largest increase in harvest during the 2020 NPSRF with 3,088 more reward size Northern Pikeminnow turned in than in 2019 (Hone et al. 2020).

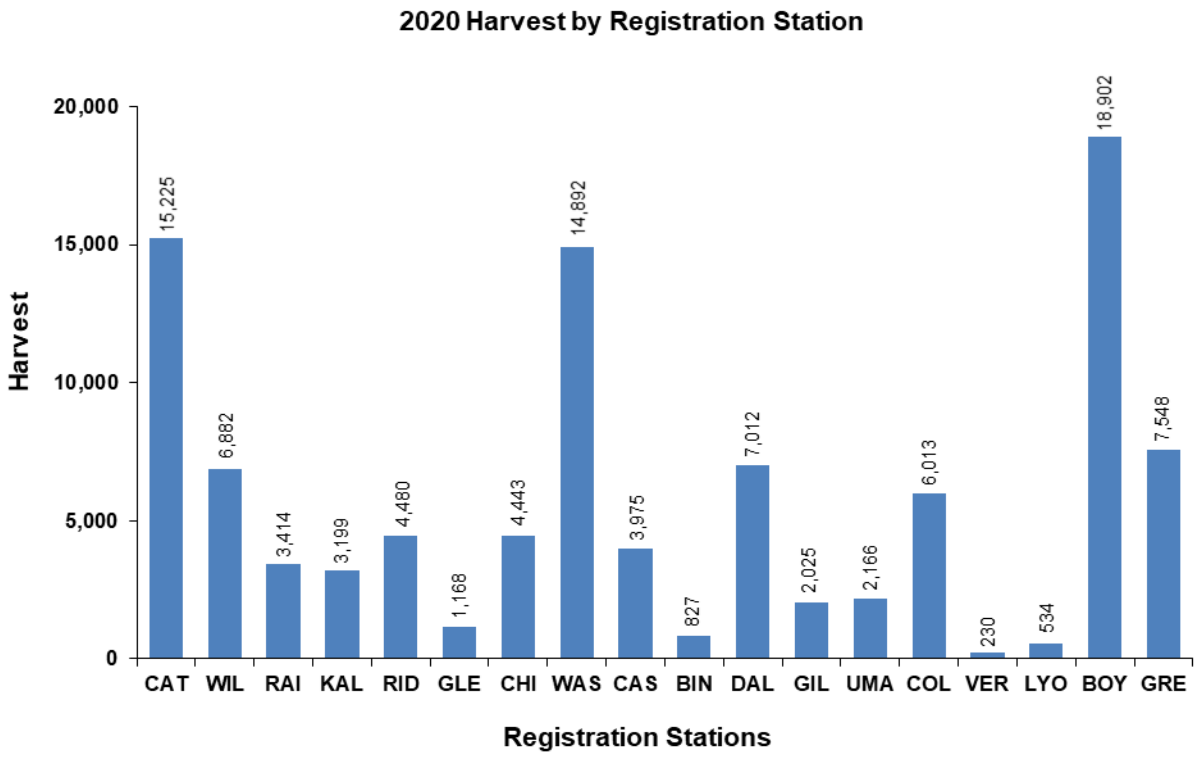


Figure 9. 2020 Northern Pikeminnow Sport-Reward Fishery harvest by registration station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, CAS-Cascade Locks, BIN-Bingen, DAL- The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Harvest by Species/ Incidental Catch

Returning anglers

In addition to catching Northern Pikeminnow, returning anglers participating in the 2020 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 2020.

Salmon

Species	Caught	Harvest	Harvest Percent
Steelhead Juvenile (Wild)	66	0	0%
Trout (Unknown)	39	6	15.38%
Steelhead Juvenile (Hatchery)	30	0	0%
Chinook (Adult)	24	5	20.83%
Chinook (Jack)	21	2	9.52%
Steelhead Adult (Wild)	14	0	0%
Cutthroat (Unknown)	14	0	0%
Chinook (Juvenile)	10	0	0%
Steelhead Adult (Hatchery)	7	1	14.29%
Sockeye (Adult)	3	1	33.33%
Coho (Adult)	1	1	100%

Anglers reported that all juvenile salmonids caught during the 2020 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 2020 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 2020 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 2020

Non-Salmonid

Species	Caught	Harvest	Harvest Percent
Northern Pikeminnow >228mm	102,938	102,935	99.99%
Northern Pikeminnow <228mm	22,648	2,583	11.40%
Peamouth	17,247	7,283	42.23%
Smallmouth Bass	7,563	605	8%
Sculpin (unknown)	5,860	4,191	71.52%
Yellow Perch	3,245	911	28.07%
Channel Catfish	1,345	132	9.81%
White Sturgeon	1,019	4	.39%
Sucker (unknown)	952	97	10.19%
Walleye	859	341	39.70%
Catfish (unknown)	475	122	25.68%
Bullhead (unknown)	380	85	22.37%
Chiselmouth	307	54	17.59%
Carp	215	44	20.47%
Starry Flounder	167	11	6.59%
Bluegill	81	4	4.94%
American Shad	80	31	38.75%
Largemouth Bass	37	4	10.81%
Crappie (unknown)	11	0	0%
Pumpkinseed	7	0	0%
Sandroller	5	0	0%

Non-Returning Anglers Catch and Harvest Estimates

As in past years, telephone interviews were conducted to randomly survey non-returning participants at each of the NPSRF's 18 stations in order to determine and record their catch and/or harvest of reward sized Northern Pikeminnow and other incidentally caught fish species. In 2020, there were 4,913 non-returning angler days recorded and a total of 974 calls were completed to non-returning anglers (19.8% 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 2020 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 2020 NPSRF. Estimated totals are listed in columns 5 and 6 of Table 3.

Table 3. 2020 NPSRF non-returning angler phone survey results with total catch & harvest estimates

Species	Caught	Harvest	%Harvested	Estimated Total Catch	Estimated Total Harvest
Peamouth	139	10	7.2%	701	50
Smallmouth Bass	124	40	32.3%	626	202
Northern Pikeminnow <228 mm	119	38	31.9%	600	192
Yellow Perch	65	28	43.1%	328	141
Catfish (unknown)	54	9	16.7%	272	45
Northern Pikeminnow ≥ 228 mm	38	37	97.4%	192	187
Walleye	35	21	60.0%	177	106
Sucker (Unknown)	19	0	0%	96	0
Bullhead (Unknown)	10	0	0%	50	0
Sculpin (Unknown)	9	0	0%	45	0
White Sturgeon	8	0	0%	40	0
Carp	8	0	0%	40	0
American Shad	5	5	100%	25	25
Trout (Unknown)	4	0	0%	20	0
Chiselmouth	4	0	0%	20	0
Chinook Salmon (Adult)	2	0	0%	10	0
Chinook Salmon (Juvenile)	1	0	0%	5	0
Sockeye Salmon (Adult)	1	0	0%	5	0
Steelhead (Adult)	1	0	0%	5	0
Steelhead (Juvenile)	1	0	0%	5	0

N=4,913 n=974

Fork Length Data

The length frequency distribution for harvested Northern Pikeminnow (≥ 200 mm) from the 2020 NPSRF is presented in Figure 10. Fork length data from 67,346 Northern Pikeminnow ≥ 200 mm FL (65% of total harvest) were taken during the 2020 NPSRF. The mean fork length for all measured Northern Pikeminnow (≥ 200 mm) in 2020 was 289.9 mm (SD= 66.93 mm), up from 281.2 in 2019 (Hone et al. 2020).

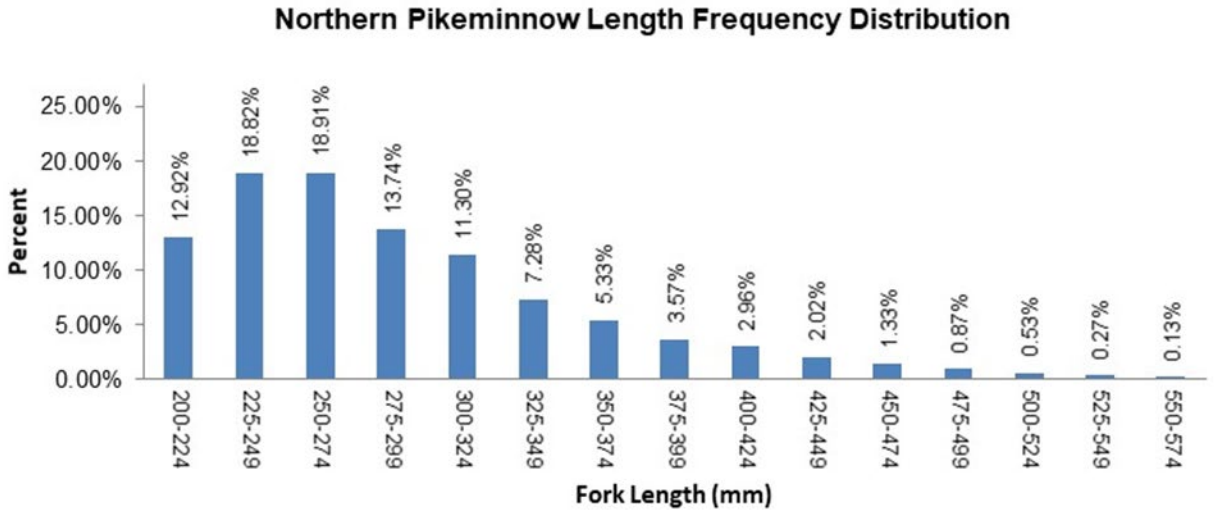


Figure 10. Length frequency distribution of Northern Pikeminnow ≥ 200 mm FL from 2020 NPSRF. n=67,346

Angler Effort

The 2020 NPSRF recorded total effort of 15,982 angler days spent during the season, a decrease of 4,304 angler days from 2019 (Hone et al. 2020) (Figure 11). The ongoing COVID-19 pandemic and the delayed NPSRF season start likely had a large negative effect on angler participation in 2020. When total effort is divided into returning and non-returning angler days, 11,069 angler days (69.3%) were recorded by returning anglers, and 4,913 angler days (30.7%) were spent by non-return anglers. The percentage of returning anglers in 2020 (69.3%) was lower than the 2019 (70.4%) season (Hone et al. 2020). In addition, 57% of total effort, and 82% of returning angler effort (9,089 angler days), was attributed to successful anglers who harvested at least one Northern Pikeminnow in 2020.

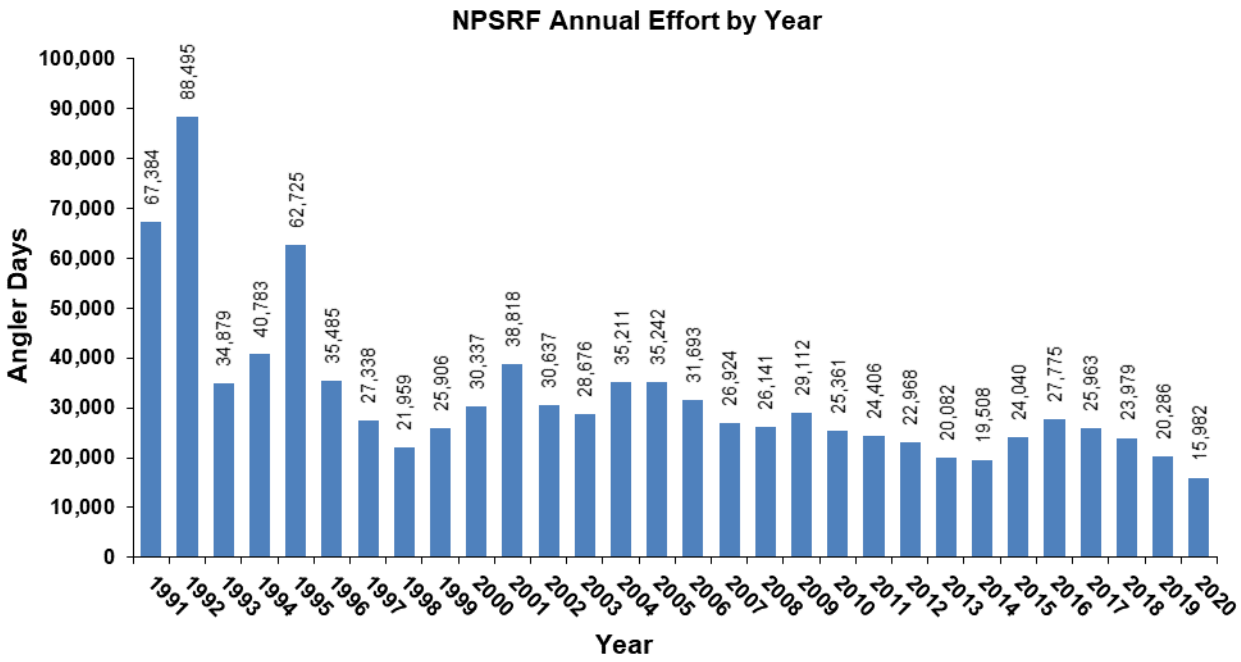


Figure 11. Annual Northern Pikeminnow Sport-Reward Fishery effort

Effort by Week

Mean weekly effort for the 2020 NPSRF was 726 angler days during the season, with the peak occurring in week 20, the first full week of the season (Figure 12). When we compare weekly effort totals for 2020 with the 2019 season, weekly effort totals from all but four weeks were down from those of 2019 (Hone et al. 2020) (Figure 13). Peak weekly effort in 2020 occurred one week later than 2019 peak harvest (week 19) (Figure 5), likely due to the delayed season start. Overall, mean weekly effort decreased from 882 in 2019 to 726 in 2020 (Hone et al. 2020). Since the tier change in 2015, weekly effort totals continue to follow a pattern where peak effort occurs at or near the first full week of the season (Figure 14). This is quite different from the historical 1991-2015 (Winther et al. 2016) pattern for effort where the typically occurred on the same week as peak harvest (Figure 14).

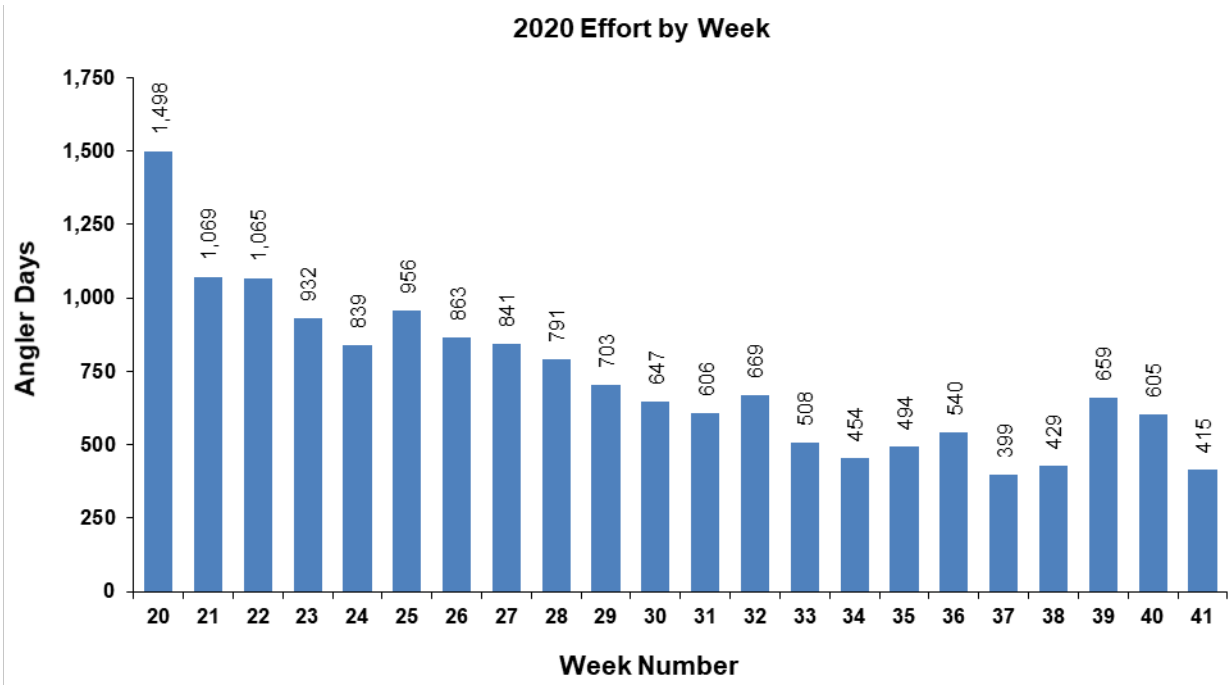


Figure 12. 2020 Weekly Northern Pikeminnow Sport-Reward Fishery angler effort

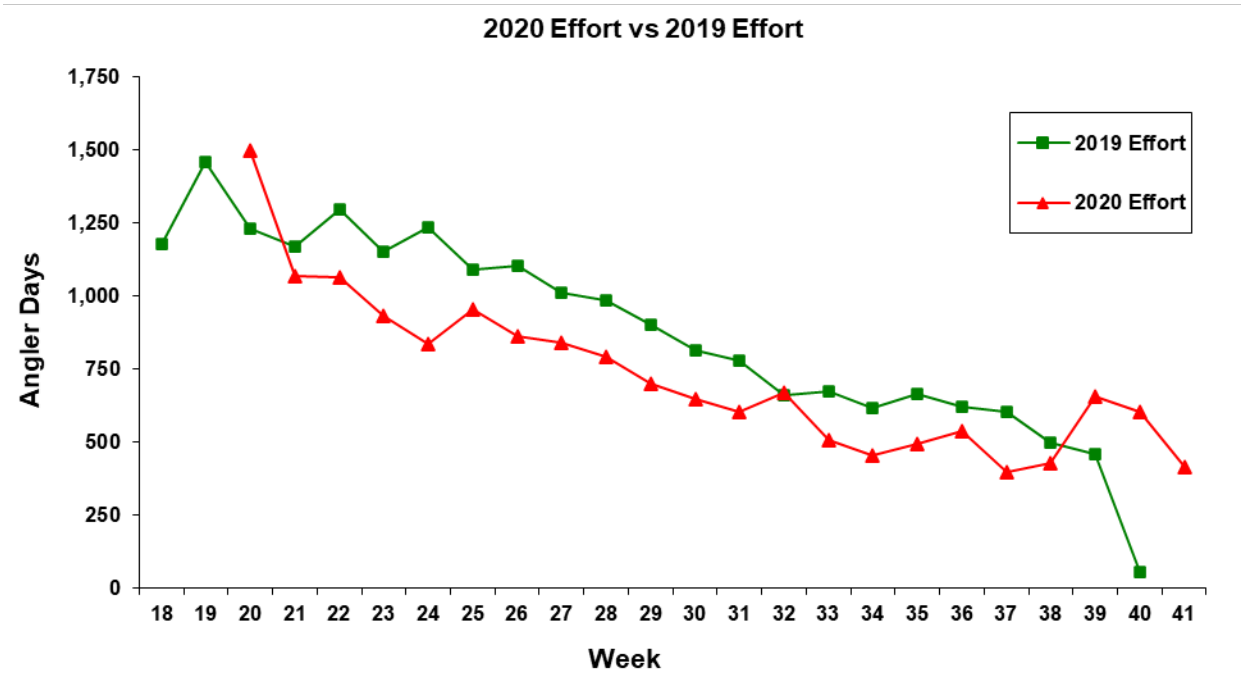


Figure 13. Effort 2020 Northern Pikeminnow Sport-Reward Fishery effort vs 2019 effort

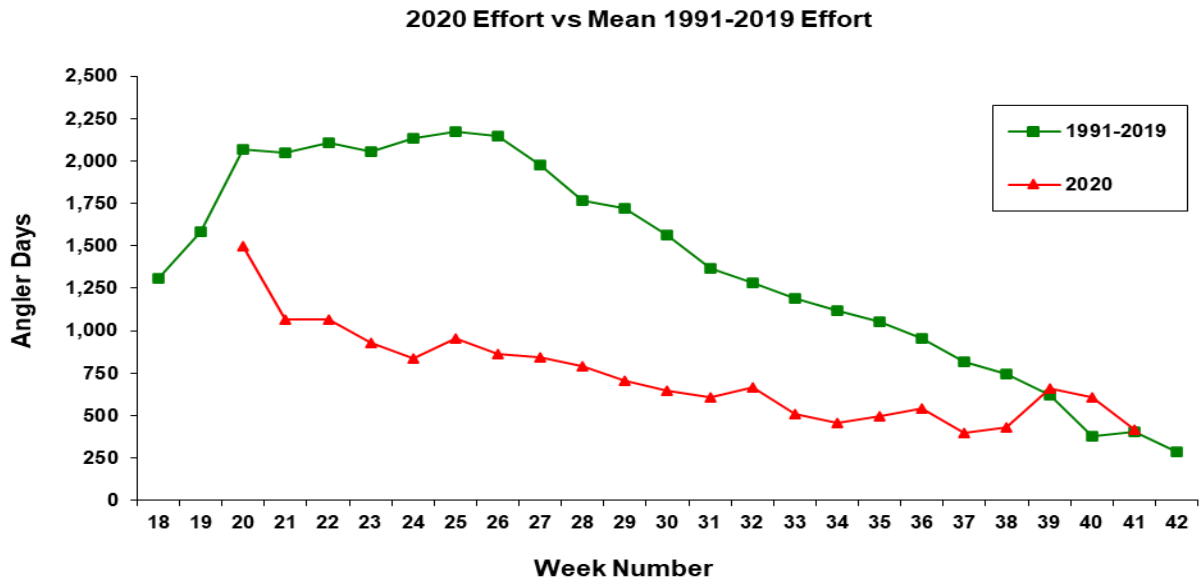


Figure 14. 2020 NPSRF weekly effort vs mean 1991-2019 effort

Effort by Fishing Location

Mean annual effort by fishing location for the 2020 NPSRF (returning anglers only) decreased from 1,191 angler days in 2019 (Hone et al. 2020) to 922 angler days in 2020. Effort totals ranged from 4,962 angler days spent in fishing location 01 (below Bonneville dam) to only 2 angler days spent in fishing location 11 on the Snake River (Lower Granite Dam to the mouth of the Clearwater River) (Figure 15). Only one(Location 4) of the 12 NPSRF fishing locations recorded an increase in angler effort in 2020.

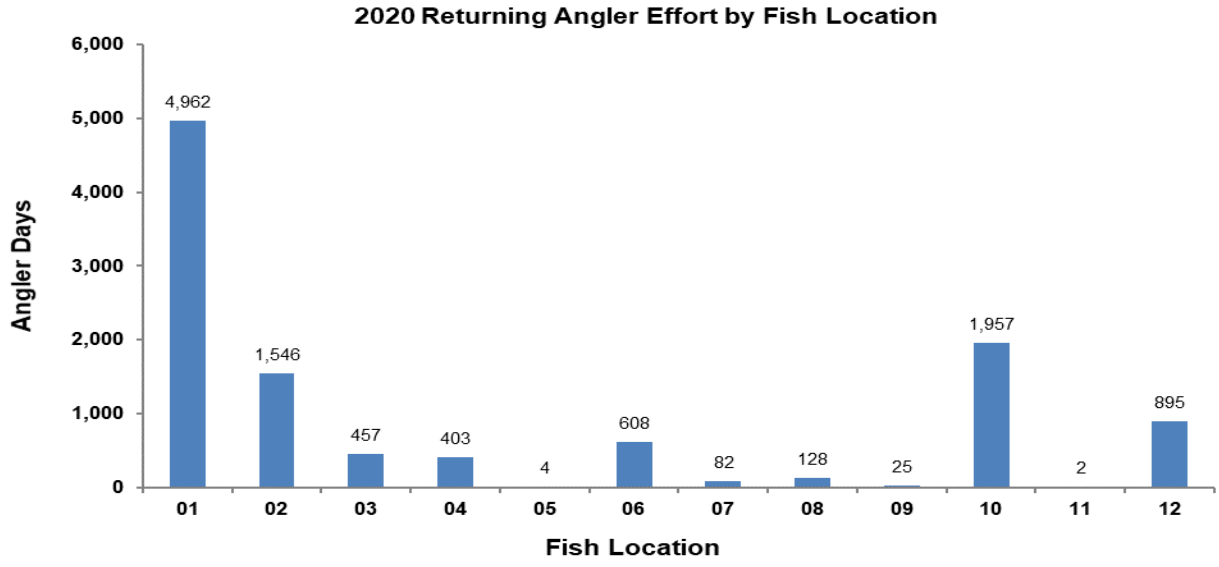


Figure 15. 2020 NPSRF angler effort by fishing location* (returning anglers only).
*Fishing Location Codes for **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth of the 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 2020 NPSRF was 888 angler days compared to 1,068 angler days in 2019 (Hone et al. 2020). Effort totals ranged from a high of 2,278 angler days at the Cathlamet station to a low of 91 angler days at the Vernita station (Figure 16). Although effort decreased at 15 of the 18 registration stations, there were slight increases in angler effort at the Chinook, Umatilla, and Lyon's Ferry registration stations in 2020.

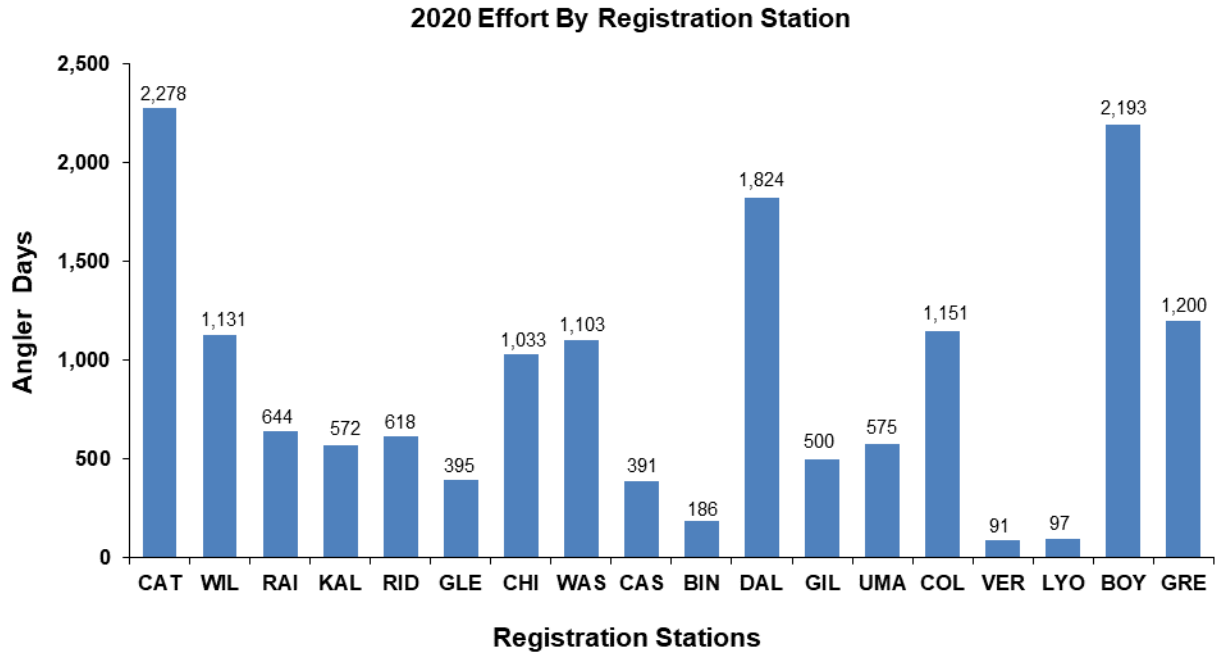


Figure 16. 2020 Northern Pikeminnow Sport-Reward Fishery angler effort by registration station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Catch Per Angler Day (CPUE)

The 2020 NPSRF recorded an overall (returning + non-returning anglers) catch per unit of effort (CPUE or "catch rate") of 6.44 Northern Pikeminnow harvested per angler day during the season. This catch rate was down from the 2019 overall CPUE of 7.21 (Figure 17) and since angler CPUE was down regardless of angler success level, it was clear that angling conditions throughout the NPSRF area were less favorable during 2020 than in 2019. Even though angler CPUE has trended upwards throughout the NPSRF's 30-year history, it fell for the second consecutive year and was the lowest it has been since 2011. Returning angler CPUE during the 2020 NPSRF was 9.30 Northern Pikeminnow per angler day, down from the 2019 returning angler CPUE of 10.23 (Hone et al. 2020). The estimated CPUE for non-returning anglers was 0.04 reward size Northern Pikeminnow per angler day based on 2020 NPSRF phone survey results and has remained constant throughout recent NPSRF history.

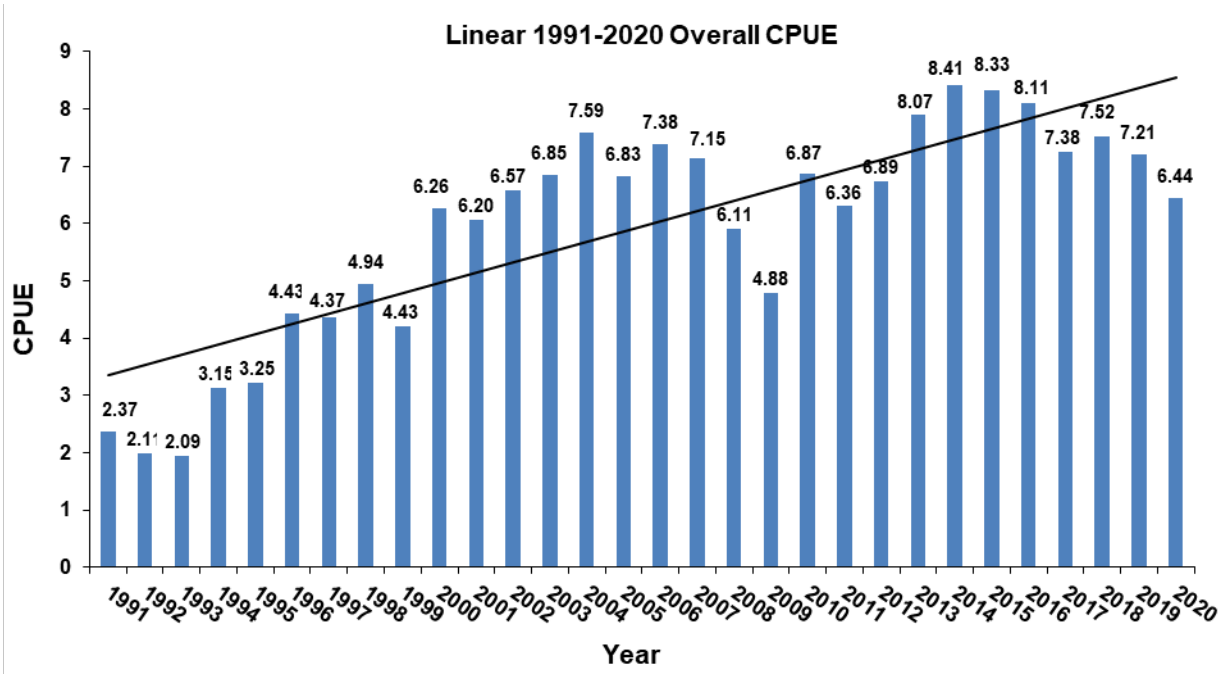


Figure 17. Annual NPSRF CPUE (returning + non-returning anglers) for the years 1991-2020

CPUE by Week

Mean angler CPUE by week for the 2020 NPSRF was 6.77 fish per angler day compared to 8.03 in 2019 (Hone et al. 2020) and ranged from a low of 3.28 in week 21 (May 18-24) to a peak of 10.54 in week 36 (August 31-September 6) (Figure 18). Weekly CPUE for the 2020 NPSRF followed a typical two-peak pattern with the first peak in week 27 near the historical Northern Pikeminnow spawning peak and then again late in the season (week 36) when favorable water and angling conditions were present in the lower Columbia and Snake rivers (Winther et al. 2011).

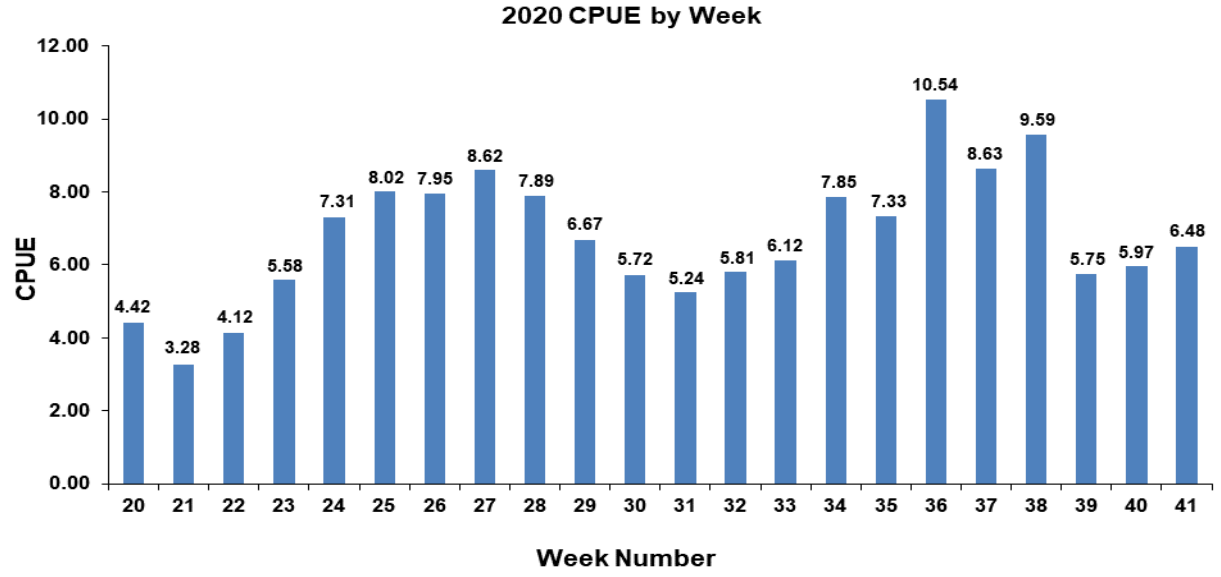


Figure 18. 2020 Northern Pikeminnow Sport-Reward Fishery angler CPUE by week

CPUE by Fishing Location

Angler success rates for the 2020 NPSRF (as indicated by CPUE), represent returning anglers only and varied by fishing location. Success rates ranged from a high of 16.88 Northern Pikeminnow per angler day in fishing location 08 (Ice Harbor Reservoir) to a low of 2.50 fish per angler per day in fishing location 5 (McNary Dam to the mouth of the Snake River) (Figure 19). CPUE increased at six of the 12 fishing locations in 2020. The average CPUE by fishing location was 8.10 Northern Pikeminnow per angler day in 2020 compared to 7.02 in 2019 (Hone et al. 2020).

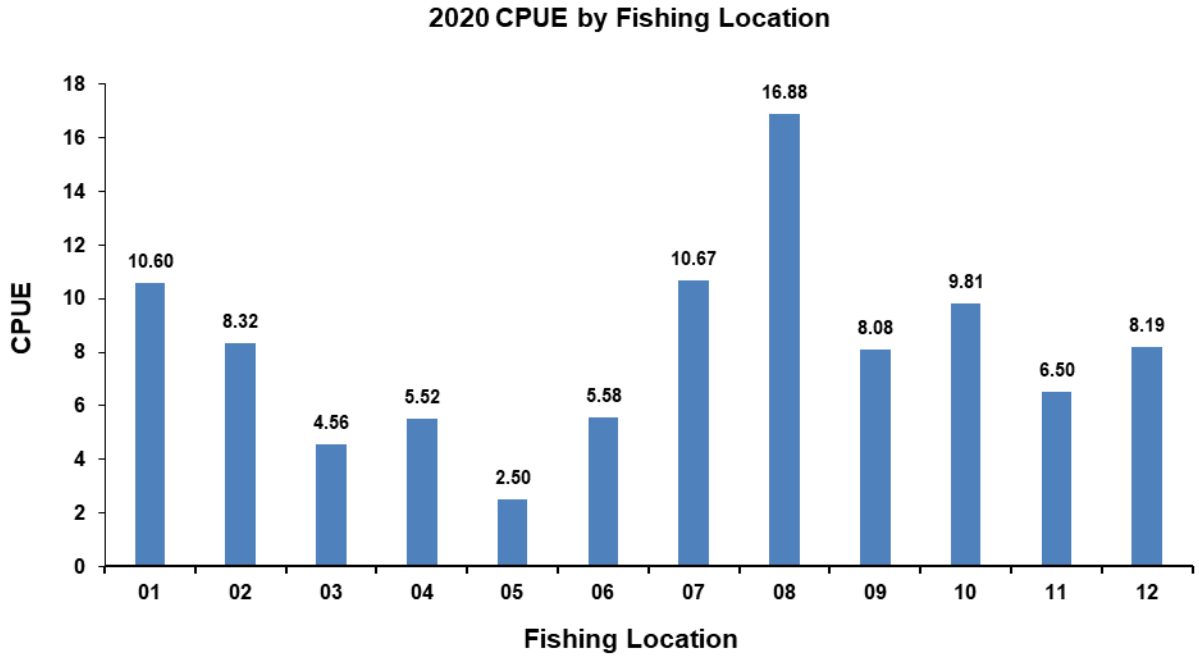


Figure 19. 2020 Northern Pikeminnow Sport-Reward Fishery angler CPUE by fishing location.*
*Fishing Location Codes for **Columbia River**; 01 = Below Bonneville Dam, 02 = Bonneville Reservoir, 03 = The Dalles Reservoir, 04 = John Day Reservoir, 05 = McNary Dam to the mouth of the Snake River, 06 = Mouth of the Snake River to Priest Rapids Dam. **Snake River**; 07 = Mouth of the Snake River to Ice Harbor Dam, 08 = Ice Harbor Reservoir, 09 = Lower Monumental Reservoir, 10 = Little Goose Reservoir, 11 = Lower Granite Dam to the mouth of the Clearwater River, 12 = Mouth of the Clearwater River to Hells Canyon Dam.

CPUE by Registration Station

The registration station with the highest CPUE during the 2020 NPSRF was the Washougal station where anglers averaged 13.50 Northern Pikeminnow per angler day (Figure 20). The registration station with the lowest CPUE was the Vernita station with a CPUE of 2.53 Northern Pikeminnow per angler day. The station average for angler CPUE was 5.90 in 2020, down from 7.01 in 2019 (Hone et al. 2020). Angler CPUE by registration station increased at five of the 18 stations during the 2020 NPSRF season. The largest CPUE increase occurred at the Washougal station, where CPUE increased from 9.98 in 2019 (Hone et al. 2020) to 13.50 in 2020.

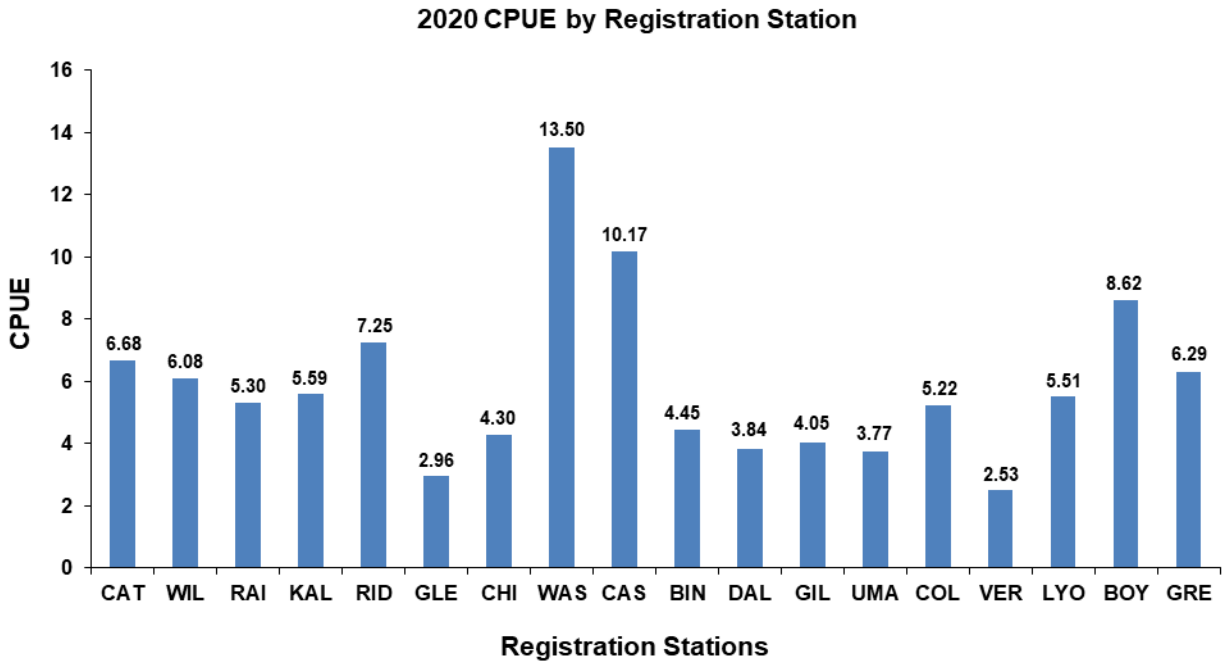


Figure 20. 2020 Northern Pikeminnow Sport-Reward Fishery angler CPUE by registration station
CAT-Cathlamet, WIL-Willow Grove, RAI-Rainier, KAL-Kalama, RID-Ridgefield, GLE-Gleason, CHI-Chinook, WAS-Washougal, BEA-Beacon Rock, CAS-Cascade Locks, BIN-Bingen, DAL-The Dalles, GIL-Giles, UMA-Umatilla, COL-Columbia Point, VER-Vernita, LYO-Lyon's Ferry, BOY-Boyer Park, GRE-Greenbelt.

Angler Totals

There were 2,433 separate anglers who participated in the 2020 NPSRF, a decrease of 284 participants from 2019. Eight hundred eighty two of these anglers (36.3% of total vs. 39.7% in 2019 were classified as successful, harvesting at least one reward size Northern Pikeminnow (for which a voucher was issued) during the 2020 season. Of the successful anglers, 73% (641 anglers) sent in their vouchers to PSMFC for payment (PSMFC 12/28/20 Sport-Reward Payment Summary) while 241 anglers (27%) did not. The average successful angler harvested 117 Northern Pikeminnow during the 2020 NPSRF compared to 135 in 2019 (Hone et al. 2020).

When we break down the 882 successful anglers by tier, 633 of these anglers (71.8%) harvested fewer than 25 Northern Pikeminnow and were classified as Tier 1 anglers (Figure 21). This is down from the 783 individual Tier 1 anglers in 2019. The number of Tier 2 anglers declined to 149 in 2020, down from 178 in 2019. The number of Tier 3 anglers (known as "highliners") decreased from 119 anglers in 2019 to 100 anglers in 2020 (Hone et al. 2020).

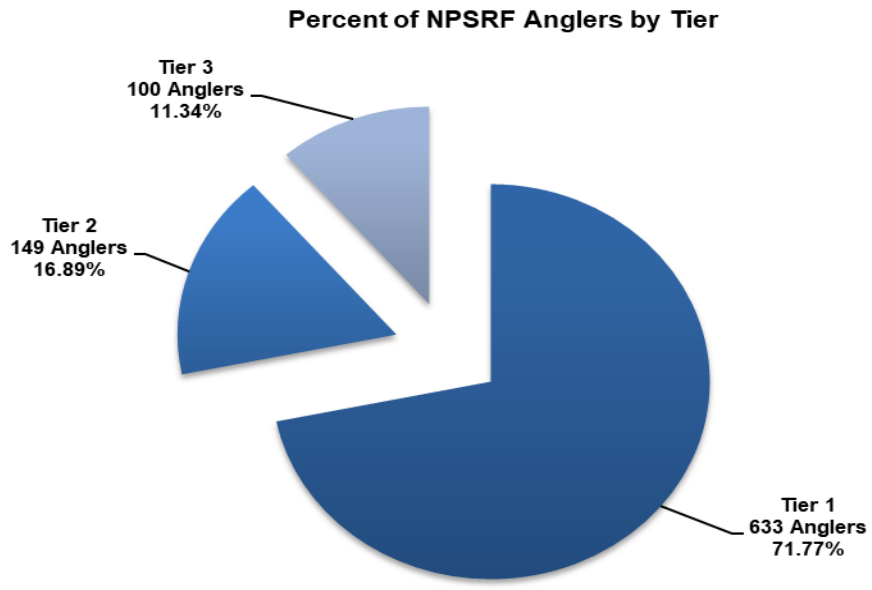


Figure 21. 2020 NPSRF anglers by tier (returning anglers) based on total harvest

Despite a decline in participation likely related to the ongoing effects of the COVID-19 pandemic, the continued relatively high number of individual anglers at Tiers 2 and 3, as a component of successful anglers, was especially important to achieving NPSRF harvest and exploitation objectives in 2020, since Tier 2 and Tier 3 anglers have a much higher CPUE than Tier 1 anglers (Hisata et al. 1996). Although the number and percentage of anglers at Tiers 1, 2 and 3 was down from 2019 and from Mean 2010-14 (prior to the last reward increase) the Mean 2015-20 totals (post reward increase) were all still above the pre reward increase totals, except for Tier 1 (Table 4). With the COVID-19 restrictions for gatherings, seminars and interacting with others, it is not surprising that Tier 1, and new angler numbers (which make up the largest group of SRF anglers) may be down, since they are the anglers most responsive to additional fishing guidance, which was not as available in 2020. Even though the COVID-19 pandemic likely caused the number of Tier 1 anglers to be down for the second consecutive year in 2020, the gains in restructuring the Tier 2 and 3 angler groups (after the tier level change in 2015), allowed the overall 2015-20 totals to remain at or above 2010-14 levels for almost all categories.

Table 4. Annual comparison of NPSRF successful anglers by tier (before and after the 2015 tier change).

Year	Tier 1 Anglers	Tier 2 Anglers	Tier 3 Anglers	Successful Anglers	Separate Anglers	%Successful Anglers
2010-2014 Mean	**1066**	**101**	**95**	**1263**	**3126**	**40.40**
2015	986	239	163	1388	3210	43.24
2016	1140	295	184	1619	3718	43.54
2017	1048	287	155	1490	3462	43.04
2018	917	226	158	1301	3048	42.68
2019	783	178	119	1080	2717	39.75
2020	633	149	100	882	2433	36.25
2015-2020 Mean	**918**	**229**	**147**	**1293**	**3098**	**41.74**

While Tier 1 anglers made up 71.8% of all successful NPSRF participants in 2020, they accounted for only 3.23% of total NPSRF harvest (3,325 Northern Pikeminnow) (Figure 22). Tier 2 anglers made up 16.89% of all successful anglers and harvested 11.35% of total NPSRF harvest (11,682 fish). Tier 3 anglers made up 4.1% of all participants (both returning and non-returning anglers), 11.34% of all successful anglers and accounted for 85.42% of total NPSRF harvest (87,928 fish).

Average annual harvest per angler was down for Tier 1, Tier 2 and Tier 3 anglers. Tier 1 anglers annual average harvest was down slightly from 5.45 fish per year in 2019 to 5.25 fish per year in 2020. Tier 2 anglers harvested an annual average of 78.40 fish per year in 2020, down slightly from 78.66 fish per year in 2019. Average annual harvest for Tier 3 anglers decreased to 879.28 fish per angler in 2020 compared to 1,075.24 fish per angler in 2019 (Hone et al. 2020).

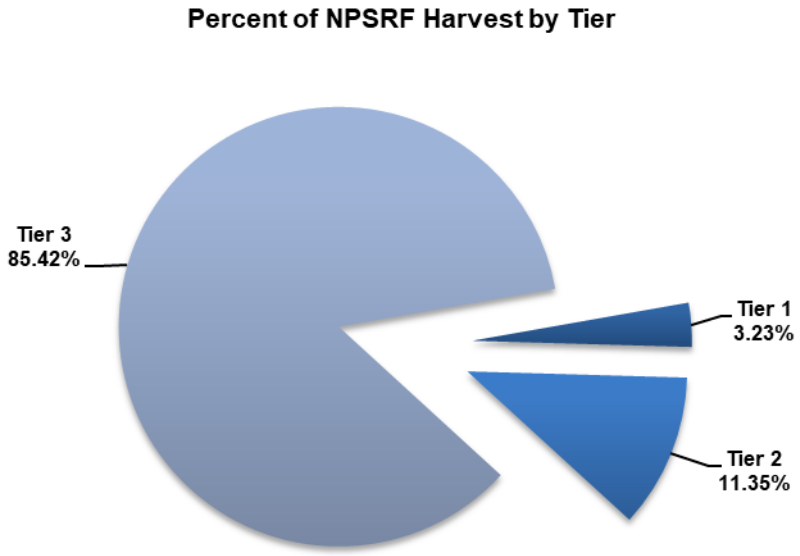


Figure 22. 2020 NPSRF harvest by angler tier (Tier 1 = ≤25, Tier 2 =26-200, Tier 3 = > 200)

The overall average NPSRF participant (returning + non-returning anglers) expended less effort pursuing Northern Pikeminnow during the 2020 season than in 2019 (6.56 vs. 7.47 angling days of effort). When we look at successful anglers only, the average successful angler also decreased their average annual effort spent to 15.38 angler days during the 2020 NPSRF compared to 16.21 days in 2019. When we break down successful angler effort by tier, none of the three tier levels spent more annual effort in 2020 than they did in 2019. Tier 1 anglers spent an average of 5 days in both 2019 and 2020 (Figure 23). Tier 2 anglers spent an average of 25 days fishing in 2020 compared to 26 in 2019. Tier 3 anglers averaged 66 days fishing in 2020, down from 72 days in 2019 (Hone et al. 2020).

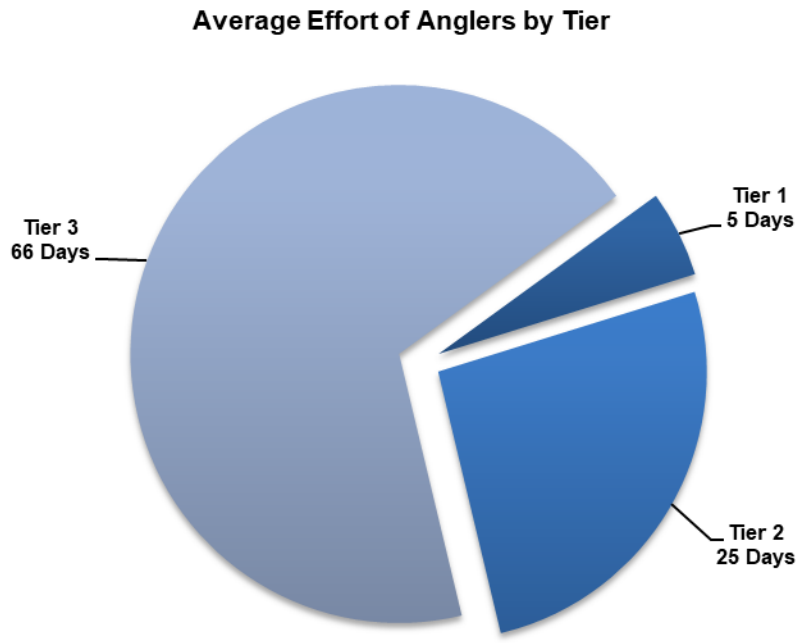


Figure 23. Average effort of 2020 NPSRF anglers by tier (Tier 1 = ≤25, Tier 2 = 26-200, Tier 3 = > 200)

When 2020 CPUE by tier is compared to 2019 there was a slight increase in CPUE at Tier 1 and Tier 2, while Tier 3 decreased in CPUE. CPUE for anglers at Tier 1 increased from 1.01 fish per angler day in 2019 to 1.05 in 2020 (Figure 24). CPUE for Tier 2 anglers increased from 2.97 fish per angler day in 2019 to 3.12 in 2020. CPUE for Tier 3 anglers decreased from 14.92 fish per angler day in 2019 to 13.26 in 2020 (Hone et al. 2020).

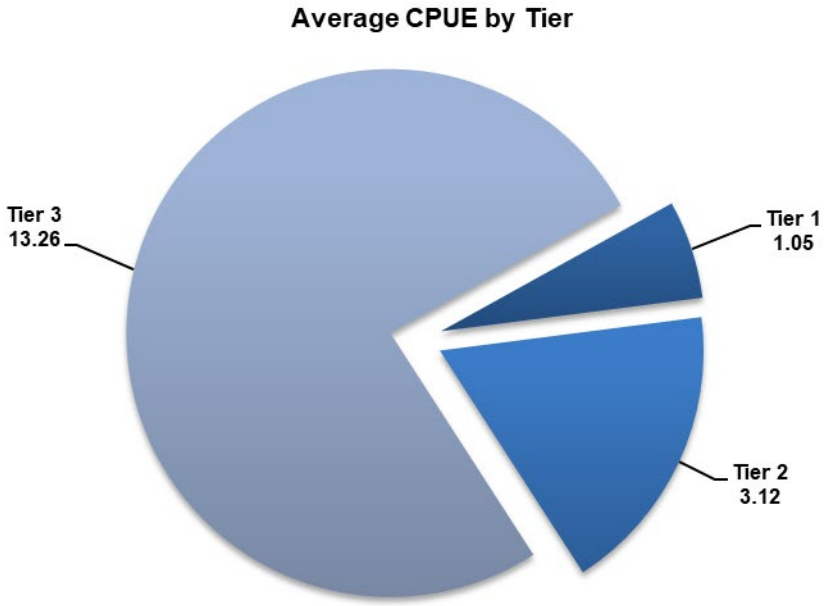


Figure 24. Average CPUE of 2020 NPSRF anglers by tier (Tier 1 = ≤25, Tier 2 =26-200, Tier 3 = > 200)

The top individual angler (based on number of fish caught) for the 2020 NPSRF harvested 5,579 Northern Pikeminnow, which also included 4 externally tagged Northern Pikeminnow and 10 tag-loss Northern Pikeminnow worth a total earnings of $48,501 (PSMFC 12/28/2020 Sport-Reward Payment Summary). The 2020 top angler caught 903 less reward sized Northern Pikeminnow than the top angler did in 2019. The CPUE for this year's top angler (46.9 fish per angler day) was down from the top angler in 2019 (51.4 fish per angler day) reflecting slightly less productive fishing/river conditions seen for all Tier 3 anglers in 2020. The top angler for the 2020 season spent 7 fewer days of effort (119 days) than the top angler did in 2019 (Hone et al. 2020). By comparison, the top angler in terms of participation (rather than harvest) for the 2020 NPSRF fished 153 days of the 154 available days (99.4% of available days) and harvested 1,573 Northern Pikeminnow.

Tag Recovery

Northern Pikeminnow Tags

Returning anglers harvested 111 Northern Pikeminnow tagged by ODFW with external spaghetti or Floy tags during the 2020 NPSRF compared to 143 external spaghetti/Floy tags harvested in 2019 (Hone et al., 2020). Tag recoveries peaked during weeks 25 and 27 (Figure 25), which was six weeks later than peak tag recovery in 2019 week 19 (Hone et al. 2020). All of the 111 externally tagged Northern Pikeminnow recovered in the 2020 NPSRF, retained PIT tags added by ODFW as a secondary mark. WDFW technicians recovered an additional 157 Northern Pikeminnow, which retained ODFW PIT tags, but had lost the external tag (referred to as "tag-loss"). ODFW used WDFW's tag recovery data from the 2020 NPSRF (Spaghetti/Floy and/or PIT) to estimate a 17.8% exploitation rate for the NPMP in 2020 (Barr et al. 2021).

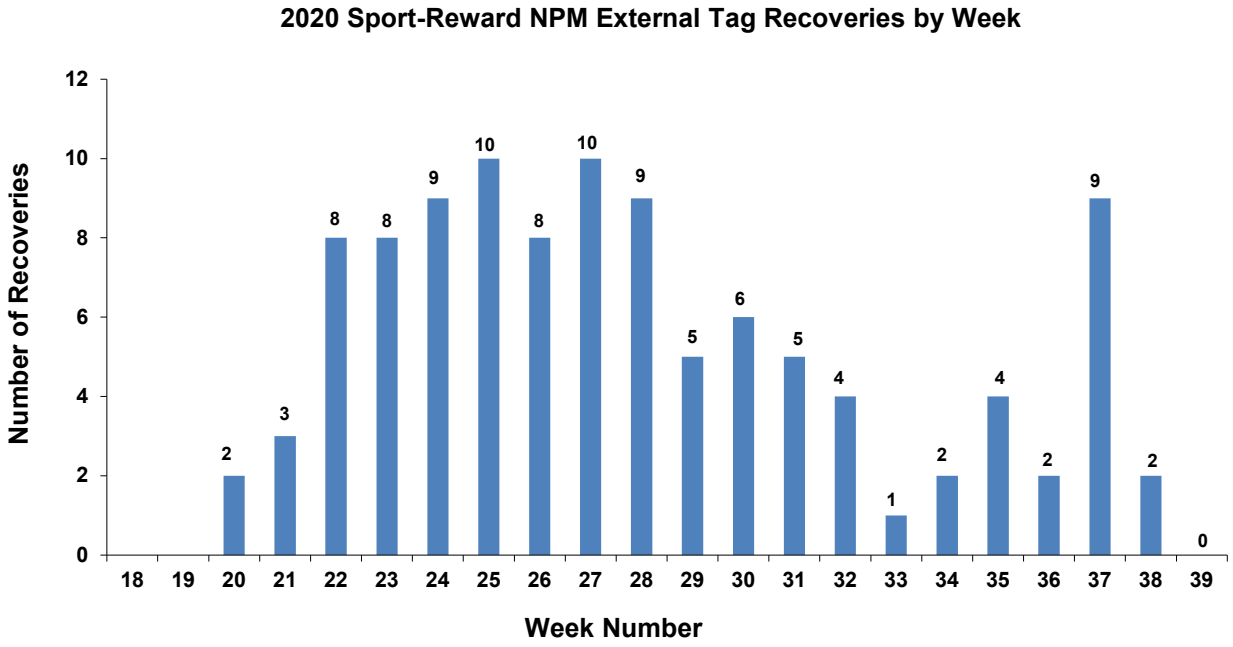


Figure 25. 2020 NPSRF external tag recoveries by week

Ingested PIT Tags

A total of 102,935 Northern Pikeminnow were individually scanned for the presence of PIT tags in 2020. This represents 100% of the total harvest of reward-size fish for the 2020 NPSRF (Northern Pikeminnow not qualifying for rewards were also scanned whenever possible). Technicians recovered a total of 21 PIT tags from consumed smolts that had been ingested by Northern Pikeminnow harvested during the 2020 NPSRF, an overall occurrence ratio of 1:4,902 compared to 1:4,062 in 2019. Total ingested PIT tag recoveries in 2020 was 15 recoveries less than the previous year. While the rate of occurrence for ingested PIT tags was moderately lower in 2020 than it was in 2019 it was still greater than the rate of occurrence than in 2018 which was 1:6,934 (Hone et al. 2019). PIT tag recoveries of salmonid smolts ingested by Northern Pikeminnow peaked during week 20 of the 2020 NPSRF (compared to weeks 19 in 2019) (Hone et al. 2020). The final ingested PIT tag recoveries for the 2020 NPSRF occurred during week 29 (July 13th – July 19th) (Figure 26).

Ingested PIT tag recoveries by fishing location during the 2020 NPSRF showed that Northern Pikeminnow harvested from fishing location 02 (Bonneville Reservoir) and 10 (Little Goose Reservoir) consumed the largest number of PIT tagged juvenile salmonids (Figure 27).

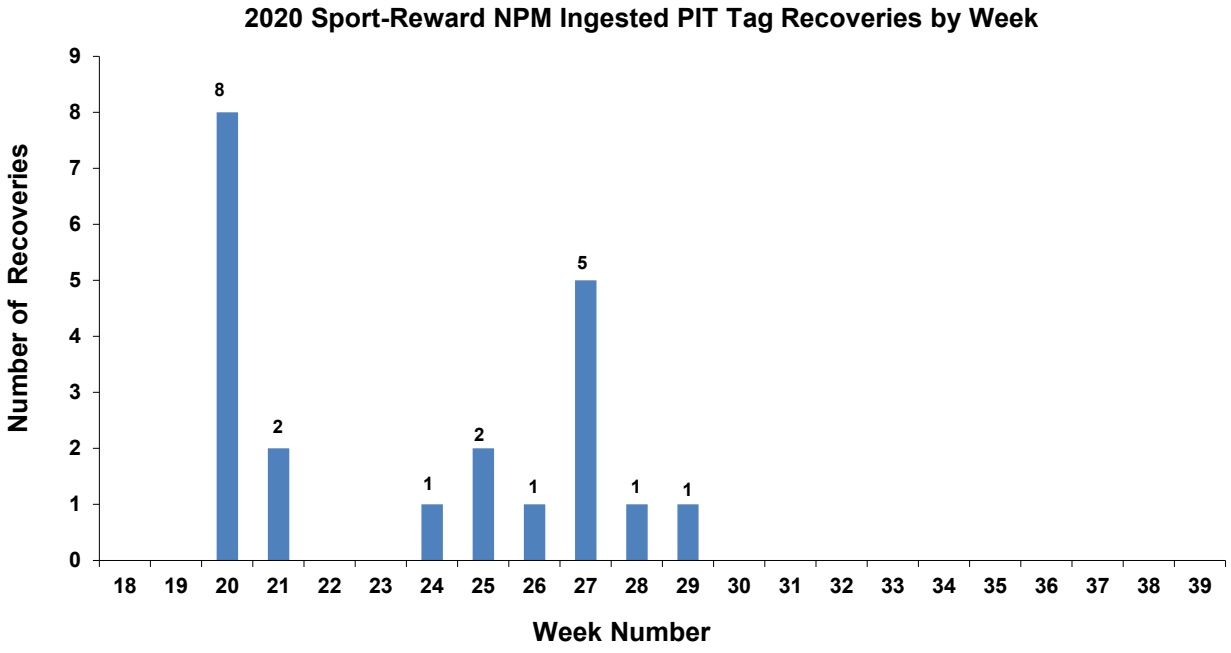


Figure 26. 2020 NPSRF ingested PIT Tag recoveries by week

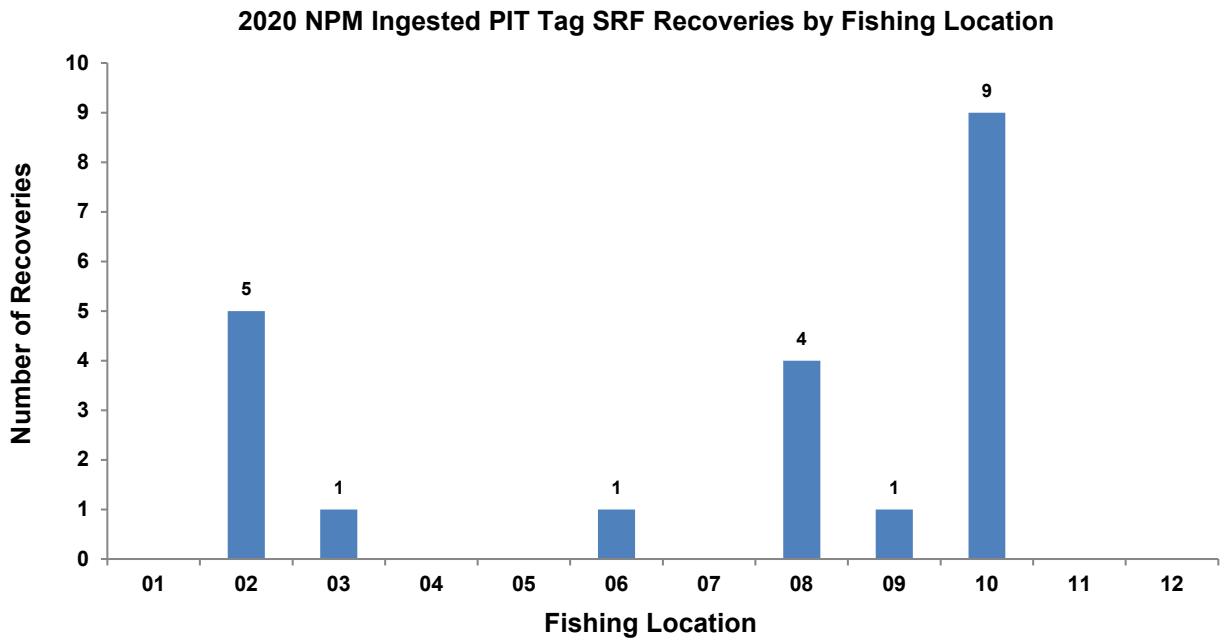


Figure 27. 2020 NPSRF ingested PIT Tag recoveries by fishing location*

*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 2020 NPSRF was obtained from PTAGIS and indicated that 20 of the 21 ingested PIT tag recoveries (95.2%) were from Chinook smolts (Figure 28). Of the Chinook smolts, 18 of the 20 PIT tags (90.0%) indicated that the smolts were of hatchery origin, one of wild origin, and one of unknown origin. PTAGIS queries further revealed that the Chinook PIT tag recoveries consisted of 9 Fall Chinook, 7 Spring Chinook, 3 Summer Chinook, and 1 unknown hatchery origin Chinook. Finally, PTAGIS queries revealed that the other 1 ingested PIT tag recovery came from a Wild Summer Steelhead.

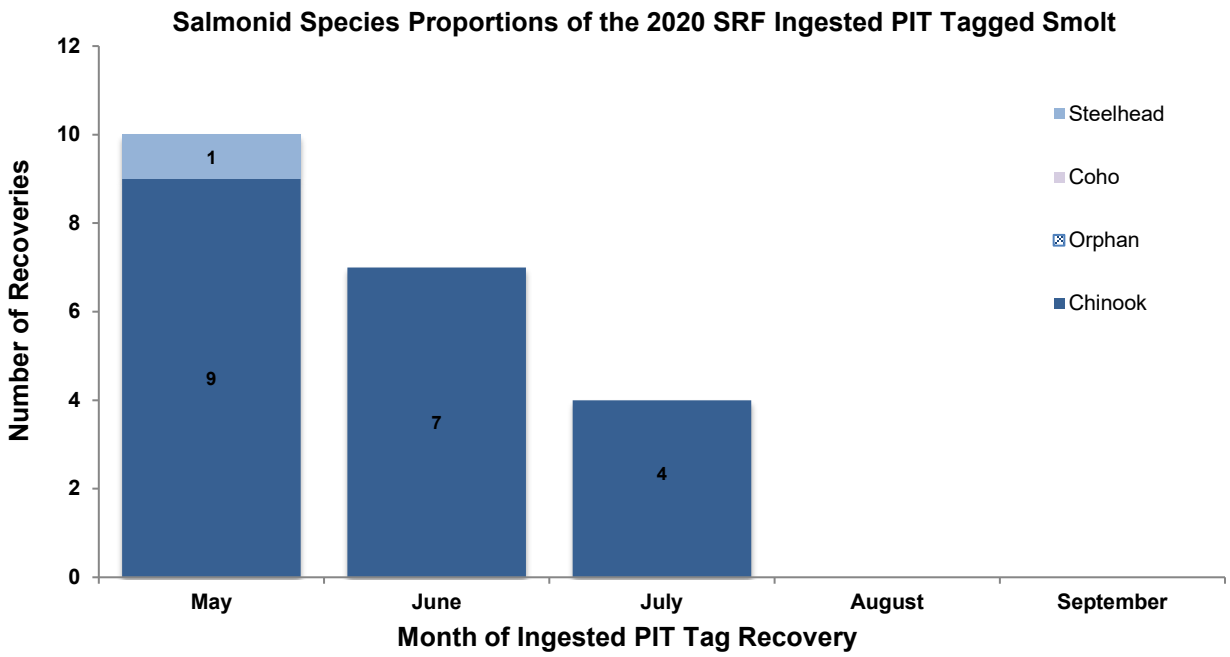


Figure 28. Recoveries of ingested Salmonid PIT Tags from the 2020 NPSRF

Analysis of PIT tag recovery data from the 2020 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 2020 season was in many ways, the most challenging NPSRF in the program's 30 year history. Given the ongoing COVID-19 pandemic and all the uncertainty surrounding it, it was remarkable that the season started only 10 days late in May. Given that the COVID-19 uncertainty also extended to the public and participants, it is no wonder that angler effort and total NPSRF harvest were down in 2020. Despite this uncertainty, the 2020 NPSRF did succeed in achieving the NPMP's 10-20% exploitation goal for the twenty-third consecutive year, with exploitation estimated to be 17.8% for the year. NPSRF harvest in 2020 was 43,290 fish lower than 2019 harvest and below mean 1991-2019 annual harvest of 175,971. Annual angler effort in 2020 decreased by 4,304 angler days from 2019. It is unclear why the NPSRF had such a large decrease in participation, at the same time that WDFW generally experienced higher license sales and angler participation in other fisheries. It may be that since participation in the NPSRF requires some interaction with NPSRF staff (at least to turn in fish and receive a voucher), there was some reluctance (given COVID-19 concerns) to participate in the fishery, especially for older anglers and new or inexperienced anglers.

The number of individuals decreased by 284 anglers in 2020, with 62% of that number coming from Tier 1 anglers. CPUE decreased from 7.21 in 2019 to 6.44 in 2020 (Hone et al. 2020). Peak weekly harvest occurred during week 25 (June 15-21) and peak weekly effort occurred during the first week of the 2020 season, which was delayed until week 20 (May 11-17) due to COVID-19 pandemic concerns. The Boyer Park registration station was the NPSRF's top station for harvest in 2020 (18,902 fish) for the first time since 2015. The Cathlamet registration station did account for the most angler effort with 2,278 angler days of effort spent.

We recovered 111 Northern Pikeminnow with external spaghetti or Floy tags implanted by ODFW as part of the NPMP's biological evaluation. Of those, 83 were spaghetti tags and 28 were the Floy tags. We recovered an additional 157 Northern Pikeminnow which were missing external tags but retained ODFW PIT tags (tag-loss). Mean fork length for Northern Pikeminnow harvested in the 2020 NPSRF was 289.9 mm, up from 281.2 mm in 2019 (Hone et al. 2020). Incidental catch consisted primarily of Peamouth, Smallmouth Bass, and Yellow Perch, reflecting a similar pattern seen in recent NPSRF seasons.

For the 2020 NPSRF, the most noteworthy occurrence was that we were able to implement a full NPSRF season in the midst of the COVID-19 global pandemic. Secondarily, the 2020 NPSRF included a season extension into October for the first time since 2010. Finally, the NPSRF was able to demonstrate adaptive management during the season by recognizing that angler effort and participation were down in 2020 (likely related to COVID-19), and taking steps to implement a temporary, one-time reward increase to a flat $10/eligible fish during the final two weeks of the regular season + the 11 day extension. The importance of implementing this temporary incentive may not be fully realized until the start of the 2021 NPSRF when the lingering effects of the COVID-19 pandemic may still be exerting downward pressure on NPSRF participation.

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 1:4,902 in 2020 versus 1:4,062

in 2019, and species composition of the 21 ingested PIT tags recovered from harvested Northern Pikeminnow indicated 20 were from Chinook smolts, 18 being of hatchery origin, 1 of wild origin, and 1 of unknow origin, along with 1 Wild Summer Steelhead (PTAGIS).

RECOMMENDATIONS

1.) Reexamine the use of "standardized season dates" (May 1st-Sept 30th) for implementation of the 2021 NPSRF in order to identify feasibility of opening a limited number of stations where high harvest is typically available during the first weeks of the season, prior to May 1st. Early openings (as the NPSRF did in the 1990's) may enhance harvest opportunities, increase program efficiency, and improve exploitation estimates for some areas by operating the SRF during earlier dates when large numbers of predatory Northern Pikeminnow are better available to anglers.

2.) Continue to implement angler incentives such as the $5 base reward level used in 2020 as an incentive designed to recruit new anglers to the 2021 NPSRF. Continue to utilize the standard Tier levels used in 2020 which were designed to incentivize current, proficient anglers to expend additional effort participating in the 2020 NPSRF.

a) Review NPSRF station times and routes for efficiencies which may allow adding additional stations or provide additional angler opportunities for participation. Consider reinstituting 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 (according to guidelines related to COVID-19) 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 and fishery participants, or to COVID-19 related requirements 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 suitability of using Floy tags as external tags on Northern Pikeminnow compared to spaghetti tags. Monitor tag-loss and review results to determine if changes to tagged fish protocol should be made in 2021.

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

2020 Annual Report

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May 2021

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 2020, the rewards paid to anglers were initially the same as in the 2019 season. For vouchers issued from May 11 thru September 18, 2020, anglers were paid $5, $6, and $8 per fish for the three payment tiers (1-25 fish, 26-200 fish and 201-up). The rewards for tagged fish were $500 per fish.

Effective September 19 the reward for all eligible Northern Pikeminnow increased from the $5 to $8 to $10 per fish - regardless of how many Northern Pikeminnow an angler caught. The reward for verified specially-tagged Northern Pikeminnow also temporarily increased from $500 to $1,000 per fish.

A total of 101,332 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 $761,811.

A combined total of 110 tagged fish (having an external spaghetti or floy tag) were paid in 2020. One hundred six tagged fish were paid at $500 each while 4 were paid at the increased rate of $1,000 each). The season total paid for tag rewards was $57,000.

A total of 156 tag-loss fish (external tag missing but still possessing a verifiable pit tag) were paid a *bonus* reward of $100. The season total paid for tag-loss *bonus* was $15,600.

A total of 505 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 $5,050.

A total of 2,343 separate anglers registered to fish, of which 641 (27%) caught one or more fish and received payments during the season. The total value for all 101,442 Northern Pikeminnow submitted for payment in 2020 (including all coupons, tagged fish and tag-loss *bonus* payments) was $839,461.

INTRODUCTION

The **Northern Pikeminnow Sport Reward Program** was again administered by PSMFC in 2020. 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, and conducted dam angling at John Day Dam and The Dalles Dam. ODFW provided fish tagging services, population studies, and food habit studies, as well as exploitation rate estimates. PSMFC provided technical administration, and the fiscal and contractual oversight for all segments of the Program and processed all reward vouchers for the sport-reward anglers.

THE 2020 SEASON

Due to the COVID-19 pandemic, the 2020 Northern Pikeminnow Sport-Reward Fishery did not open on May 1, as originally planned. Stay at home orders issued in March by governors in Washington and Oregon closed or limited fishing and limited access to some recreational facilities, including boat ramps. Washington's limited re-opening of many outdoor recreational activities (including opening most fishing seasons and allowing day-use of many boat ramps) allowed the Pikeminnow Sport-Reward Fishery to open on May 11, 2020.

PSMFC maintained an accounting system during the season to determine the appropriate reward amount due each angler for particular fish. From May 11 thru September 18, rewards were paid at $5 for the first 25 fish caught during the season, $6 for fish in the 26-200 range, and $8 for all fish caught by an angler above 200 fish.

To offset the delay at the start of the season and to mitigate the discouragement that some anglers apparently felt from the pandemic (the number of anglers in September were down 28% from the same time in 2019), the Northern Pikeminnow Sport Reward Program was extended until October 11, 2020 and rewards were increased.

Effective September 19, the reward for all eligible Northern Pikeminnow increased to a flat $10 per fish. The reward for verified specially-tagged Northern Pikeminnow also *temporarily* increased from $500 to $1,000 per fish.

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 5 years (2015 – 2019) and to those who signed up for our mailing list at the various sportsmen's shows. The 2020 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 505 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 $5,050.

PARTICIPATION AND PAYMENT

A total of 882 anglers who registered were successful in catching one or more fish in 2020. Of those anglers; 641 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 2020 a total of 102,935 fish were harvested in the sport-reward fishery. Of this total, 101,442 fish were submitted for payment and paid prior to the 2020 payment deadline (To obtain payment, vouchers must have been received no later than November 15, 2020). In addition, any *received* vouchers with issues preventing payment (missing information, voiding of voucher for program violations, etc.) not resolved by November 15, 2020 became null and void.

TAGGED FISH AND PAYMENTS

Registered anglers caught and submitted a total of 110 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 $57,000.

TAG-LOSS BONUS PAYMENT

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. That said; all qualifying Northern Pikeminnow submitted by registered anglers were scanned to check for the presence of a PIT tag. When a PIT tag was detected on a fish with no spaghetti/floy tag, the fish was considered a *standard* fish (and paid at the standard tier rate of $5, $6, and $8 per fish) but was also flagged for verification (by ODFW) of a valid program PIT tag. Upon positive confirmation by ODFW; the angler was then sent an additional $100 *bonus* check and congratulatory letter which included the tagging date and approximate area of release. A total of 156 tag-loss fish qualified for and were paid the *bonus* reward of $100. The season total paid for tag-loss *bonus* was $15,600.

TOTAL ACCOUNTING

Total payments for the season of regular vouchers, *$10 bonus coupons,* tag vouchers and *tag-loss bonus* payments were $839,461.

All IRS Form 1099-MISC Statements were sent to the qualifying anglers for tax purposes in the fifth week of January 2021. Appropriate reports and copies were provided to the IRS by the end of February 2021.

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

2020 SPORT REWARD PAYMENTS SUMMARY

The following is a summary of all vouchers received and paid in 2020.

5-11-2020 thru 9-18-2020	Fish	Incentives	Reward
Fish paid @ tier 1 ($5 each):	7,783	-	$38,915
Fish paid @ tier 2 ($6 each):	23,850	-	$143,100
Fish paid @ tier 3 ($8 each):	58,597	-	$468,776
Tags paid (@ $500 each):	106	-	$53,000
Coupons issued (@ $10 each):	-	455	$4,550
Tag-loss issued (@ $100 each):	-	140	$14,000
Total:	90,336		$722,341

Anglers @ tier 1	*368*
Anglers @ tier 2	*123*
Anglers @ tier 3	*97*
Number of separate anglers	*588*
Anglers with 10 fish or less:	*284*
Anglers with 2 fish or less:	*157*

9-19-2020 thru 10-11-2020	Fish	Incentives	Reward
Fish paid @ tier 1 ($10 each):	607	-	$6,070
Fish paid @ tier 2 ($10 each):	1,369	-	$13,690
Fish paid @ tier 3 ($10 each):	9,126	-	$91,260
Tags paid (@ $1,000 each):	4	-	$4,000
Coupons issued (@ $10 each):	-	50	$500
Tag-loss issued (@ $100 each):	-	16	$1,600
Total:	11,106		$117,120

Anglers @ tier 1	*74*
Anglers @ tier 2	*60*
Anglers @ tier 3	*68*
Number of separate anglers	*202*
Anglers with 10 fish or less:	*97*
Anglers with 2 fish or less:	*46*

2020 SPORT REWARD PAYMENTS SUMMARY

The following is a summary of all vouchers received and paid in 2020.

	Fish	Incentives	Reward
Fish paid @ tier 1:	8,390	-	$44,985
Fish paid @ tier 2:	25,219	-	$156,790
Fish paid @ tier 3:	67,723	-	$560,036
Tags paid:	110	-	$57,000
Coupons issued:	-	505	$5,050
Tag-loss issued:	-	156	$15,600
Total:	101,442		$839,461

Anglers @ tier 1	*402*
Anglers @ tier 2	*139*
Anglers @ tier 3	*100*
Number of separate anglers	*641*
Anglers with 10 fish or less:	*312*
Anglers with 2 fish or less:	*174*

	Total Fish	$500 Tags	Tag Loss	Coup.	Total Reward
1.	5,579	4	$ 1,000	$ 10	$ 48,501
2.	4,182	5	$ 700	$ 10	$ 37,797
3.	4,092	6	$ 1,200	$ 10	$ 37,505
4.	3,616	7	$ -	$ 10	$ 32,905
5.	3,435	2	$ 300	$ 10	$ 28,589
6.	2,385	2	$ 400	$ 10	$ 20,869
7.	2,388	1	$ 500	$ 10	$ 19,861
8.	2,134	4	$ 100	$ 10	$ 19,133
9.	2,214	1	$ 300	$ 10	$ 18,759
10.	2,091	2	$ -	$ 10	$ 17,649
11.	1,876	4	$ 300	$ 10	$ 17,645
12.	1,736	2	$ 300	$ 10	$ 15,247
13.	1,562	2	$ 100	$ 10	$ 13,671
14.	1,573	0	$ -	$ 10	$ 12,475
15.	1,511	0	$ 300	$ 10	$ 12,435
16.	1,408	1	$ -	$ -	$ 11,331
17.	1,353	0	$ 600	$ 10	$ 11,255
18.	1,339	1	$ 100	$ -	$ 11,089
19.	1,279	1	$ -	$ 10	$ 10,884
20.	1,265	1	$ 100	$ 10	$ 10,671
	47,018	46	$ 6,300	$ 180	$ 408,271

NORTHERN PIKEMINNOW SPORT-REWARD FISHERY VOUCHER

2020 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

2020

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 11/15/20.

[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

2020 TAG

LAST NAME | FIRST NAME | MI

ADDRESS

CITY | STATE | ZIP CODE

ANGLER TELEPHONE NUMBER – –

TAG VOUCHER #

MONTH DAY 2020

DOCUMENT #

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

PIT TAG #

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

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 11/15/20.

[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, 2020. Any issues preventing payment (missing information, voiding of voucher for program violations, etc.) must be resolved by Nov. 15, 2020 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

Prepared by

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ABSTRACT

Since 1990, the Northern Pikeminnow Management Program (NPMP) has applied targeted removal fisheries in the Columbia and Snake rivers to restructure populations of Northern Pikeminnow *Ptychocheilus oregonensis* in an effort to suppress predation on out-migrating juvenile Pacific salmon and steelhead *Oncorhynchus* spp. During 2020, the Oregon Department of Fish and Wildlife evaluated the continued efficacy of the Northern Pikeminnow removal program and assessed potential outcomes of the fisheries through a combination of field activities, laboratory work, and data analyses. This report augments historical information with current data and seeks to 1) estimate rates of exploitation of Northern Pikeminnow; 2) quantify the potential reduction in predation on juvenile salmonids resulting from the targeted removal fisheries; 3) characterize population parameters of Northern Pikeminnow, Smallmouth Bass *Micropterus dolomieu*, and Walleye *Sander vitreus* below Bonneville Dam and in Bonneville Reservoir; and 4) assess evidence of possible intra- and inter-specific compensatory responses by Northern Pikeminnow, Smallmouth Bass, and Walleye related to the sustained removal of Northern Pikeminnow from the lower Columbia and Snake rivers. To quantify exploitation during 2020, we used standardized boat electrofishing to tag and release Northern Pikeminnow throughout the lower Columbia and Snake rivers. We used tags recovered in the NPMP Sport Reward Fishery 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 2020 was 17.8% (95% confidence interval, 8.0–22.4%). The point estimate was within the NPMP targeted goal of 10-20% exploitation, above the historical average (14.0 ± 0.6% SE), and greatest since 2010. Based on this level of exploitation, modeled results predict that predation will be reduced by 34% (range: 12-46%) relative to pre-program levels in 2021. These metrics suggest that the program continues to be successful. In 2020, we deployed an alternative tag type for the second year in a row with decreased tag loss rates and indications that it may increase post-release survival for small fish, resulting in higher return rates and a more accurate estimate of exploitation. However, as a result of the coronavirus pandemic in 2020, we had a substantially shorter field season with reduced spatial coverage for tagging efforts and subsequently relatively few tags deployed. This likely affected our exploitation estimate, may have contributed to the unusually broad confidence interval, and could explain the discrepancy between the historically low overall harvest in the Sport Reward Fishery and high exploitation estimate. For all species monitored, the indices of predator abundance, consumption, and predation continue to be variable across time and space, producing few consistent patterns and making broad conclusions difficult. In 2020, we did not see evidence of compensation by remaining Northern Pikeminnow, however we did observe an increase in the predation index in the Bonneville Reservoir tailrace area, suggesting that Northern Pikeminnow predation can have localized hot spots. Smallmouth Bass consumption was relatively consistent with recent observations, but current abundance index values continue to be elevated compared to baseline levels, meaning the predatory impact of this fish has likely increased since program inception below Bonneville Dam and in Bonneville Reservoir. In contrast, the predatory impact of Walleye seems unlikely to have increased since the program began based on 2020 results in these areas. Walleye continue to be captured infrequently relative to the other target predators. Although very few Walleye stomach samples were obtained, the frequency of occurrence of salmonids in the diet was the greatest of all species monitored, suggesting the strong potential for the predatory impact of this species to increase, should its abundance increase.

INTRODUCTION

The Columbia and Snake rivers historically supported large numbers of naturally produced anadromous Pacific salmon *Oncorhynchus* spp. Declines in adult returns have been attributed to factors including habitat degradation and overexploitation (Nehlsen et al. 1991; Wismar et al. 1994), hydroelectric and flood control activities (Raymond 1988), and predation on out-migrating juveniles (Rieman et al. 1991; Collis et al. 2002). Escalating concern in the 1980s surrounding the impacts of predation on juvenile salmon prompted researchers to further examine the degree to which predation, by resident fishes in particular, may constrain juvenile salmon survival in the Columbia River Basin. To this end, the John Day Reservoir in the Columbia River was selected as a "model" system to investigate predator impacts on juvenile salmonids given that: (1) the reservoir was known to be an important area for rearing of subyearling Chinook Salmon *Oncorhynchus tshawytscha*; (2) passage and residualism of juvenile salmonids was considered an issue in the reservoir; and (3) John Day Reservoir supported substantial populations of resident predatory fishes (Poe and Rieman 1988). Based 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 John Day Reservoir provided evidence that of the species considered, 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 John Day Reservoir, questions remained surrounding impacts of Northern Pikeminnow predation in other areas of the lower Columbia and Snake rivers. To explain these questions, indices were developed to allow rapid assessment of the extent of predation by Northern Pikeminnow throughout the system. From 1991 through 1993, researchers applied these indices to data collected in other Columbia River reservoirs (1990 and 1993), the Columbia River downstream of Bonneville Dam (1991), and several Snake River reservoirs (1992) to characterize abundance, consumption, and predation (Ward et al. 1995). Results from these evaluations showed, although variable in time, predation by Northern Pikeminnow on juvenile salmonids was problematic in areas throughout the lower Columbia and Snake river reservoirs. With the extent of the issue identified, work was conducted to further examine management strategies that could limit predation based on the premise that even modest exploitation of Northern Pikeminnow (i.e., 10–20%) could precipitate a disproportionate reduction in predation (i.e., up to 50%; Rieman and Beamesderfer 1990). Ultimately, assessments of various management strategies identified targeted removal fisheries as a favorable option to address the issue of predation on juvenile salmonids and provided the foundation for the contemporary Northern Pikeminnow Management Program (NPMP).

From its inception, the NPMP has operated based on two underlying objectives: (1) implementation of the predator control program (see reports A, B, and D) and (2) evaluation of the predator control strategy. To address the latter objective, the Oregon Department of Fish and Wildlife (ODFW) has sampled standardized areas since the early 1990s in the Columbia and

Snake rivers to evaluate the efficacy of targeted removals to reduce predation and assess possible compensatory consequences (e.g., intra- and inter-specific responses to management actions) that may be related to sustained removals of Northern Pikeminnow. This report augments historical information with data collected during 2020 in areas of the Columbia and Snake rivers and, wherever possible, evaluates temporal and spatial changes. Specific goals for this reporting period were to:

(1) Estimate rates of exploitation of Northern Pikeminnow and quantify potential reduced predation resulting from the targeted removal fisheries;
(2) Characterize population parameters of Northern Pikeminnow, Smallmouth Bass, and Walleye below Bonneville Dam and in Bonneville 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 Columbia and lower Snake rivers.

METHODS

In March of 2020 the State of Oregon implemented restrictions to protect government employees and citizens alike during the advent of the novel coronavirus pandemic. Due to these statewide restrictions, which included travel bans and shutdowns of all non-essential work, the 2020 field season for ODFW's evaluation of the NPMP was substantially delayed. This, coupled with electrofishing restrictions related to elevated water temperatures typically seen in early and mid-July, resulted in a substantially shortened field season. Lab work was also delayed in 2020 due to necessary social distancing practices related to the pandemic.

ODFW researchers conducted sampling during 2020 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 new 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. The boats contain anodes suspended from two boom arms extending forward from the bow and each supports a single array composed of six electrodes. Electrodes hanging from the boat hull function as the cathodes. We set electrofishing controls according to federal guidelines where peak output does not exceed 800 V at water conductivity 100 to 300 µS/cm (NMFS 2000). The targeted average electrical current during all electrofishing events was 3–4 A. We standardized all controls across boats with minor adjustments to the duty cycle to achieve the targeted output. We utilized electrofishing protocols 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, we developed and implemented protocols to reduce interactions with species listed under the U.S. Endangered Species Act to guide sampling efforts.

Sport Reward Fishery Evaluation and Predation Reduction Estimates

Field Procedures

We tagged Northern Pikeminnow and estimated exploitation rates with tag recovery data from the Sport Reward Fishery (SRF). We used boat electrofishing to collect Northern Pikeminnow in the Columbia River from river kilometer (rkm) 76 (near Clatskanie, Oregon) upstream to rkm 560 (near Ringold boat launch), and in the Snake River from rkm 146 (near Willow Landing boat launch) to Lower Granite Dam and from rkm 215 (near Clarkston, WA) to rkm 251 (near Asotin, WA) upstream of Lower Granite Dam (Figure 1). We conducted four sampling events within each 1.61 river kilometer (1 river mile), consisting of 900 s of boat electrofishing effort each. We sampled along shallow shoreline areas as the effective range of boat electrofishing tends to be limited to a maximum depth of approximately 3 m. We sampled from 28 May to 22 June 2020 between 1800 and 0500 hours, except near Asotin, WA on the Snake River (rkm 130–156), where daytime sampling was necessary to navigate safely. In 2020, we did not sample The Dalles Reservoir (308 rkm – 347 rkm), John Day Reservoir (349 rkm – 368 rkm), or the Hanford Reach of McNary Reservoir (561 rkm - 637 rkm) in the Columbia River. We also did not sample from 17 rkm (Ice Harbor Dam) to 64 rkm (Lower Monumental Dam) and from 172 rkm (Lower Granite Dam) to 214 rkm (near Clarkston) in the Snake River. These areas were not sampled due to the aforementioned compressed field season associated with the coronavirus pandemic. We attempted to adaptively manage our field schedule and adjusted sampling plans

to ensure un-sampled areas occurred only in locations where electrofishing catch rates were historically low. Ideally, all tagging activities would conclude before the Sport Reward and Dam Angling fisheries began, but that proved unachievable due to time constraints, the extent of the sampling area, and COVID-19 restrictions. In 2020, we tagged all Northern Pikeminnow concurrent with fishery activities.

We tagged and released Northern Pikeminnow ≥ 200 mm fork length (FL) with uniquely numbered Floy® FT-4 lock-on external loop tags or Floy® FD-94 external T-bar anchor tags. We tagged approximately half of target sized Northern Pikeminnow (≥ 200 mm FL) with T-bar anchor tags and half with locking loop tags to evaluate tag retention and post-release survival of tagged fish by tag type for the second year in a row. Tag type was assigned randomly so that we evenly distributed tag types across all sizes of fish within a given area or reservoir. We inserted each loop tag between the pterygiophores below the midpoint of the dorsal fin. We inserted each T-bar anchor tag between the pterygiophores below the dorsal fin on the left side of the fish. We also marked all externally tagged fish with an internal 134.2 MHz passive integrated transponder (PIT) tag injected into the dorsal sinus cavity. During Northern Pikeminnow tagging operations, we also opportunistically captured, measured, and weighed Walleye in an attempt to gain some understanding of their populations in these areas and supplement data collected during biological evaluation activities (see below).

Working with the Washington Department of Fish and Wildlife (WDFW), we obtained tag recovery information from the SRF and the Dam Angling Fishery (DAF). The SRF occurred daily from 11 May to 11 October 2020 (see Report A). Participating anglers received payment for all harvested Northern Pikeminnow greater than or equal to 230 mm (9 in) total length (TL). This size criterion for TL corresponds to the minimum FL (200 mm) of Northern Pikeminnow marked during tagging operations. The 2020 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 $100 reward for each "tag-loss" fish (i.e., those fish for which an external tag had been lost in the environment, but retained a functioning PIT tag internally). Given this, we 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 20 May to 12 October 2020 (see Report D for details) 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 internal PIT tags. We accounted for tagged Northern Pikeminnow removed in the DAF when estimating exploitation rates for the SRF.

Data Analysis

We quantified the proportion of the Northern Pikeminnow population removed during program fisheries using mark-recapture data for both continuous zones separated by dams (area-specific) and the entire area sampled (system-wide). To account for a reduction in the minimum length of Northern Pikeminnow eligible for sport-reward payment from 11 in. TL (≥ 278 mm TL; ≥ 250 mm FL) to 9 in. TL (≥ 230 mm TL; ≥ 200 mm FL) beginning in the year 2000, we calculated rates of exploitation for three size-classes: 1) ≥ 200 mm FL (all tagged fish), 2) 200–249 mm FL,

and 3) ≥ 250 mm FL. We used the subset of fish ≥ 250 mm FL for long-term temporal comparisons.

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

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

where

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

Beginning in 2014, the NPMP incentivized the return of tag-loss Northern Pikeminnow with a cash reward and since that time, a correction for tag retention has not been applied to exploitation estimates.

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

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

where

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

When tagging and fishing efforts occurred concurrently (as occurred for all areas sampled in 2020), we treated each week as a separate sampling period according to the function:

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

where

R_{ij} = the number of tagged fish recaptured in area j during the i^{th} week, and
M_{ij} = the number of marked fish at large in area j at the beginning of the i^{th} week of the SRF.

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

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

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

where

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

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

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

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.

We applied a model based on Friesen and Ward (1999) to estimate current predation on juvenile salmon relative to predation before the implementation of the program. The model estimates potential predation reduction from pre-program levels by incorporating: (1) Northern Pikeminnow population size structure before removals by fisheries, (2) area- and size-specific annual exploitation rates, (3) an estimate of natural mortality, (4) area- and size-specific abundance estimates, and (5) area- and size-specific estimates of seasonal consumption of juvenile salmon by Northern Pikeminnow. Based on estimated levels of abundance and consumption for the current year, the model estimates system-wide total annual loss of juvenile salmon to Northern Pikeminnow predation in the following year and compares those losses to pre-program levels. The model assumes removal of Northern Pikeminnow through completion of the SRF in the current year will reduce predation on out-migrating juvenile salmon in spring and summer of the following year. We applied a ten-year mean age-structure (based on catch curves) for a pre-program baseline and assumed constant recruitment. Since its development, we revised the model to include FL increments derived from annual mark-recapture growth observations rather than growth estimates obtained from length and age data. With these inputs, the model predicts changes in potential predation that are directly related to removals, if all other variables remain constant. We estimate the potential predation during 2021 based on observed exploitation rates from 2020 and predict three future predation rates (maximum, median, and

minimum) using the mean level of exploitation observed during contemporary program rules (2001; 2004–2020). Additional model documentation is described in Friesen and Ward (1999).

Biological Evaluation

Field Procedures

We used standardized boat electrofishing techniques (Ward et al. 1995; Zimmerman and Ward 1999) to evaluate Northern Pikeminnow, Smallmouth Bass, and Walleye population parameters below Bonneville Dam and in Bonneville Reservoir during 2020. We conducted early morning (0200–1000 hours) sampling during summer (29 Jun–10 July 2020) in the areas below Bonneville Dam (rkm 225-233) and in Bonneville Reservoir (forebay, rkm 234-239; mid-reservoir, rkm 273-281; and tailrace, rkm 302-305). Our objective in analyzing the diets of predatory fishes in relation to salmonid consumption is to perform field sampling during peak smolt outmigration. We sampled randomly selected fixed-site transects, approximately 500 m long, in each reservoir area along both shores of the river. Effort at each transect consisted of a 900-second boat electrofishing period with continuous output of approximately 3-4 A.

We recorded catch and biological data for all Northern Pikeminnow, Smallmouth Bass, and Walleye collected. We measured FL (nearest mm) and mass (nearest 10 g) for all fish collected above target size (>199 mm FL). We sacrificed all untagged target-sized Northern Pikeminnow and collected diet samples (whole digestive tracts) for subsequent laboratory analyses. We removed digestive tracts by securing both ends with hemostats, removing extra tissue, and placing whole in individual sample bags. New in 2020, we squeezed out digestive tract contents and added water in an attempt to reduce post-collection digestion of diet items. Whenever possible, we recorded sex and stage of maturity. We collected diet samples from target-sized Smallmouth Bass and Walleye by a non-lethal gastric lavage method using a modified Seaburg sampler (Seaburg 1957). We flushed contents from the foregut of each fish into a 425-µm sieve and then transferred the diet contents into individual sample bags. For all species, we stored diet samples on ice while in the field and transferred to a freezer until processing.

Using the protocol described above, we also collected diet samples from Northern Pikeminnow captured during the 2020 DAF in Bonneville and The Dalles reservoirs. We collected diets from a representative subsample of catches at each dam weekly from 19 May–7 October 2020, generally two days per week with a target of 20 fish per day at each dam. In addition, we collected morphometric measurements (FL and mass), sex, and stage of maturity for each fish sampled. It should be noted that due to COVID-19 and staffing restrictions that no samples were taken in Bonneville during weeks 23–24, in The Dalles weeks 22–23, or in either reservoir weeks 37–38.

Laboratory Procedures

We examined the contents of diets from Northern Pikeminnow, Smallmouth Bass, and Walleye collected during biological evaluation field activities, and Northern Pikeminnow collected from the DAF to quantify relative consumption of juvenile salmonids. Due to the reduced number of diet samples collected during 2020 field sampling, we processed all samples.

We thawed frozen field samples in the laboratory and sorted the diet contents into general prey categories (i.e., fish, crayfish, other crustaceans, insects, other invertebrates, vegetation, miscellaneous). We noted parasitic invertebrates (e.g., tapeworms, nematodes, parasitic copepods) found in the diet samples in our dataset comments, but did not weigh, categorize as prey items, or include them in our prey consumption calculations. We weighed (blotted wet mass) diet material to the nearest 0.01 g according to prey category. For Smallmouth Bass and Walleye, we returned portions of diet samples containing fish to the original sample bags for chemical digestion. To ensure complete recovery of diagnostic structures from Northern Pikeminnow diet samples, we chemically digested the entire digestive tract along with possible fish parts. To chemically digest soft tissues, we added 20 ml of a solution of pancreatin (20 g/L) and sodium sulfide nonahydrate (Na_2O_9S; 10 g/L) in tap water — to each sample. Next, we placed sample bags in a desiccating oven at approximately 48°C for 24 h. After removal from the oven, we added a 20 ml solution of sodium hydroxide (lye, NaOH) mixed at 30g/L with tap water to dissolve remaining fatty materials and agitated the sample. Contents of each sample bag were then poured into a 425 µm sieve and rinsed with tap water. In rare cases, we recorded the presence of fish during the initial sorting and weighing, but did not find any bones after chemical digestion. When this occurred, we assumed that those bones were lost, and therefore we assumed one unidentified fish was present in the sample (unless the taxa was identified during the preprocessing stage, e.g., lamprey). We included diet samples of fishes that did not contain any diet items (empty) in all statistical analyses.

We examined bones remaining after chemical digestion to identify prey fish to the lowest possible taxon (typically family) using stereoscopic dissecting microscopes and standard keys (Hansel et al. 1988, Frost 2000, and Parrish et al. 2006). We enumerated paired structures to arrive at minimum counts of a given prey taxon in a diet sample, but we could only evaluate presence/absence for certain prey items. For example, if we only encountered ventral scutes of American Shad *Alosa sapidissima* in a diet sample, we assumed one American Shad had been consumed because the total number of scutes associated with an individual fish is ambiguous. The same assumption was made for instances in which we encountered lamina of lampreys (family Petromyzontidae) in diet samples. Further, for samples where only fish vertebrae were observed, we were able to distinguish between salmonid and other fish prey, but could only conclude that at least one juvenile salmonid had been consumed if salmonid vertebrae were present. Given these constraints, in addition to comparing the relative size and quality of diagnostic bones encountered, we enumerated the total numbers of prey fish in samples as necessarily conservative. Lastly, to calibrate identification accuracy among analysts, we re-analyzed a minimum of 10% of all samples at random by a second reviewer.

Data Analysis

Following the methods of Ward et al. (1995), we calculated seasonal abundance index values for each predator species by calculating the mean catch per 900 s of boat electrofishing by season and area, then multiplying by the surface area (ha) of the specific sampling locations in each river area and dividing by 1,000 for scale. We then applied the models of Ward et al. (1995) and Ward and Zimmerman (1999) to calculate consumption index values for Northern Pikeminnow (CI_{NPM}) and Smallmouth Bass (CI_{SMB}) using the formulas:

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

and

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

where

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

Although these consumption indices do not provide direct estimates of the number of juvenile salmon eaten per day by an average predator, the output values are correlated with consumption rates for Northern Pikeminnow (Ward et al. 1995) and Smallmouth Bass (Ward and Zimmerman 1999). Therefore, the abundance and consumption indices provide a means to characterize relative predation impacts. We calculated consumption index values only when sample sizes exceeded five fish for a given species, season, and sampling area. We used the product of seasonal abundance and consumption index values to generate period- and location-specific predation index estimates for Northern Pikeminnow and Smallmouth Bass. Currently, no comparable model exists to evaluate Walleye consumption and predation.

Rates of exploitation of Northern Pikeminnow increase with increasing fish size (Zimmerman et al. 1995). Thus, sustained fisheries should decrease the abundance of larger fish in the population. With this in mind, we applied a model describing proportional size distribution (PSD; Anderson 1980; Guy et al. 2007) to characterize variation in size structure for Northern Pikeminnow to three groups; those sampled during fishery evaluation, biological evaluation, and from the DAF. We also applied models describing PSD for Walleye populations sampled during both fishery and biological evaluation and Smallmouth Bass sampled during biological evaluation using the formula:

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

where

FQ_i = number of fish ≥ quality-length for species i, and
FS_i = number of fish ≥ stock-length for species i.

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

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

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). We took stock, quality, and preferred minimum length categories 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 and to remove any bias in our data from variation in sampling procedures among years, we chose to use our target size as 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 ($FL_{WAL} = TL_{WAL}/1.060$), we calculated these categories as 236, 358, 481 mm FL, respectively. We calculated annual PSD and PSD – P values only when sample sizes exceeded 19 stock-length fish in an area. To characterize uncertainty surrounding PSD and PSD – P values, we applied a non-parametric bootstrap approach using the 'boot' package (Fox and Weisberg 2011) in the R programming environment (R Core Team 2013) to calculate 95% confidence intervals.

Similar to shifts in size-structure, changes in body condition may indicate a compensatory response by remaining predators to the sustained exploitation of Northern Pikeminnow. We used relative weight (W_r; Wege and Anderson 1978) to compare the condition of Northern Pikeminnow, Smallmouth Bass, and Walleye over time. We used length-specific standard weights predicted by a length-mass regression model ($\log_{10}[W_s] = a' + b \cdot \log_{10}[L]$) for Northern Pikeminnow (Parker et al. 1995), Smallmouth Bass (Kolander et al. 1993), and Walleye (Murphy et al. 1990) to calculate W_r according to the equation:

$$W_r = 100 \times \frac{W}{W_s}, \quad (10)$$

where

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

To account for sexual dimorphism, we calculated W_r values separately for male and female Northern Pikeminnow. However, field sampling methodologies precluded diagnosis of sex for Smallmouth Bass and Walleye as they were not euthanized. Therefore, calculations of W_r for

Smallmouth Bass and Walleye are for both sexes combined. Additionally, we only included fishes that met minimum target sizes (250 mm FL for Northern Pikeminnow and 200 mm FL for Smallmouth Bass and Walleye) in our samples. We calculated annual median W_r values only when sample sizes exceeded 4 target sized fish in a given reservoir and by sex for Northern Pikeminnow. Similar to PSD and PSD – P, we estimated 95% confidence intervals for median W_r values using a non-parametric bootstrap approach (Fox and Weisberg 2011; R Core Team 2013).

We assessed temporal monotonic trends in PSD 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, we also analyzed PSD – P with this method for Walleye. A monotonic trend means that the variable consistently increases or decreases through time, although the trend may be non-linear. We used spline interpolation 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), we did not interpolate data for this large data gap. Instead, we treated them as two different time series; data collected before 1997 as "early" and data collected after 2005 as "late." We then used a non-parametric Mann-Whitney U test to compare PSD values between early and late years for each reservoir. Lastly, to help visualize trends, we fit locally weighted scatterplot smoothing (LOWESS) curves to the data. We conducted all analyses in the R programming environment using the 'Kendall' (McLeod 2011) and, where necessary, the 'boot' or 'tsboot' (Fox and Weisberg 2011) packages. We considered all tests significant at $\alpha < 0.05$.

RESULTS

Sport Reward Fishery Evaluation and Predation Reduction Estimates

We marked 793 Northern Pikeminnow greater than or equal to 200 mm FL throughout the Columbia and lower Snake rivers during 2020, of which 432 were greater than or equal to 250 mm FL (Table 1). While boat electrofishing for tagging purposes, we recaptured 10 Northern Pikeminnow greater than or equal to 200 mm FL that were tagged in previous years. These previously tagged fish are accounted for in annual exploitation calculations and are included as in-year marked or handled fish for 2020 estimates. Overall, 72 of the fish marked in 2020 were recovered in the Sport Reward Fishery and one in the Dam Angling Fishery. Two fish marked below Bonneville Dam, one fish in Bonneville Reservoir, and one in Lower Granite Reservoir were recaptured within the same week they were tagged. They are excluded from recapture totals and our calculations of exploitation to avoid violating mark-recapture assumptions (i.e., incomplete mixing). Fish tagged in 2020 and subsequently recaptured in the SRF were at large from 8 to 121 days (mean = 49.5 d; SE = 4.0). Sport Reward Fishery recaptures greater than or equal to 250 mm FL accounted for 64% of all 2020 tag recoveries (Table 1). The median length of the Sport Reward Fishery catch was 273 mm FL (E.C. Winther, WDFW, personal communication).

Of the 783 new tags deployed in 2020, 49% were T-bar anchor tags and 51% were lock-loop tags. Of those fish tagged and recovered in the same year, 51% were marked with a T-bar tag and 49% were marked with a lock-loop tag. Recaptured fish marked with T-bar anchor tags consisted of 65% of the catch measuring 200-249mm FL and 43% of fish greater than 249mm FL. As tagged fish contained an internal PIT tag even if the external tag was lost to the environment, we were able to identify these "tag loss fish" as being initially marked. The tag loss rate for T-bar anchor tags deployed in 2020 was 32% and 3% for lock-loop tags.

System-wide exploitation of Northern Pikeminnow greater than or equal to 200 mm FL during the Sport Reward Fishery was 15.2% (95% confidence interval 8.0–22.4%) and above average (Table 2). Tag returns were sufficient ($n \geq 4$) to calculate area-specific exploitation estimates for the Columbia River downstream of Bonneville Dam and in Bonneville, Little Goose, and Lower Granite reservoirs, where rates ranged from 5.3 to 16.3%. For Northern Pikeminnow within the 200–249 mm FL size class, system-wide exploitation was estimated to be 8.4% (95% confidence interval 4.4–12.4%) and also above average (Table 3). Area-specific rates of exploitation for this size class could be estimated only for Bonneville Reservoir at 7.9%. The system-wide exploitation rate for Northern Pikeminnow greater than or equal to 250 mm FL exceeded those of the other size classes (17.8%, 95% confidence interval 18.5–27.1%; Table 4). This estimate was within the targeted range of 10-20% and above average while the confidence interval was one of the widest of the time series (Figure 2). Area-specific exploitation rates of those fish greater than or equal to 250 mm FL were: 19.0% for the Columbia River downstream of Bonneville Dam and 10.1% for Bonneville Reservoir.

The model-estimated median reduction of predation on juvenile salmonids relative to pre-program levels for 2020 was 29% (range: 13–42%) and for 2021 will be 34% (range: 12–46%; Figure 3). Model projections based on continuation of the current fishery, population structure,

and mean rates of exploitation suggest predation on juvenile salmon by Northern Pikeminnow will remain at suppressed levels through 2024 with an estimated median reduction near 32%.

Biological Evaluation

Field staff conducted 160 electrofishing runs during summer 2020 below Bonneville Dam and in Bonneville Reservoir to collect fishes for biological evaluation. Our total effort was lower than past seasons due to limited time available resulting from both budget reductions and coronavirus related restrictions. We adaptively managed our sampling plan to optimize efficiency by distributing our 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. This is in contrast to prior sampling plans which attempted to distribute an equal amount of effort between all sampling areas. As a result of the 2020sampling plan, 41% of our sampling transects were concentrated on the mid-reservoir section of Bonneville. Due to limited time and recent poor catch rates, we elected to not sample boat-restricted zones adjacent to Bonneville Dam and therefore did not report data from these areas collected in prior years in this report. The timing of our annual biological evaluation field work is planned to coincide with predicted peak juvenile salmon out migrations. Summer sampling in 2020 mainly overlapped with subyearling Chinook Salmon outmigration at Bonneville Dam (Figure 4).

In the tailrace area below Bonneville Dam, Smallmouth Bass and Northern Pikeminnow were the most abundant species caught (Figure 5). Walleye were also caught at this sampling site, although infrequently. Based on CPUE, among all areas sampled in Bonneville Reservoir, Smallmouth Bass were the most abundant species in 2020 (Figure 6). Smallmouth bass were captured at more than 3 times the rate of Northern Pikeminnow throughout this reservoir. Northern Pikeminnow were caught most frequently in tailrace and forebay areas, whereas Walleye were primarily caught in the tailrace of Bonneville Reservoir. It is of note that we sampled for Walleye in the forebay of Bonneville Reservoir, but were unable to capture a single fish from this location. In total, only 11 Walleye were captured among all areas sampled in 2020.

Northern Pikeminnow abundance index values were lower than the series mean in all areas with the exception of Bonneville tailrace, which was nearly double the series mean and 4.5 times greater than the previous observation in 2017 (Table 5). All areas were marked decreases from baseline summer values in 1990, with the exception of Bonneville tailrace. Of the other three sites, two had abundance index values lower than our last estimation in 2017 (below Bonneville Dam tailrace and Bonneville mid-reservoir), while Bonneville forebay was 1.4 times greater. For Smallmouth Bass, abundance index values were above the mean of the time series, though lower than our record high 2017 estimates in all areas sampled (Table 6). We have observed an increase in Smallmouth Bass abundance index values over 30 years since our initial estimate in 1990, with substantial increases occurring within the last 15 years. The abundance index for Walleye decreased compared to our 2017 estimates with the exception of Bonneville tailrace (Table 7). Values estimated in 2020 are relatively similar to baseline values with the exception of Bonneville tailrace, which is a fourfold increase, but considerably lower than that of the other species.

In 2020, we examined diets from 124 Northern Pikeminnow, 375 Smallmouth Bass, and 11 Walleye across one site below Bonneville Dam and three sites in Bonneville Reservoir (Table 8). The non-native predators were generally found containing food; 96% for Smallmouth Bass and 91% for Walleye, though few Walleye were sampled. For Northern Pikeminnow, 70% of diets examined contained food. Diets of Northern Pikeminnow were generally similar among areas with crayfish as the most frequently encountered diet item followed by fish. Unlike Northern Pikeminnow, Smallmouth Bass prey item frequency differed greatly between Bonneville Reservoir and below Bonneville Dam, primarily in fish and crayfish. Below Bonneville Dam, Smallmouth Bass diets consisted primarily of fish, followed by insects and crustacea. In Bonneville Reservoir, crayfish and other crustacea were the most frequent prey types observed. Walleye diets frequently contained fish, crustacea, and insects in both locations. When combining all areas sampled, salmonid frequency in diets was highest for Walleye at 0.18, then Smallmouth Bass at 0.05, and 0.02 for Northern Pikeminnow. We continued to observe low frequencies of lamprey in diets sampled during biological evaluation in the lower Columbia River which stands in contrast to diets examined from the Dam Angling Fishery where lamprey are a common diet item. When diets were broken down into main fish groups, the greatest frequency of occurrence for salmonids came from Walleye below Bonneville Dam (Figure 7). For Smallmouth Bass and Walleye, non-salmonids occurred in diets more frequently than other fish categories. Sculpin (family Cottidae) and minnows (family Cyprinidae) comprised the majority of non-salmonid fishes in diets identified in 2020. Northern Pikeminnow below Bonneville Dam were found to contain American Shad most frequently, followed by non-salmonids. Unknown fish in diet samples were prevalent in diets of Smallmouth Bass in both reservoirs and the most abundant fish category in Bonneville Reservoir for Northern Pikeminnow. Despite being skilled at fish taxa identification using diagnostic bones and multiple dichotomous keys available, we are unable to identify highly digested materials beyond classification as fish at times.

Northern Pikeminnow 2020 consumption index values varied widely across reservoir areas and, when calculable, were below the mean of the time series (Table 9). In the tailrace of Bonneville Reservoir, we observed a stark increase in the summer consumption index value (0.69) compared to 2017 (0.00) and this value was similar to the baseline number from 1990 (0.67). We did not collect sufficient sample sizes at Bonneville mid-reservoir to be able to calculate a consumption index and our index at Bonneville forebay was 0.00. The consumption index value at below Bonneville Dam tailrace was consistent with the 2017 estimate at 0.21, which is roughly half of the baseline value and one third of the mean of the time series. The 2020 predation index for Northern Pikeminnow was highest at Bonneville tailrace, followed by below Bonneville Dam tailrace, and Bonneville forebay (Table 10). The 2020 Bonneville tailrace predation index value is above the baseline and mean for the time series at 0.63, although it is much less than the peak of the time series observed in 2004 at 1.40.

With respect to Smallmouth Bass consumption index values, the highest observations were found in the tailrace below Bonneville Dam and Bonneville forebay (Table 11). There were increases over the prior observed values in Bonneville forebay and mid-reservoir, though neither were the max value of the time series. Due to the large abundance index of Smallmouth Bass in Bonneville mid-reservoir, the corresponding predation index was greatest among areas at 1.32 (Table 12). This result is roughly double the mean of the time series, though a decrease from the

series high observed in 2017. The predation index value at Bonneville forebay in 2020 was the highest observed in that area for the time series. Decreases in predation index values were observed at all other areas from 2017 estimates.

When length data recorded from Northern Pikeminnow during fishery evaluation were analyzed using PSD, we found a significant monotonic decrease over time in McNary reservoir (Mann-Kendall $\tau = -0.32$, $P = 0.02$; Figure 8). A general decreasing trend was also observed in Bonneville Reservoir though it was not statistically significant. We did not collect sufficient data in Snake River reservoirs to calculate estimates for 2020 ($n < 20$). PSD data for Walleye opportunistically sampled during fishery evaluation in McNary reservoir also demonstrated a decreasing trend over time (Mann-Kendall $\tau = -0.35$, $P = 0.07$; Figure 9) and we found a significant monotonic decrease in Walleye PSD-P across the time series (Mann-Kendall $\tau = -0.41$, $P = 0.03$; Figure 10).

When considering biological evaluation data, Northern Pikeminnow PSD below Bonneville Dam was 41%, compared to 18% in Bonneville Reservoir (Figure 11). These values were below average for the time series in both areas (below Bonneville Dam mean = 46%; SE 4; Bonneville Reservoir mean = 26%; SE 2). Results from analyses of the trends revealed no significant monotonic trends for either reservoir (below Bonneville Dam Mann-Kendall $\tau = 0.39$, $P = 0.05$; Bonneville Reservoir Mann-Kendall $\tau = -0.31$, $P = 0.16$). Though not significant, PSD in Bonneville Reservoir appears to be decreasing over time. PSD below Bonneville Dam steadily increased from 1996, peaked in 2008, and has since steadily decreased.

Smallmouth Bass PSD remained unchanged in recent years below Bonneville Dam (30%) and in Bonneville Reservoir (54%; Figure 12). Smallmouth Bass PSD below Bonneville Dam was below the average for the time series (mean = 38%; SE 3) and slightly above average in Bonneville Reservoir (mean = 52%; SE 2; Table 13). With respect to trends over time, below Bonneville Dam remains relatively stable and a steady increasing trend was observed in Bonneville Reservoir. PSD-P below Bonneville Dam was 9%, compared to 26% in Bonneville Reservoir, with variable trends over time for both reservoirs (Figure 13).

No PSD or PSD-P values were calculated in 2020 in either reservoir for Walleye due to sample size constraints ($n < 20$) during biological evaluation. Only 5 stock-length (≤ 236 mm FL) Walleye were caught below Bonneville Dam, and only 2 caught in Bonneville Reservoir during biological evaluation. These results are relatively consistent with past data, as we have only been able to calculate PSD and PSD-P once in 15 sampling years for each reservoir.

Median W_r of female Northern Pikeminnow below Bonneville Dam decreased from recent years to 101%, and no significant trend was evident (Mann-Kendall $\tau = 0.30$, $P = 0.14$; Figure 14). Median W_r for male Northern Pikeminnow below Bonneville Dam is lower than females at 93%, which was lower than previously observed in recent years. Analyses of the trends over time showed a significant increasing monotonic trend for male Northern Pikeminnow below Bonneville Dam (Mann-Kendall $\tau = 0.43$, $P = 0.04$). In Bonneville Reservoir, female W_r remained relatively the same as previous years at 103% (Figure 15). Male median W_r decreased from recent years to 93%. There were no monotonic trends for either sex in Bonneville Reservoir (female Mann-Kendall $\tau = 0.15$, $P = 0.50$; male Mann-Kendall $\tau = 0.08$, $P = 0.76$).

The 2020 median W_r value for Smallmouth Bass collected below Bonneville Dam (104%) was higher than in Bonneville Reservoir (94%; Figure 16). Annual median W_r values below Bonneville Dam have varied over time, and did not show significant increasing or decreasing trends (Mann-Kendall τ = -0.23, P = 0.30). Although median W_r began to increase in 2011, data from 2020 shows a decrease from our last sampling event in 2017. Smallmouth Bass W_r in Bonneville Reservoir has remained nearly consistent over time, and shows no significant monotonic trend (Mann-Kendall τ = -0.21, P = 0.32). Alternatively, median W_r of Walleye was relatively similar below Bonneville Dam (96%) and in Bonneville Reservoir (94%), with overlapping confidence intervals (Figure 17). The large confidence intervals were due to limited sample sizes. Data from below Bonneville Dam indicates an increasing trend of condition factor (Mann-Kendall τ = 0.27, P = 0.28), while Bonneville Reservoir suggests a decreasing trend in condition factor (Mann-Kendall τ = -0.14, P = 0.71). Trends in Walleye body condition over time from either reservoir were not significant.

During the 2020 DAF season, we were able to collect 885 Northern Pikeminnow diet samples from fish harvested from the angler accessible areas in the powerhouse tailraces of Bonneville Reservoir (fishing from The Dalles Dam) and The Dalles Reservoir (fishing from John Day Dam). These fish ranged in size from 230 to 544 mm FL in Bonneville Reservoir (mean = 378 mm; SE 3) and from 228 to 593 mm FL in The Dalles Reservoir (mean = 410 mm; SE 2). In both reservoirs, large proportions of the diets of Northern Pikeminnow examined contained food (Bonneville $\hat{p}$ = 0.69; The Dalles $\hat{p}$ = 0.70; Table 14). Fish were the most prevalent diet item from Bonneville ($\hat{p}$ = 0.49) and The Dalles ($\hat{p}$ = 0.48) reservoirs DAF samples, while other invertebrates not identified as crayfish were the second most abundant diet item in both reservoirs (Bonneville $\hat{p}$ = 0.26; The Dalles $\hat{p}$ = 0.39). A large proportion of the "other invertebrates" prey category consisted of non-native prawns and amphipods. In Bonneville Reservoir, the proportion of salmonids found in 2020 DAF diet samples ($\hat{p}$ = 0.16) is over double that of 2019 ($\hat{p}$ = 0.07), which was much less than the mean proportion for all other years ($\hat{p}$ = 0.13). In The Dalles Reservoir, the proportion of salmonids found in 2020 diet samples ($\hat{p}$ = 0.13) stayed roughly the same as the last few years and close to the mean proportion for the time series ($\hat{p}$ = 0.14). The proportions of the "other fishes" prey category in the diet of samples taken from Bonneville Reservoir in 2020 ($\hat{p}$ = 0.13) consisted of sculpin (Cottidae spp.), Smallmouth Bass and one unknown Centrarchidae, Northern Pikeminnow, Mountain Whitefish, catfish (Ictaluridae spp.), and unknown species (non-salmonid and unidentified). In The Dalles Reservoir, the "other fishes" proportions in diets for 2020 ($\hat{p}$ = 0.03) were down from 2019 ($\hat{p}$ = 0.06) and consisted of sculpin (Cottidae spp.) and unknown fishes species (non-salmonid and unidentified).

In Bonneville Reservoir, lampreys (Petromyzontidae spp.) were encountered in the greatest proportion of Northern Pikeminnow diet samples during week 21 ($\hat{p}$ = 0.79: Figure 18). The proportion of lampreys encountered dropped sharply during week 29 ($\hat{p}$ = 0.03), where it remained low through the rest of the DAF season. Salmon and steelhead were encountered in the greatest proportion of Northern Pikeminnow diet samples during week 21 ($\hat{p}$ = 0.50) and 27 ($\hat{p}$ = 0.24). Juvenile salmon and steelhead were not observed after week 31. American Shad in the diet were not encountered until week 32 in Bonneville Reservoir and remained a prevalent diet item, though sample sizes were low starting in week 34.

In The Dalles Reservoir, lampreys were encountered in the greatest proportion of Northern Pikeminnow diet samples during week 25 ($\hat{p}$ = 0.60), dropped off during week 29 ($\hat{p}$ = 0.18), and again during week 32 ($\hat{p}$ = 0.03), where it continued to remain low through the rest of the season. For salmon and steelhead, they were observed in the greatest proportion of Northern Pikeminnow diet samples during weeks 28 ($\hat{p}$ = 0.38) and 29 ($\hat{p}$ = 0.38). Salmonids were present in less than 10% of Northern Pikeminnow diet samples during weeks 21 and 32–41. In week 34, American Shad was the most frequent taxon observed in diet samples through the end of the season, with a peak in week 40 appearing in 94% of samples.

The weekly juvenile salmonid consumption index for Northern Pikeminnow removed from Bonneville Reservoir in 2021 was the greatest during weeks 27 and 29 (Figure 19). For The Dalles Reservoir, week 31 was the peak of the juvenile salmonid weekly consumption index. Due to COVID-19, daily smolt outmigration sampling data from Fish Passage Center were not consistent and we were unable to use data for any salmonid species/group. During week 27, biological evaluation also sampled Northern Pikeminnow diets in the tailrace of Bonneville Reservoir which resulted in a consumption index 0.69, compared to 3.15 observed in the diets of Northern Pikeminnow caught in the Dam Angling Fishery. While there are differences between the two capture methods and areas, these index values are vastly different.

PSD of Northern Pikeminnow captured in both Bonneville (W = 84, P = 0.001) and The Dalles (W = 66, P = 0.051) reservoirs during the DAF was significantly greater during the early years (1990–1996) of sampling than during the later years (2006–2020; Figure 20). The trends between the two reservoirs in later years appears to follow the same general shape with an uptick since 2018. Data could be cyclical in nature, however, we will continue monitoring these trends. There was no significant monotonic trend for *Wr* of either female (Mann-Kendall τ = -0.07, P = 0.77) or male (Mann-Kendall τ = -0.11, P = 0.62) Northern Pikeminnow captured in Bonneville Reservoir (Figure 21). Additionally, there was no significant *Wr* monotonic trend overtime for either female (Mann-Kendall τ = 0.12, P = 0.58) or male (Mann-Kendall τ = -0.01, P = 1.00) Northern Pikeminnow captured in The Dalles Reservoir (Figure 22).

DISCUSSION

The 2020 Sport Reward Fishery system wide exploitation rate of Northern Pikeminnow ≥ 250 mm FL was 17.8% and the 95% confidence bounds of the estimate were 8.5% to 27.1% (Table 4 and Figure 2). While the point estimate is within the management goal of 10-20% exploitation, the confidence interval is broad relative to prior year estimates and exceeds the targeted range. This wide confidence interval for the 2020 estimate is likely a reflection of the relatively low number of fish marked and recaptured this year, both repercussions of the travel restrictions associated with the coronavirus pandemic. Overall, SRF total harvest was one of the lowest on record (Report A), while the system wide exploitation estimate for all fish was above average (Table 2). This could be a result of the reduced sampling area which utilized targeted locations with known high catch rates for tagging efforts and was a consequence of the abbreviated season which resulted from the coronavirus pandemic. Alternatively, it could also reflect changes in the Northern Pikeminnow population (a smaller population overall), but we have little reason to suspect a substantial reduction in total population would have occurred between the 2019 and 2020 seasons. Another possibility is that fish marked with lock loop tags in prior years had a substantial post release mortality resulting from the large size of the tag relative to the body size of the fish and the highly invasive application (piercing the entire body), which would artificially decrease our prior exploitation estimates. We may be observing increased survival of fish marked with T-bar tags, but this will require additional years of observations to make any further conclusions. In the near future, we hope to explore alternative methods for estimating exploitation, such as the Brownie bird band recovery model which could make better use of information from Northern Pikeminnow tagged among years.

The targeted exploitation range of 10-20% has been shown to produce predation reduction values of up to 50% compared to pre-program levels via statistical modeling (Rieman and Beamesderfer 1990). Exploitation through the current year is expected to reduce predation on out migrating smolts in the following year. Modeled estimates for 2021 show a range of 12% to 46% with a median value of 34% predation reduction (Figure 3). The 2020 system-wide exploitation rate of Northern Pikeminnow ≥ 250 mm FL is the highest reported since 2010 (17.8%; Table 4). The exploitation estimate coupled with the estimated predation reduction value suggest that the removal program continues to be successful.

For the second year in a row we deployed an alternative tag type, the T-bar anchor tag, in addition to the traditional lock-loop tag that has been used since program inception. We achieved our goal of distributing these two tag types in approximately equal amounts in 2020 (408 lock-loop and 385 T-bar). Since reducing the minimum size of reward fish to 200mm FL in 2000, tag return rates for Northern Pikeminnow 200-249 mm FL have been low and our ability to estimate exploitation for this size class has been inconsistent (Table 3). At the same time, fish in this size range continue to be a substantial portion of the overall harvest (e.g. 37% of the total catch in 2019; Hone et al. 2020). Previously, we hypothesized that post-release mortality due to tagging injuries associated with the traditional lock loop tag could be a major factor in these observations, especially for 200–249 mm FL sized Northern Pikeminnow (Anderson et al. 2020). In 2020 we did not observe high numbers of tag returns or a subsequent high system wide exploitation rate for this size class as we did in 2019 and we were unable to produce an area specific estimate for all but Bonneville Reservoir (Table 3). Reduced tagging and harvest effort resulting from the 2020 coronavirus pandemic may be influencing these observations. However,

we found that 65% of the tag returns for Northern Pikeminnow 200- 249 mm FL in 2020 were initially marked with T-bar anchor tags and 85% of tag returns for this size class were marked with T-bar anchor tags in 2019. Similar to our conclusions last year (Anderson et al. 2020), the 2020 results imply a modest improved survival for smaller fish marked with the less invasive T-bar tag versus those marked with the lock loop tags. Observed tag loss of T-bar anchor tags with recaptures in the SRF was reduced from 65% in 2019 to 32% in 2020. While this change shows improvement in training protocols and optimized anatomical placement of the T-bar anchor tags, it is still much higher than 2020 loss rates for lock loop tags (3%). We intend to reevaluate the relative strengths and weaknesses of each tag type with more data and utilize both tag types in 2021.

The NPMP requires continued monitoring of the system-wide catch from the SRF and the DAF to evaluate the success of the ongoing removal efforts. From our biological evaluation, the primary indicator of a compensatory response is whether the level of predation changes within Northern Pikeminnow populations and how it compares with other fish predators of salmon and steelhead, particularly non-native Smallmouth Bass and Walleye. Changes in the abundance of the predator populations, their rates of consumption of juvenile salmonids, or both can influence changes in the predation index. If we observe changes in predation, we could describe potential explanatory mechanisms by variations in recruitment to reproductive or predatory size, condition factor of individuals, and changes in diet including prey composition and capacity (proportion full stomachs, distribution (and species) of fishes, and invertebrates consumed, etc.).

During our 2020 biological evaluation we were unable to sample during peak smolt outmigration in spring, but we were still able to effectively sample piscivorous fish below Bonneville Dam and in Bonneville Reservoir during subyearling Chinook Salmon outmigration later in the year (Figure 4). Although it was a shortened biological evaluation season, our total summer effort was similar to recent years as we had an additional boat sampling each day and a delayed water temperature increase in the Columbia River which allowed us to sample later into the year than normal. We reduced the number of sites sampled below Bonneville Dam to only the tailrace area, on the basis that catch rates at other sites were historically low (rkm 173-181, rkm 188-194) or only reliably produce Northern Pikeminnow (rkm 116-121; Carpenter et al. 2018). This selective sampling provided the opportunity to collect larger sample sizes at the remaining sites in hopes of meeting minimum sample size requirements for metrics such as our consumption index. This strategy was not completely successful as we still did not collect enough samples to calculate a consumption index and subsequent predation index for Northern Pikeminnow in the mid-reservoir area of Bonneville Reservoir (Table 9). However, this has occurred in 3 of the last 5 sampling events. Similarly, we were unable to calculate PSD or PSD-P for Walleye in either reservoir, though this has been an ongoing problem since monitoring began. Walleye catch rates are regularly low in these areas, suggesting low relative abundance. If the catchability of a given species is consistently low in a particular area, our ability to evaluate its predatory impact is necessarily constrained. We intend to continue to adaptively manage our sampling and optimize our ability to effectively monitor these populations of piscivorous fishes as our research continues. This is especially imperative given recent external constraints such as flat funding and the need to reduce take associated with electrofishing or eliminate electrofishing as stated in the 2020 CRS Biological Opinion (NMFS 2020).

There is little indication from our data to suggest that remaining Northern Pikeminnow below Bonneville Dam and in Bonneville Reservoir exhibit a compensatory response to the targeted removals of Northern Pikeminnow via the SRF and DAF. Across the time series, Northern Pikeminnow consumption index values have varied but do not show a consistent increasing trend, indicating that rates of salmonid consumption have not increased over time (Table 9). In addition, we observed little change in relative weight across the time series for both sexes in both locations (Figures 14-15). While male Northern Pikeminnow below Bonneville Dam do show a statistically significant increasing trend, the 2020 data point is lower than recent prior observations, which supports the need for continued monitoring. Northern Pikeminnow 2020 abundance indices are generally lower than baseline 1990 values (Table 5), suggesting that the project has been successful in keeping the population suppressed, with the exception of Bonneville tailrace where the abundance index increased relative to the baseline level. Coincidentally, this location also had the highest 2020 consumption index (Table 9) and therefore predation index value as well (Table 10). This could indicate localized groups of Northern Pikeminnow can have greater impacts on salmon and steelhead smolt survival than the population overall. Similarly, Carpenter et al. (2019) hypothesized that localized predation hot spots may occur for other predatory fishes such as Smallmouth Bass.

While our 2020 Northern Pikeminnow abundance index values signify successful population suppression in most areas, the proportional size distribution for these populations have not demonstrated monotonic decreases over time below Bonneville Dam or in Bonneville Reservoir (Figures 8, 11). These data indicate that though we have maintained a targeted removal fishery, the fishery has not restructured the size distribution of the population of Northern Pikeminnow via removal of the very largest fish in these locations as intended. However, when looking at the fishery evaluation data, we observed a significant monotonic decrease for PSD in McNary Reservoir (Figure 8), implying that the NPMP may have different effects in each reservoir.

In contrast to Northern Pikeminnow, abundance index values of Smallmouth Bass have generally increased since 1990, with large peaks documented in 2017 (Table 6). The 2020 observations continue to be above average for all sites, indicating that the population size remains at elevated levels. Changes in the Smallmouth Bass consumption index over time do not signal consistent increasing trends across areas (Table 11). This implies that Smallmouth Bass diets are not shifting to more salmonids in response to Northern Pikeminnow removals. However, within each reservoir sampled during 2020, salmonids were observed more frequently in the diets of Smallmouth Bass than Northern Pikeminnow (Figure 7). Thus, it seems that this species has the potential to consume as many salmonids as Northern Pikeminnow, if not more, especially when the size of their population is considered. Therefore, regardless of changes in consumption, the observed large increases in abundance suggests that the predatory impact of this species has increased substantially since the program began. Accordingly, we observed relatively high predation index values for Smallmouth Bass in 2020, with the exception of Bonneville tailrace (Table 12). Notably, the highest predation index value comes from the Bonneville mid-reservoir area which had one of the lower consumption index values, but also the highest abundance index value for 2020. Thus, in this instance, the relative predatory impact appears to be driven primarily by species abundance.

Our dataset did not detect notable trends in the size distributions (Figures 12 and 13) or body condition (Figure 16) of Smallmouth Bass, indicating that at the reservoir level, some population

characteristics have not changed over time in the lower Columbia River. While we did not observe consistent changes over time, we have regularly documented lower median relative weight for Smallmouth Bass in Bonneville Reservoir versus below Bonneville Dam (Figure 16). The lower relative weight in Bonneville Reservoir may result from factors such as lower levels of quality habitat or lower prey availability. Our anecdotal experience is that Bonneville Reservoir contains more favorable Smallmouth Bass habitat than below Bonneville Dam which may also be reflected by higher catch rates in Bonneville Reservoir. These results combined could suggest that high abundance and intra-specific competition may be limiting the body condition of Smallmouth Bass in Bonneville Reservoir.

Walleye populations in Bonneville Reservoir and below Bonneville Dam seem to have experienced little change in abundance since the study began in 1990, with the exception of the Bonneville Reservoir tailrace area (Table 7). Median W_r for Walleye in Bonneville Reservoir and below Bonneville Dam, showed diverging trend lines, neither of which is statistically significant (Figure 17). Large error bars can be attributed to small sample sizes of Walleye collected during sampling. For any given sampling event where the number of fish was fewer than five, the data points were removed from the time series. We were unable to evaluate size distribution (PSD and PSD-P) as a result of low sample sizes during 2020 biological evaluation. Of the three predators, salmonids were found most frequently in the diets of Walleye in the tailrace below Bonneville Dam (Figure 7). However, based on their low abundance they likely pose a lower threat to salmonid populations compared to the other predators monitored in this stretch of the Columbia River. Looking at data collected during fishery evaluation, we found no change in proportional size distribution of Walleye in McNary Reservoir (Figure 9), but a significant monotonic decrease over time in the larger, preferred-size fish (PSD-P) was observed (Figure 10). While the recreational Walleye fishery appears to have generally restructured the size distribution of Walleye towards smaller fish, fishing pressure or environmental factors may have significantly decreased the amount of the biggest preferred size Walleye (≥ 481 mm FL) from the population over time.

As evidenced by minimal catch of tagged Northern Pikeminnow in the Dam Angling Fishery (1 out of 324 new 2020 tags deployed in Bonneville Reservoir), these fish appear to be isolated from those available to recreational anglers participating in the Sport Reward Fishery. As we have noted in previous years, diets of Northern Pikeminnow taken in the DAF are dominated by salmonids and lampreys early in the season, followed by American Shad later in the summer through early fall (Figure 18), suggesting their diets are influenced largely by prey availability. We were unable to compare our diet data to salmonid passage index data collected by the Fish Passage Center from John Day Dam due to coronavirus related sampling constraints, however, we likely sampled during the majority of the yearling salmon and part of the subyearling Chinook Salmon out-migration based on data from Bonneville Dam (Figure 4). We observed variable weekly consumption index values from both reservoirs in 2021 (Figure 19), and assume patterns are generally consistent with the timing of smolt out-migration pulses through John Day and The Dalles dams. Monitoring the diets of fish caught at the dam provide an opportunity to characterize within year changes in diet that would not be possible under our current biological evaluation sampling methods and funding structure.

The group of Northern Pikeminnow removed in the Dam Angling Fishery appear to be feeding regularly (69-70% of diets contained food), with around 50% of diets containing fish (Table 14).

In contrast, 16% of Northern Pikeminnow diets from biological evaluation contained fish (Table 8). However, Northern Pikeminnow caught via hook-and-line, such as with the Dam Angling Fishery, are probably actively feeding and could be more likely to contain prey fish. With food apparently abundant near the dams in Bonneville and The Dalles reservoirs, it seems that the Northern Pikeminnow populations are experiencing little change based on their size distribution (Figure 20) and relative weight (Figures 21-22). The fishery was successful in restructuring the population to smaller fish early on and data since 2006 show the population may have reached equilibrium although there are recent increasing trends in both reservoirs (Figure 20). Our data suggest a generally consistent relative weight for both sexes in both locations (Figures 21-22). We observed females having greater relative weight than males, which we also observed with biological evaluation data. Northern Pikeminnow spawn when water temperatures reach approximately 65 degrees F, which is usually in mid to late June and they will continue to spawn into early July. As we were sampling the Dam Angling Fishery before and well after the spawning window, the influence of stage of maturity on fish weight was likely negligible and probably averaged-out over the year.

Brown and Moyle (1981) found that Northern Pikeminnow only appear to be significant predators of salmonids in unusual or altered circumstances. The Columbia and lower Snake rivers contain such habitats as a result of the hydropower dams, which create environments that are favorable for salmonid predation (e.g. Poe et al. 1991). Indeed, the Northern Pikeminnow consumption index values observed in 2020 were highest in the two tailraces areas where they have often been throughout the time series (Table 9). Further, a study of Northern Pikeminnow on free-flowing sections of the Willamette River found only 2% of diets contained salmonids (Buchanan et al. 1981) while observations in dammed sections of the Columbia River have reached 34% (Poe et al. 1991). During the same week in 2020 (week 27), we observed a much higher consumption index value for Northern Pikeminnow caught in the Dam Angling Fishery at the Dalles Dam (3.0) and in close proximity to the dam versus those captured during biological evaluation further down river in the tailrace area (0.69). Similarly, we found lamprey in 1% of Northern Pikeminnow diets during the 2020 biological evaluation in Bonneville Reservoir (Table 8) but observed lamprey in 26% of the dam angling diets taken from The Dalles Dam tailrace area in Bonneville Reservoir (Table 14). Thus, Northern Pikeminnow predation on salmonids and other species of concern, such as lamprey, appear highest in close proximity to the dams.

The results observed and conclusions drawn herein are undoubtedly influenced by the timing and location of our sampling, which is an inherent limitation of our data. Our weekly observations of Northern Pikeminnow diets captured in the Dam Angling Fishery indicate how variable diet content can be on a weekly basis and how diet contents change over the course of a year (Figure 18). Our diet data from fish captured during biological evaluation are likely strongly influenced by the timing of the sampling, especially as it relates to smolt out migration and given the brief sampling period. Thus, predation rates on juvenile salmonids likely reflect the relative abundance of smolt compared to other prey items as Northern Pikeminnow are known to be opportunistic feeders on the most abundant and easy to capture prey (Buchanan et al. 1981). Such variables could make it difficult to distinguish the true factors contributing to observed inter-annual differences in consumption.

Our current rapid assessment methods provide brief snap shots of the predatory fish communities in time and space. Nonetheless, they are cost effective and useful monitoring tools as we have

detected potential Northern Pikeminnow predation hot spots and noted continued high abundance of Smallmouth Bass in Bonneville Reservoir and below Bonneville Dam. There are indeed many factors that influence the predatory impact of piscivorous fishes on ESA listed salmonids. As we continue to adapt our methods of research, we hope to determine the most influential drivers of predation in our ongoing effort to improve the evaluation of the Northern Pikeminnow Management Program and help ensure its most effective implementation.

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TABLES

Table 1. Numbers of Northern Pikeminnow marked and recaptured[a] in the Sport Reward Fishery during 2020 by location and size class.

	200–249 mm FL		≥ 250 mm FL		Combined	
Reach/Reservoir	Marked	Recaptured	Marked	Recaptured	Marked	Recaptured
Below Bonneville	41	3	258	31	299	34
Bonneville	210	16	114	11	324	27
McNary	29	1	26	2	55	3
Little Goose	13	3	15	1	28	4
Lower Granite	68	3	19	1	87	4
Combined	361	26	432	46	793	72

[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). In 2020 this included 2 fish from below Bonneville Dam, 1 from Bonneville Reservoir, and 1 from Lower Granite Reservoir.

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

Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	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
mean (SE)	13.9 (0.9)	10.3 (0.6)	14.2 (3.5)	*b*	11.8 (1.3)	14.8 (2.7)	13.1 (4.1)	13 (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 3. 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	Ice Harbor	Little Goose	Lower Granite	All areas
2000	9.7	4.1	*a*	*a*	*a*	—	*a*	*a*	6.6
2001	*a*	*a*	*a*	*a*	*a*	—	—	*a*	10.6
2002	3.1	*a*	*a*	*a*	*a*	—	—	*a*	3.4
2003	*a*	*a*	*a*	*a*	*a*	—	—	*a*	*a*
2004	*a*	13.5	*a*	*a*	*a*	—	—	*a*	10.9
2005	*a*	*a*	*a*	*a*	*a*	—	—	*a*	*a*
2006	9.6	6.7	*a*	*a*	*a*	—	17.4	*a*	9.9
2007	*a*	*a*	*a*	*a*	*a*	—	*a*	*a*	*a*
2008	4.6	5.8	10.5	*a*	4.9	—	4.8	1.3	5.7
2009	*a*	*a*	*a*	*a*	*a*	—	5.6	*a*	1.8
2010	*a*	*a*	*a*	*a*	12.4	—	*a*	*a*	7.6
2011	17.9	*a*	*a*	*a*	11.0	—	*a*	*a*	9.8
2012	7.8	5.8	*a*	*a*	4.5	—	*a*	*a*	6.0
2013	6.7	10.1	*a*	*a*	5.8	—	*a*	*a*	7.7
2014	3.0	*a*	*a*	*a*	3.7	—	11.0	*a*	5.3
2015	*a*	*a*	*a*	*a*	*a*	—	*a*	10.6	4.5
2016	1.6	3.8	*a*	*a*	*a*	—	4.8	2.8	2.8
2017	*a*	10.4	*a*	*a*	7.3	*a*	10.6	*a*	8.7
2018	3.5	*a*	*a*	*a*	10.6	*a*	*a*	*a*	4.5
2019	11.7	21.1	*a*	*a*	13.0	*a*	29.9	9.9	19.4
2020	*a*	7.9	—	—	*a*	—	*a*	*a*	8.4
mean (SE)	7.2 (1.5)	8.9 (1.7)	*b*	*b*	8.1 (1.2)	*b*	12 (3.4)	6.2 (2.4)	7.4 (1.0)

Note: *a* = no exploitation calculated ($n \leq 3$), dashes (—) = no sampling conducted, *b* = no mean exploitation calculated ($n \leq 2$). Sport Reward Fishery regulations changed in 2000 to allow angler retention of Northern Pikeminnow ≥ 200 mm FL. During prior years (1991–1999), Sport Reward Fishery retention was limited to Northern Pikeminnow ≥ 250 mm FL.

Table 4. Time series of annual exploitation rates (%) of Northern Pikeminnow (≥ 250 mm) in the Sport Reward Fishery by location. Mean and SE were calculated for each location across the time series.

Year	Below Bonneville	Bonneville	The Dalles	John Day	McNary	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
mean (SE)	14 (0.8)	10.1 (0.8)	14.2 (1.8)	3.1 (0.2)	14.9 (1.3)	13.4 (3.2)	14 (1.2)	14 (0.6)

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

Table 5. Summer abundance index values (mean catch per 900-s boat electrofishing per surface area [ha] divided by 1,000; and SE) for Northern Pikeminnow (≥ 250 mm FL) below Bonneville Dam and in Bonneville Reservoir, 1990–2020. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

Season,	Below Bonneville Dam	Bonneville Reservoir		
Year	TR	FB	Mid	TR
Summer,				
1990	7.18 (2.64)	2.40 (0.40)	10.96 (2.17)	0.14 (0.08)
1991	7.85 (2.46)	0.47 (0.18)	11.01 (4.07)	0.94 (0.42)
1992	3.01 (1.05)	—	—	—
1993	8.01 (2.93)	1.66 (0.44)	9.02 (3.58)	0.56 (0.23)
1994	2.31 (0.73)	1.68 (0.40)	3.61 (0.89)	0.29 (0.16)
1995	1.09 (0.45)	2.09 (0.47)	5.38 (2.20)	1.26 (0.40)
1996	3.07 (1.53)	1.00 (0.29)	4.45 (1.49)	0.46 (0.18)
1999	3.57 (1.09)	1.05 (0.25)	1.56 (0.57)	0.88 (0.31)
2004	2.11 (0.88)	—	2.27 (0.94)	1.30 (0.48)
2005	0.56 (0.18)	0.62 (0.27)	1.25 (0.52)	0.16 (0.06)
2008	1.16 (0.33)	0.07 (0.04)	0.30 (0.21)	0.08 (0.05)
2011	1.72 (0.43)	0.18 (0.07)	1.05 (0.43)	0.39 (0.21)
2014	—	—	—	—
2017	1.33 (0.26)	0.35 (0.10)	3.05 (1.08)	0.20 (0.10)
2020	0.58 (0.17)	0.48 (0.21)	0.65 (0.30)	0.92 (0.47)
mean (SE)	3.11 (0.71)	1.00 (0.23)	4.20 (1.06)	0.59 (0.12)

Note: dashes (—) = no sampling conducted.

Table 6. Summer abundance index values (mean catch per 900-s boat electrofishing per surface area [ha] divided by 1,000; and SE) for Smallmouth Bass (≥ 200 mm FL) below Bonneville Dam and in Bonneville Reservoir, 1990–2020. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

Season,	Below Bonneville Dam	Bonneville Reservoir		
Year	TR	FB	Mid	TR
Summer				
1990	0.12 (0.08)	0.18 (0.13)	2.88 (1.61)	0.72 (0.26)
1991	0.45 (0.32)	0.00 (0.00)	3.42 (1.39)	1.68 (0.31)
1992	0.50 (0.16)	—	—	—
1993	0.30 (0.21)	0.31 (0.15)	5.41 (1.80)	1.68 (0.39)
1994	0.38 (0.20)	0.20 (0.09)	4.81 (1.16)	1.38 (0.19)
1995	0.79 (0.33)	0.25 (0.07)	2.50 (0.89)	1.86 (0.25)
1996	0.47 (0.27)	0.22 (0.10)	3.61 (1.23)	0.63 (0.17)
1999	0.60 (0.28)	0.65 (0.16)	3.31 (0.87)	1.78 (0.32)
2004	0.40 (0.18)	—	11.55 (3.23)	1.60 (0.27)
2005	0.53 (0.18)	1.14 (0.28)	12.53 (2.53)	0.64 (0.13)
2008	0.42 (0.15)	1.64 (0.43)	13.82 (2.31)	2.36 (0.34)
2011	0.64 (0.19)	1.43 (0.32)	22.23 (3.46)	2.87 (0.36)
2014	—	—	—	—
2017	1.54 (0.37)	3.06 (0.55)	55.31 (7.11)	3.87 (0.54)
2020	0.92 (0.23)	2.58 (0.59)	15.77 (2.23)	3.21 (0.77)
mean (SE)	0.58 (0.09)	0.97 (0.29)	12.09 (3.99)	1.87 (0.28)

Note: dashes (—) = no sampling conducted.

Table 7. Summer abundance index values (mean catch per 900-s boat electrofishing per surface area [ha] divided by 1,000; and SE) for Walleye (≥ 200 mm FL) below Bonneville Dam and in Bonneville Reservoir, 1990–2020. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

Season,	Below Bonneville Dam	Bonneville Reservoir		
Year	TR	FB	Mid	TR
Summer				
1990	0.18 (0.18)	0.00 (0.00)	0.29 (0.29)	0.05 (0.05)
1991	0.08 (0.08)	0.00 (0.00)	0.00 (0.00)	0.09 (0.09)
1992	0.03 (0.03)	—	—	—
1993	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
1994	0.35 (0.21)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
1995	0.30 (0.21)	0.00 (0.00)	0.51 (0.51)	0.08 (0.04)
1996	0.23 (0.16)	0.00 (0.00)	0.64 (0.36)	0.06 (0.04)
1999	0.14 (0.08)	0.00 (0.00)	0.19 (0.19)	0.06 (0.04)
2004	0.07 (0.07)	—	0.69 (0.69)	0.02 (0.02)
2005	0.00 (0.00)	0.00 (0.00)	0.16 (0.16)	0.00 (0.00)
2008	0.11 (0.07)	0.00 (0.00)	0.15 (0.15)	0.00 (0.00)
2011	0.11 (0.06)	0.00 (0.00)	0.30 (0.21)	0.02 (0.02)
2014	—	—	—	—
2017	0.29 (0.13)	0.00 (0.00)	0.89 (0.46)	0.00 (0.00)
2020	0.14 (0.06)	0.00 (0.00)	0.21 (0.15)	0.21 (0.14)
mean (SE)	0.14 (0.03)	0.00 (0.00)	0.31 (0.08)	0.04 (0.02)

Note: dashes (—) = no sampling conducted

Table 8. Number (n) of Northern Pikeminnow, Smallmouth Bass, and Walleye (≥ 200 mm FL) diets examined during biological evaluation below Bonneville Dam and in Bonneville Reservoir during summer 2020 and proportion of samples containing specific prey items (cray = crayfish, crust = all crustacea not identified as crayfish, sal = salmon or steelhead, lam = lamprey).

Season,	Northern Pikeminnow								Smallmouth Bass								Walleye							
Area	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{crust}$	$\hat{p}_{insect}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{crust}$	$\hat{p}_{insect}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$	n	$\hat{p}_{food}$	$\hat{p}_{fish}$	$\hat{p}_{cray}$	$\hat{p}_{crust}$	$\hat{p}_{insect}$	$\hat{p}_{sal}$	$\hat{p}_{lam}$
Summer																								
Below Bonneville Dam	28	0.68	0.21	0.39	0.07	0.07	0.04	0.00	43	0.93	0.81	0.37	0.44	0.49	0.07	0.02	6	1.00	1.00	0.00	0.33	0.17	0.33	0.00
Bonneville	96	0.71	0.15	0.35	0.08	0.10	0.02	0.01	332	0.96	0.30	0.76	0.32	0.19	0.04	0.00	5	0.80	0.60	0.20	0.20	0.40	0.00	0.00
All	124	0.70	0.16	0.36	0.08	0.10	0.02	0.01	375	0.96	0.36	0.71	0.33	0.22	0.05	0.01	11	0.91	0.82	0.09	0.27	0.27	0.18	0.00

Table 9. Annual summer consumption index values for Northern Pikeminnow (≥ 250 mm FL) captured during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

Season,	Below Bonneville Dam	Bonneville Reservoir		
Year	TR	FB	Mid	TR
Summer,				
1990	0.54	1.68	0.00	0.67
1991	—	—	—	—
1992	2.89	—	—	—
1993	—	0.36	0.00	0.27
1994	0.55	0.14	0.00	2.70
1995	1.25	0.00	0.00	0.92
1996	0.60	0.00	0.00	0.00
1999	0.24	0.00	0.00	0.30
2004	0.20	—	0.00	1.07
2005	0.00	0.00	*a*	*a*
2008	0.25	*a*	*a*	*a*
2011	0.32	0.00	0.00	0.84
2014	—	—	—	—
2017	0.23	0.32	0.00	0.00
2020	0.21	0.00	*a*	0.69
mean (SE)	0.61 (0.23)	0.25 (0.16)	0.00 (0.00)	0.75 (0.25)

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

Table 10. Annual summer predation index values for Northern Pikeminnow (≥ 250 mm FL) captured during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

Season,	Below Bonneville Dam	Bonneville Reservoir		
Year	TR	FB	Mid	TR
Summer,				
1990	3.90	4.04	0.00	0.10
1991	—	—	—	—
1992	8.69	—	—	—
1993	—	0.60	0.00	0.15
1994	1.27	0.24	0.00	0.78
1995	1.36	0.00	0.00	1.16
1996	1.83	0.00	0.00	0.00
1999	0.85	0.00	0.00	0.26
2004	0.42	—	0.00	1.40
2005	0.00	0.00	*a*	*a*
2008	0.29	*a*	*a*	*a*
2011	0.55	0.00	0.00	0.33
2014	—	—	—	—
2017	0.31	0.11	0.00	0.00
2020	0.12	0.00	*a*	0.63
mean (SE)	1.63 (0.71)	0.50 (0.40)	0.00 (0.00)	0.48 (0.16)

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

Table 11. Annual summer consumption index values for Smallmouth Bass (≥ 200 mm FL) captured during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

Season,	Below Bonneville Dam	Bonneville Reservoir		
Year	TR	FB	Mid	TR
Summer,				
1990	*a*	*a*	*a*	*a*
1991	—	—	—	—
1992	*a*	—	—	—
1993	—	*a*	0.00	0.00
1994	0.00	0.39	0.00	0.04
1995	0.00	0.00	0.00	0.03
1996	0.00	0.00	0.00	0.00
1999	0.00	0.12	0.00	0.00
2004	*a*	—	0.00	0.00
2005	0.09	0.17	0.08	0.09
2008	0.10	0.10	0.13	0.03
2011	0.10	0.11	0.05	0.00
2014	—	—	—	—
2017	0.35	0.04	0.04	0.02
2020	0.21	0.14	0.08	0.00
mean (SE)	0.09 (0.04)	0.12 (0.04)	0.04 (0.01)	0.02 (0.01)

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

Table 12. Annual summer predation index values for Smallmouth Bass (≥ 200 mm FL) captured during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Mean and SE were calculated for each location across the time series. FB = forebay, Mid = mid-reservoir, and TR = tailrace.

Season,	Below Bonneville Dam	Bonneville Reservoir		
Year	TR	FB	Mid	TR
Summer,				
1990	*a*	*a*	*a*	*a*
1991	—	—	—	—
1992	*a*	—	—	—
1993	—	*a*	0.00	0.00
1994	0.00	0.08	0.00	0.05
1995	0.00	0.00	0.00	0.05
1996	0.00	0.00	0.00	0.00
1999	0.00	0.08	0.00	0.00
2004	*a*	—	0.00	0.00
2005	0.05	0.19	1.04	0.05
2008	0.04	0.17	1.86	0.07
2011	0.06	0.15	1.16	0.00
2014	—	—	—	—
2017	0.54	0.12	2.33	0.07
2020	0.19	0.37	1.32	0.00
mean (SE)	0.10 (0.06)	0.13 (0.04)	0.70 (0.26)	0.03 (0.01)

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

Table 13. Number of stock-length (n_s) Smallmouth Bass, proportional size distribution (PSD, %), and proportional size distribution of preferred-length fish (PSD – P, %) collected during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Mean and SE were calculated across the time series.

	Below Bonneville Dam			Bonneville Reservoir		
Year	n_s	PSD (%)	PSD-P (%)	n_s	PSD (%)	PSD-P (%)
1990	3	*a*	*a*	95	46	18
1991	8	*a*	*a*	63	44	14
1992	93	30	8	—	—	—
1993	3	*a*	*a*	113	36	13
1994	84	48	42	225	53	17
1995	143	50	18	257	37	12
1996	58	40	9	231	66	16
1999	42	60	17	195	56	16
2004	110	39	6	193	53	21
2005	116	28	3	284	55	27
2008	201	29	5	502	53	17
2011	80	40	4	547	59	27
2014	12	*a*	*a*	172	54	22
2017	80	29	10	876	57	15
2020	43	30	9	333	54	26
mean (SE)	72 (15)	38 (3)	12 (3)	292 (58)	52 (2)	19 (1)

Note: *a* = no PSD or PSD – P value calculated (n_s < 20), dashes (—) = no sampling conducted.

Table 14. 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
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

FIGURES

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

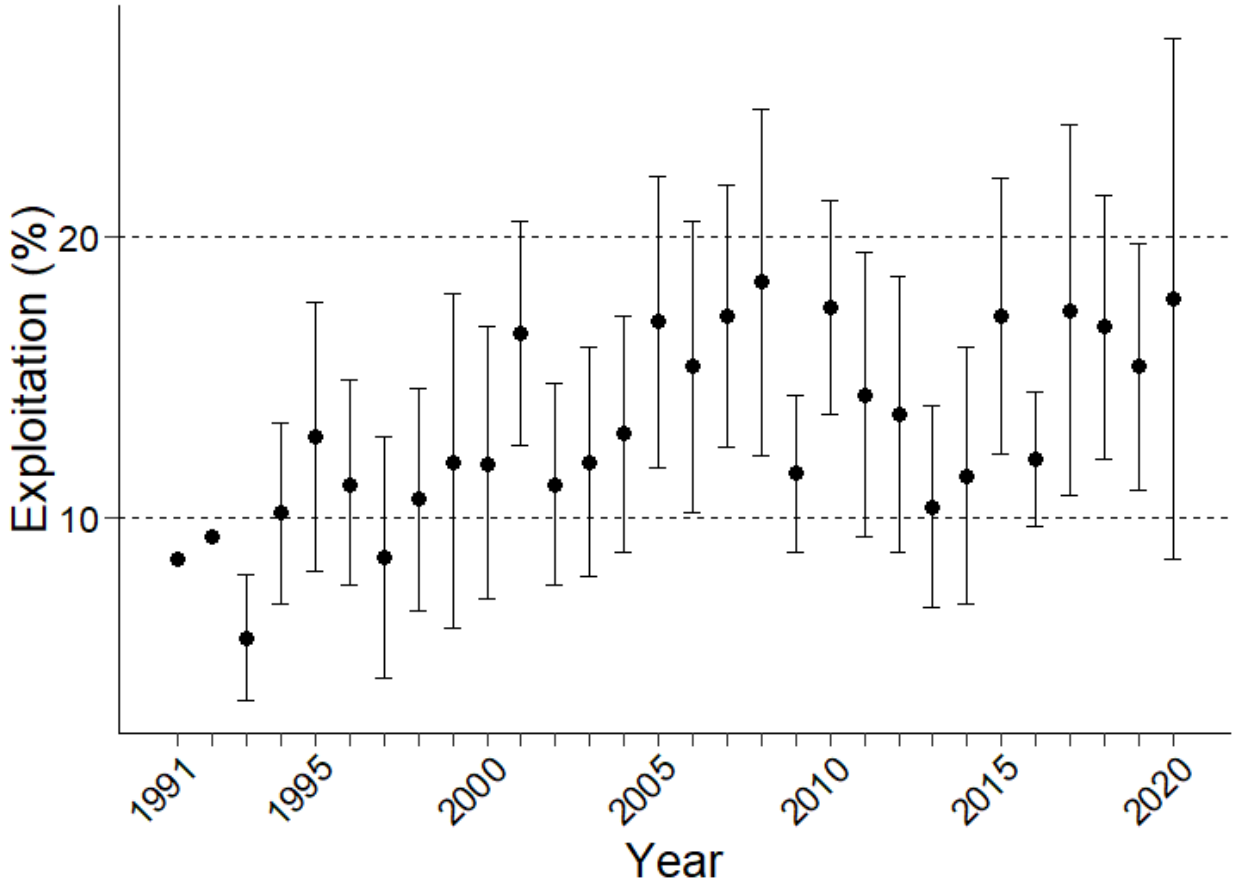

Figure 2. System-wide exploitation rates of Northern Pikeminnow (≥ 250 mm FL) in the Sport Reward Fishery, 1991–2020. Error bars represent 95% confidence intervals, though variation was not estimated for the years 1991–1992. Target exploitation is 10–20% (dashed lines).

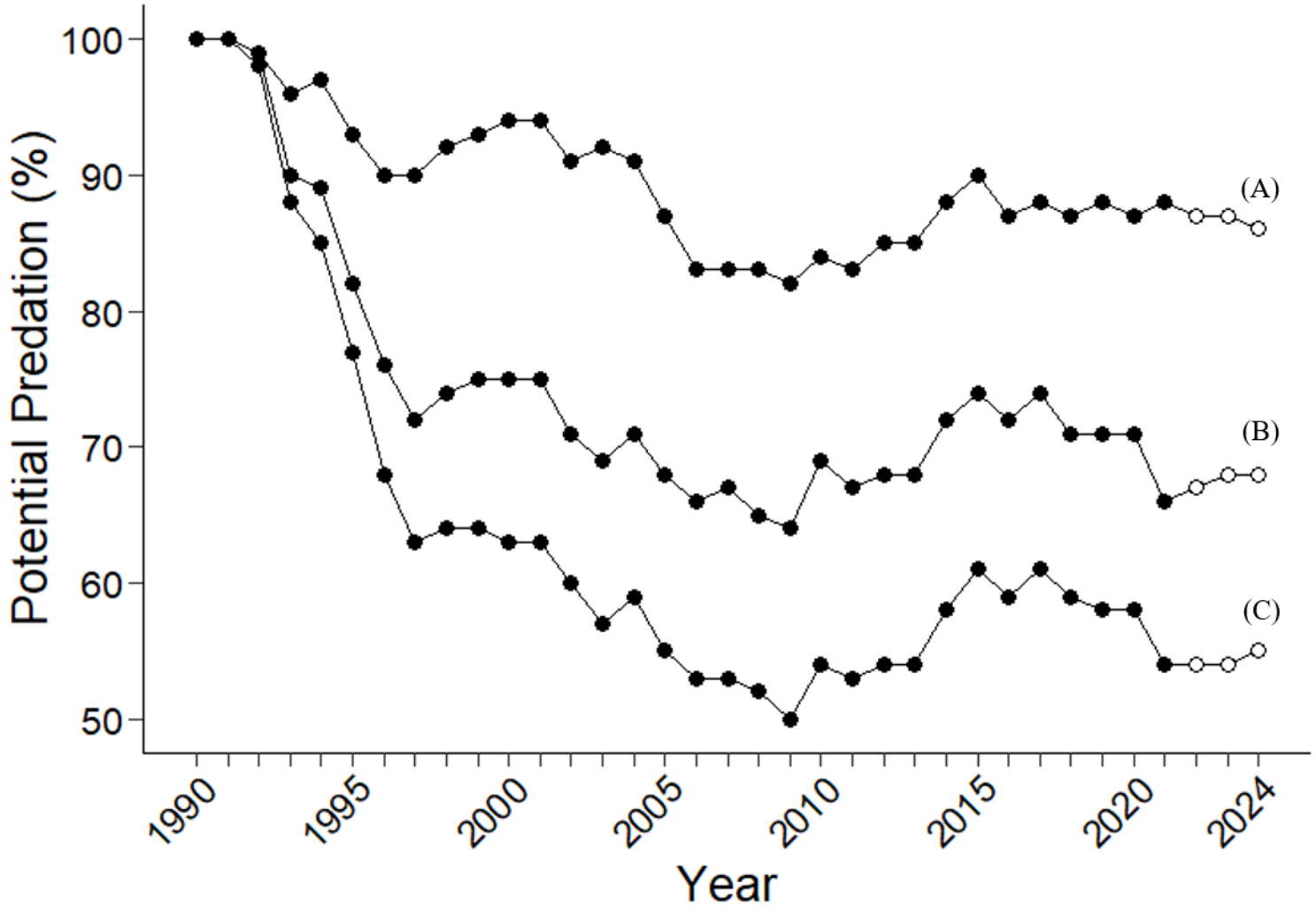

Figure 3. Estimates of (A) maximum, (B) median, and (C) minimum annual levels of potential predation by Northern Pikeminnow on juvenile salmon relative to predation levels before implementation of the Northern Pikeminnow Management Program. For the years 1991–2021, model estimates (filled circles) are based on exploitation rates from the previous year. Model forecast predictions after 2021 (open circles) are based on average exploitation estimates from years with similar fishery structure (2001, 2004–2020).

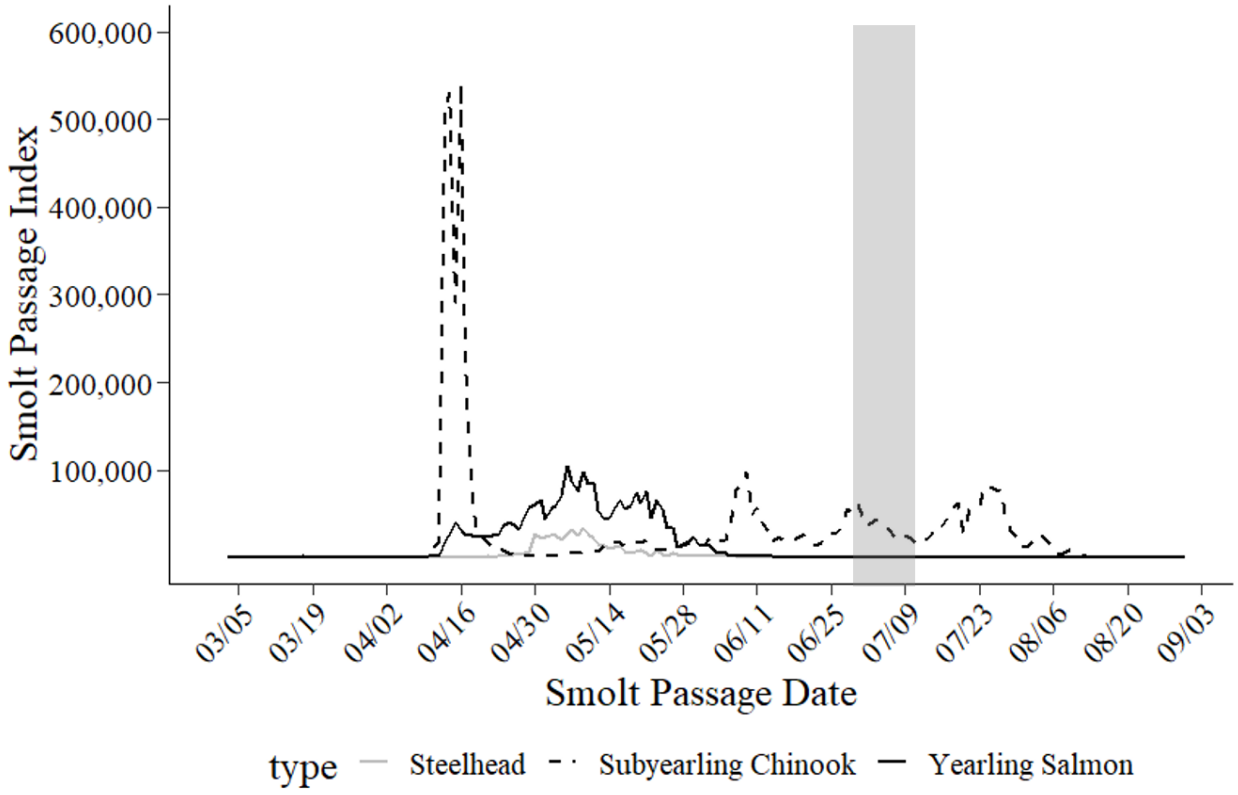

Figure 4. Period of biological evaluation (vertical bar) below Bonneville Dam and in Bonneville Reservoir and juvenile salmon and steelhead daily passage index through Bonneville Dam, March–September 2020 (Source: Fish Passage Center, unpublished data).

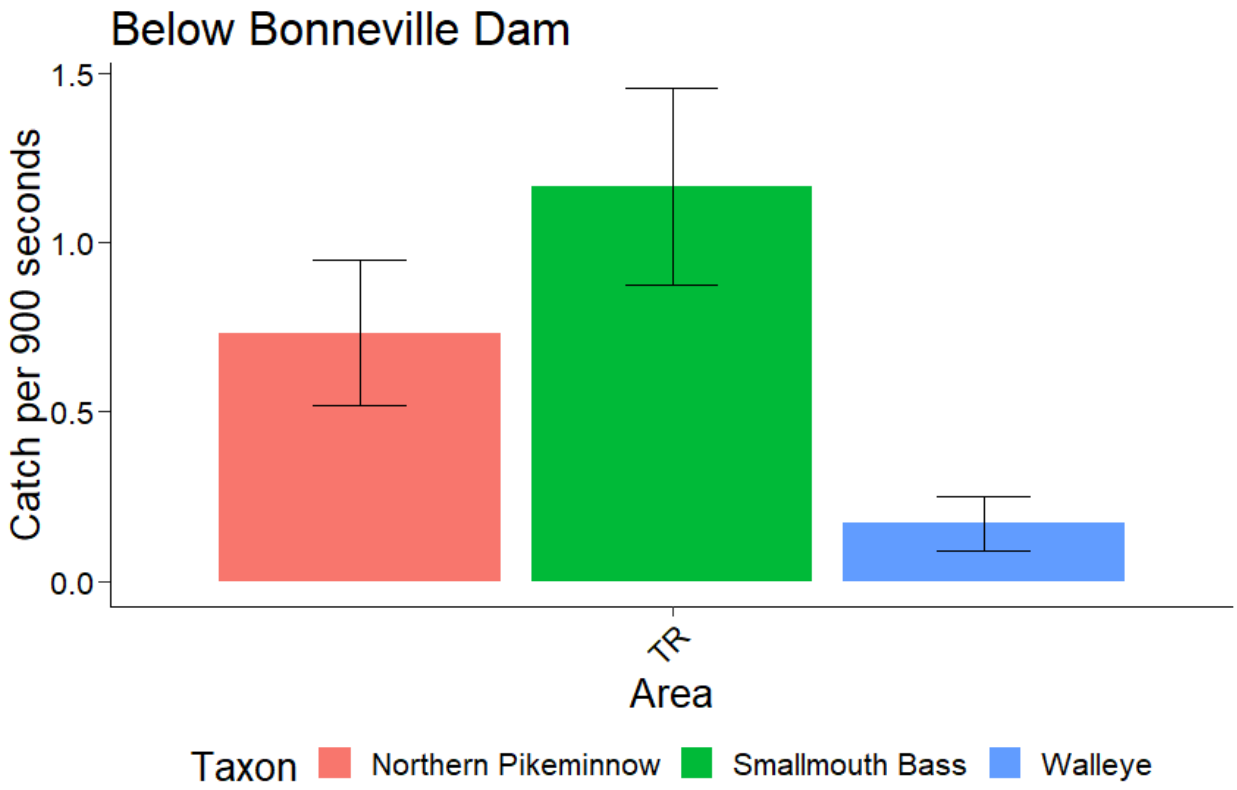

Figure 5. Mean catch per 900-s boat electrofishing (CPUE; and SE) of Northern Pikeminnow (≥ 250 mm FL), Smallmouth Bass (≥ 200 mm FL), and Walleye (≥ 200 mm FL) that were captured during biological evaluation below Bonneville Dam during summer 2020. TR = tailrace.

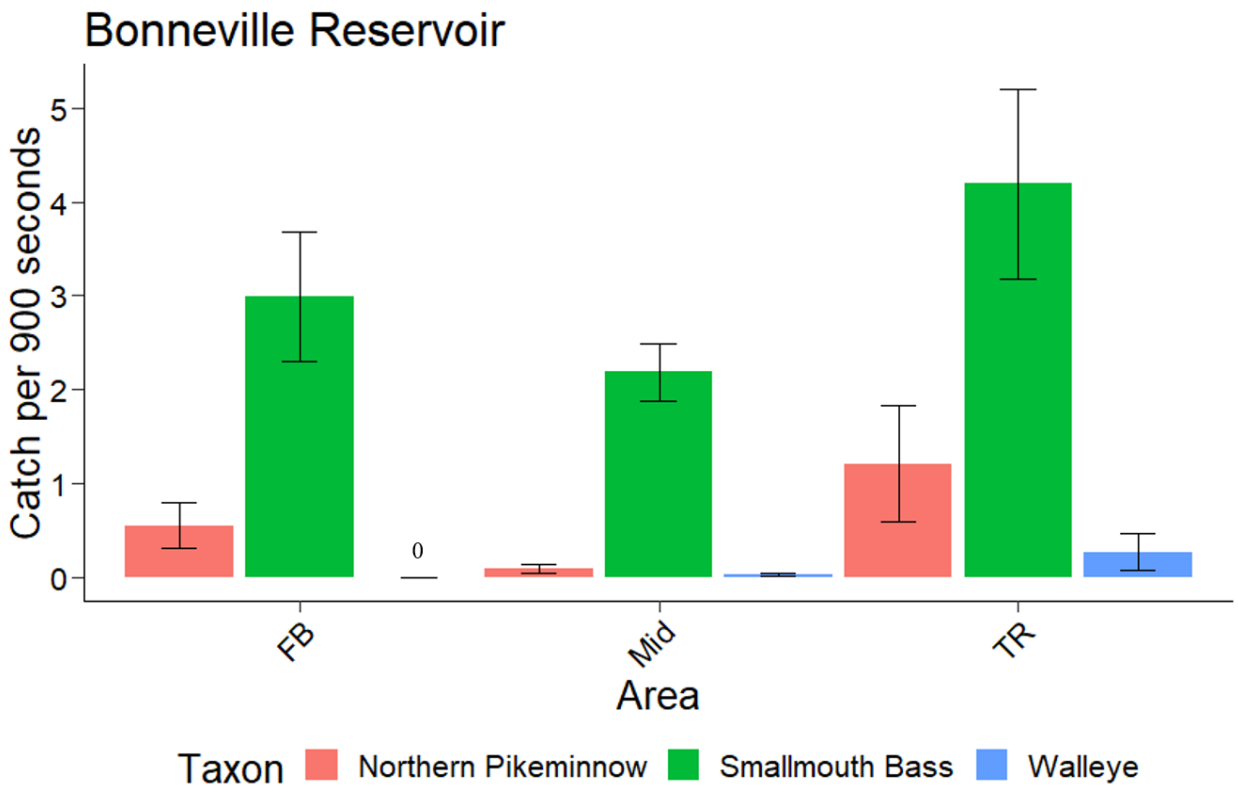

Figure 6. Mean catch per 900-s boat electrofishing (CPUE; and SE) of Northern Pikeminnow (≥ 250 mm FL), Smallmouth Bass (≥ 200 mm FL), and Walleye (≥ 200 mm FL) that were captured during biological evaluation in Bonneville Reservoir during summer 2020. FB = forebay, Mid = mid-reservoir, and TR = tailrace. Number above the x-axis represents the sample size.

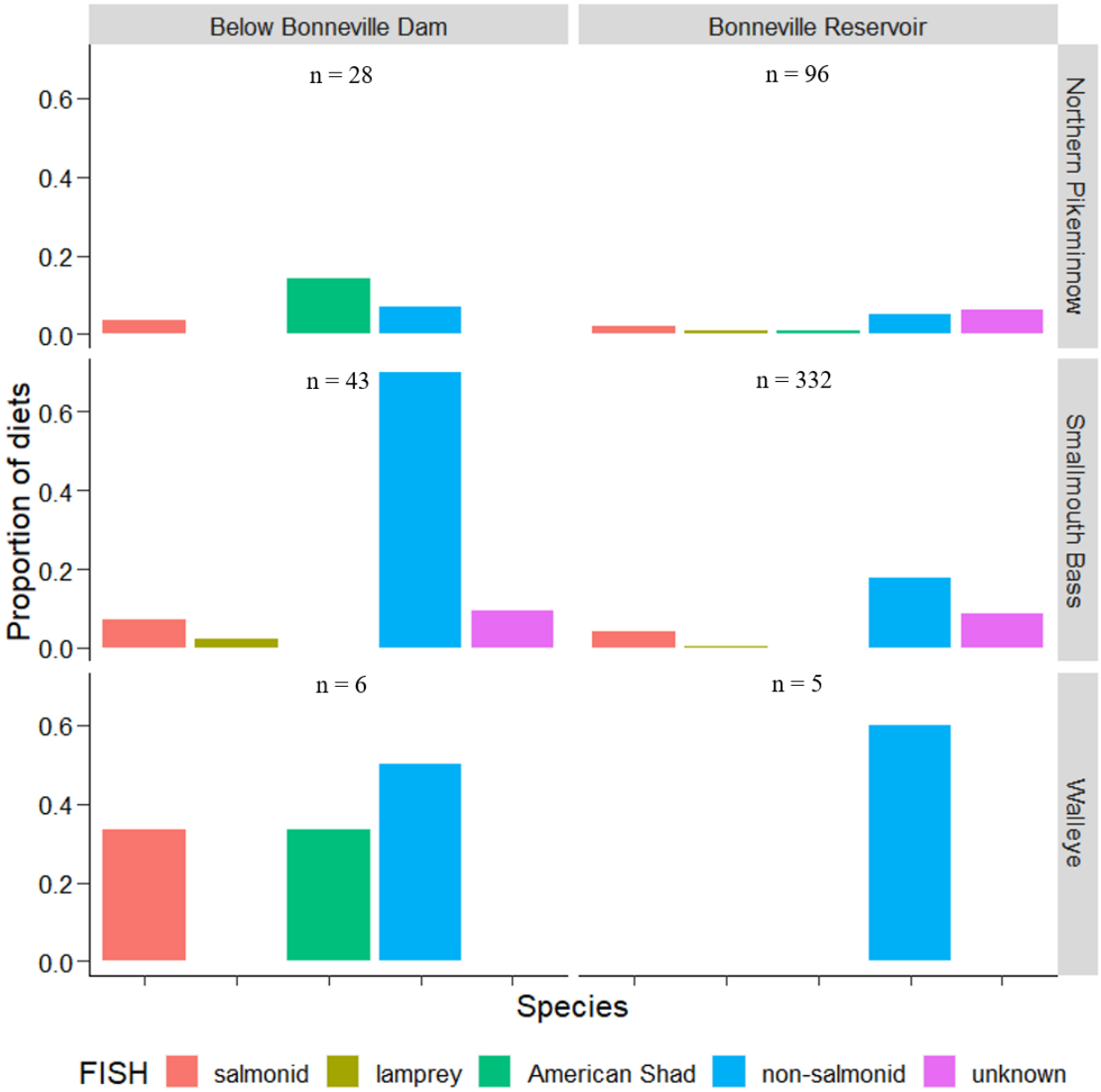

Figure 7. Proportion of all Northern Pikeminnow, Smallmouth Bass, and Walleye diet samples by fish prey type collected during biological evaluation below Bonneville Dam and in Bonneville Reservoir, summer 2020. Sample sizes (n) for all diets (including empties and diets that did not contain fish) listed by predator and location in each panel. Multiple fish groups may be represented in individual predator diets.

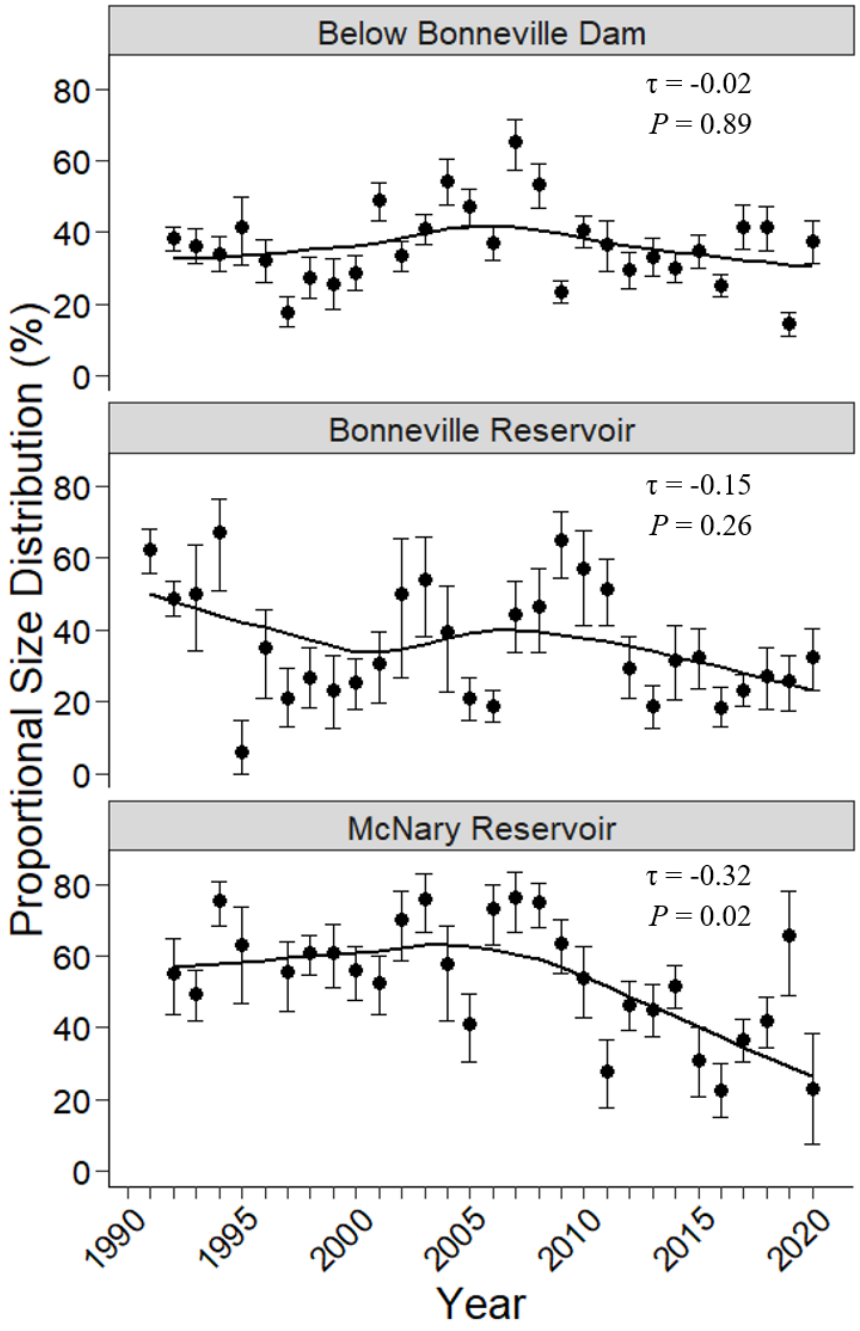

Figure 8. Estimates of proportional size distribution (PSD, %) for Northern Pikeminnow collected during fishery evaluation in the Columbia River, 1991–2020. Estimates for other areas sampled in 2020 but did not have sufficient sample sizes were not included. Error bars represent 95% bootstrap confidence 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 ($n_s < 20$).

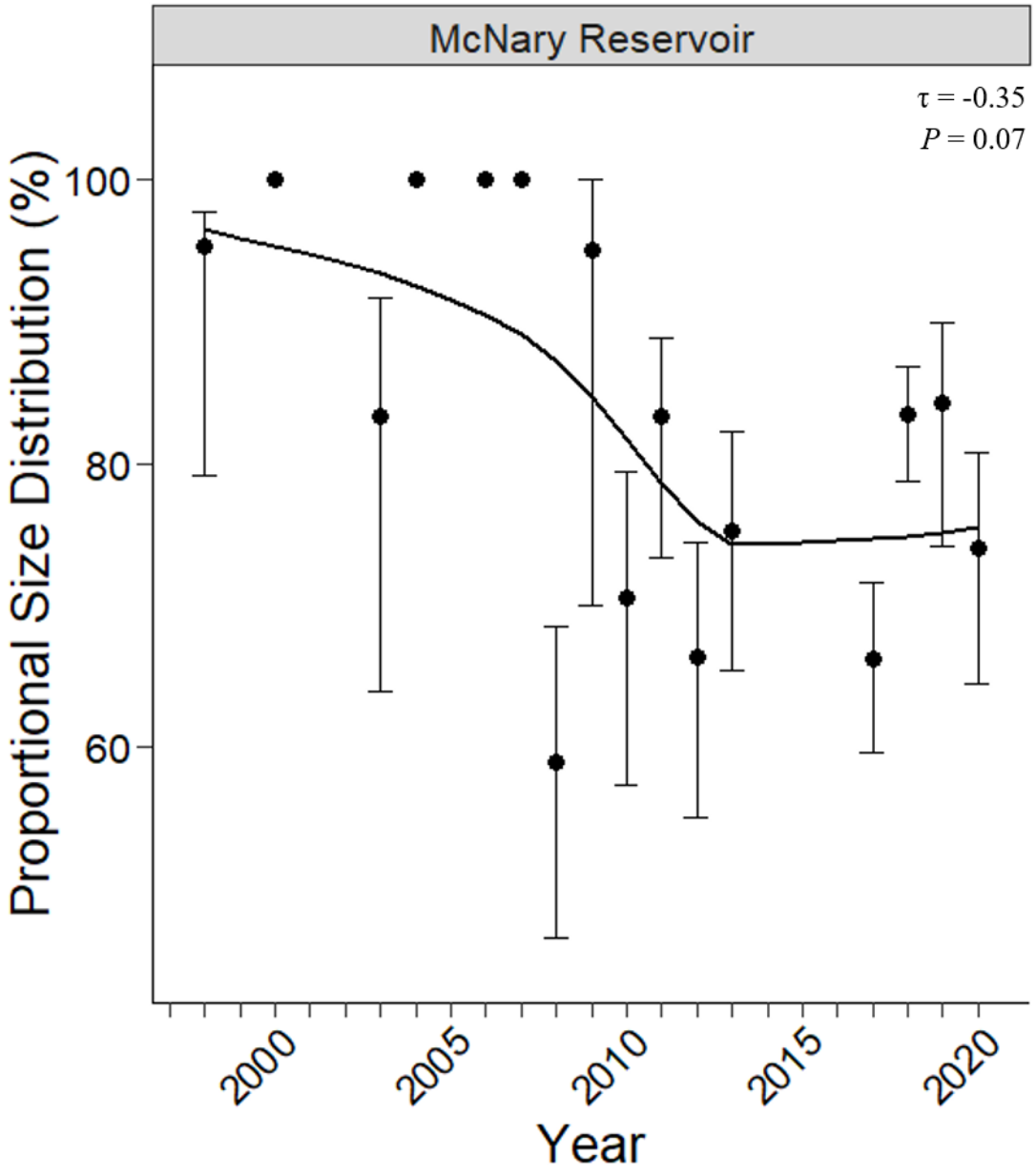

Figure 9. Estimates of proportional size distribution (PSD, %) of Walleye collected during fishery evaluation in McNary Reservoir, 1998–2020. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years without data indicate no sampling or sample sizes were insufficient for analysis ($n_s < 20$).

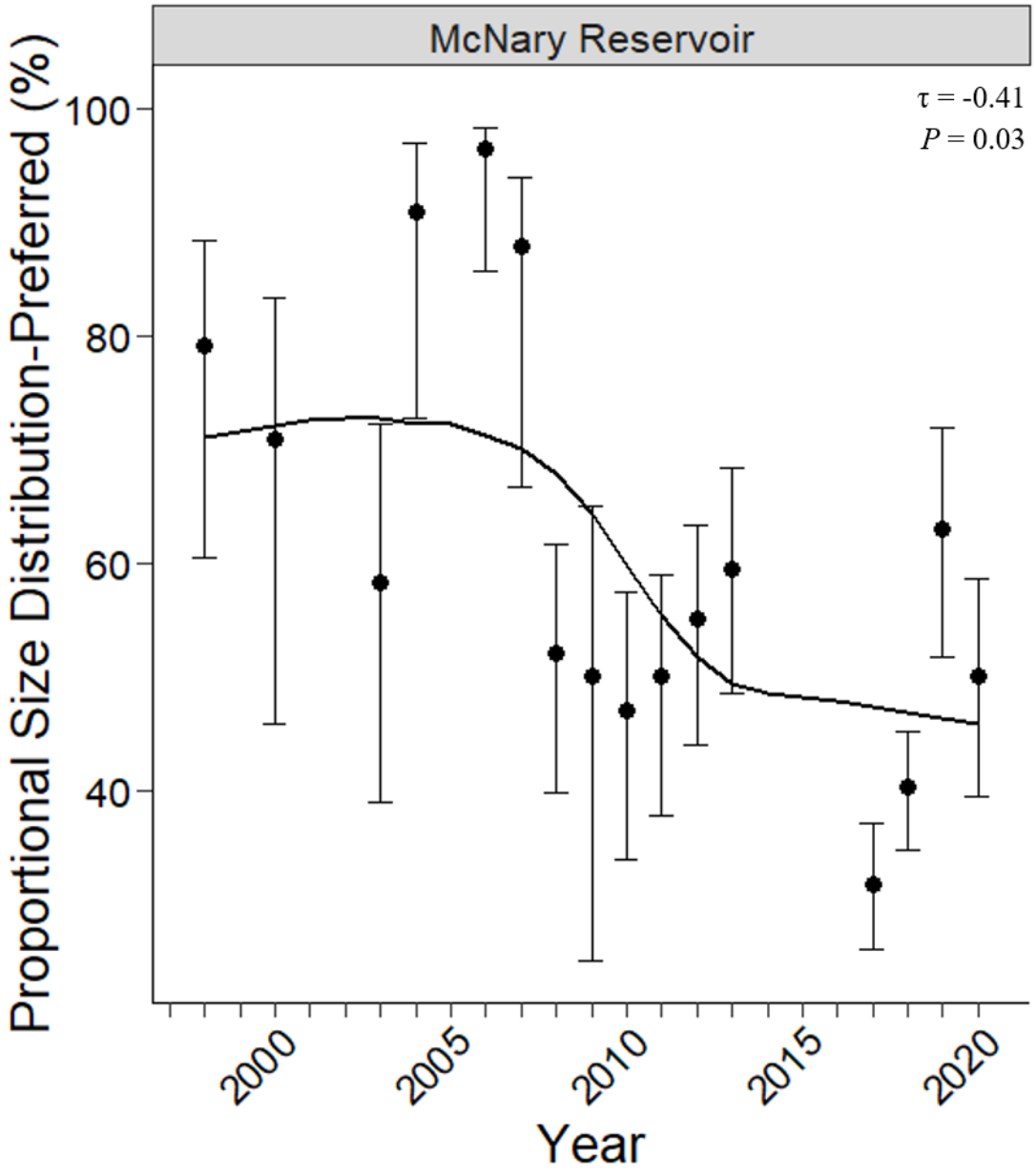

Figure 10. Estimates of proportional size distribution of preferred-length (PSD – P, %) Walleye collected during fishery evaluation in McNary Reservoir, 1998–2020. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years without data indicate no sampling or sample sizes were insufficient for analysis ($n_s < 20$).

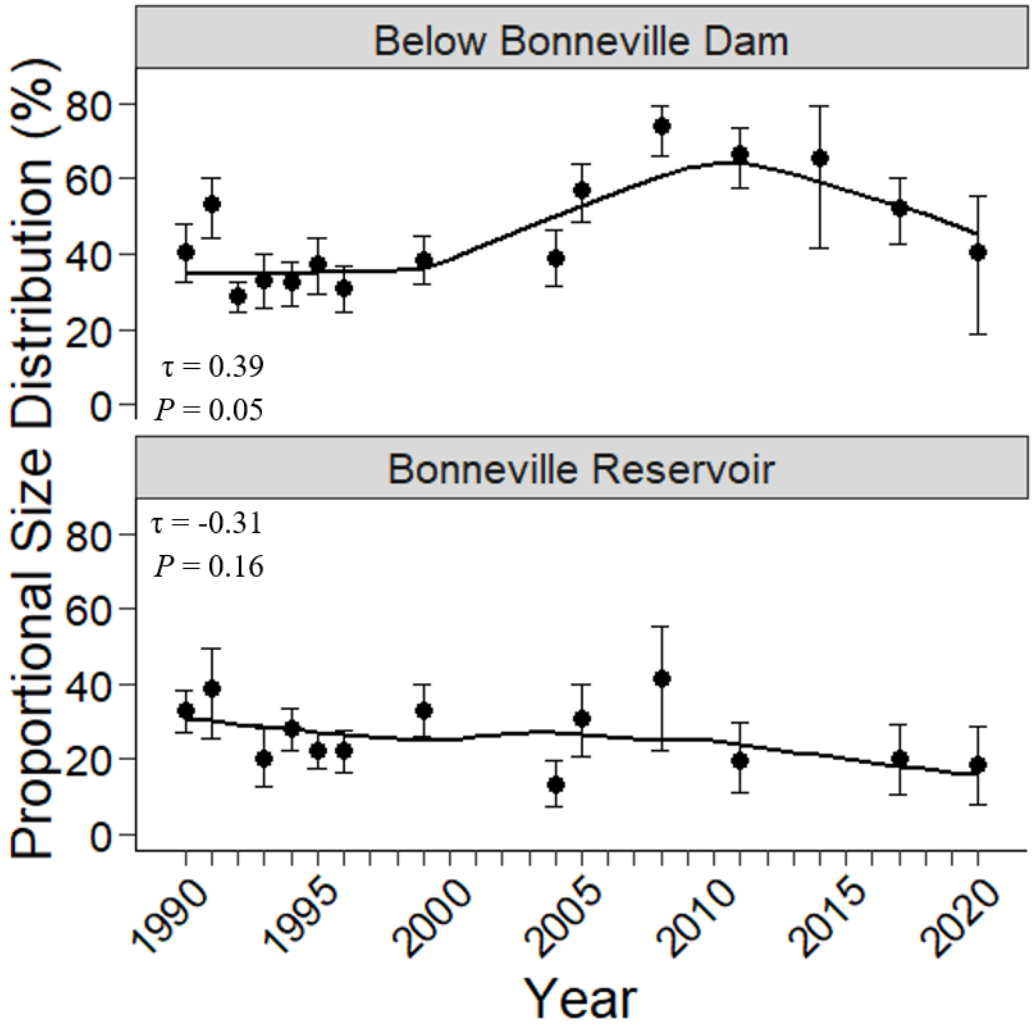

Figure 11. Estimates of proportional size distribution (PSD, %) of Northern Pikeminnow collected during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Error bars represent 95% bootstrap confidence intervals. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Data are fit with LOWESS curves. Years without data indicate sampling was not conducted or sample sizes were insufficient for analysis ($n_s < 20$).

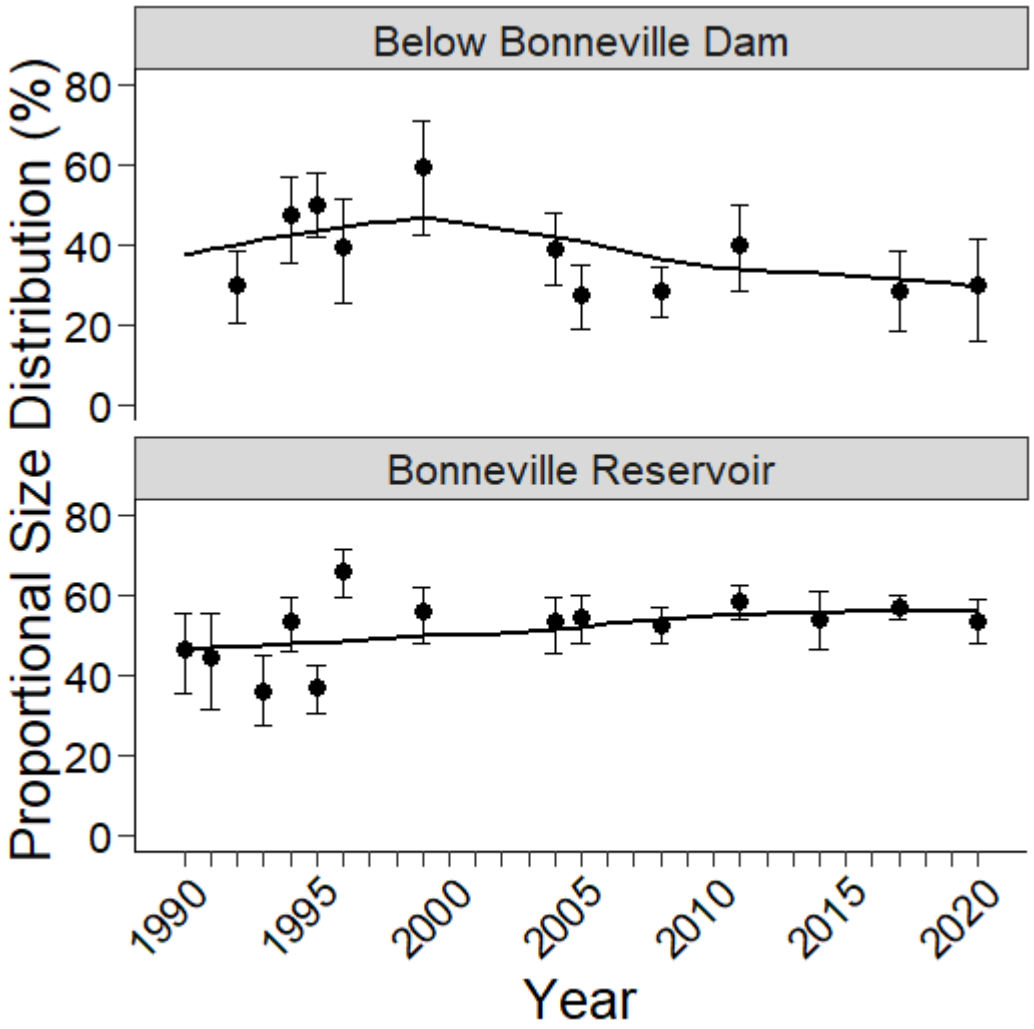

Figure 12. Estimates of proportional size distribution (PSD, %) of Smallmouth Bass collected during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Years without data indicate sampling was not conducted or sample sizes were insufficient for analysis ($n_s < 20$).

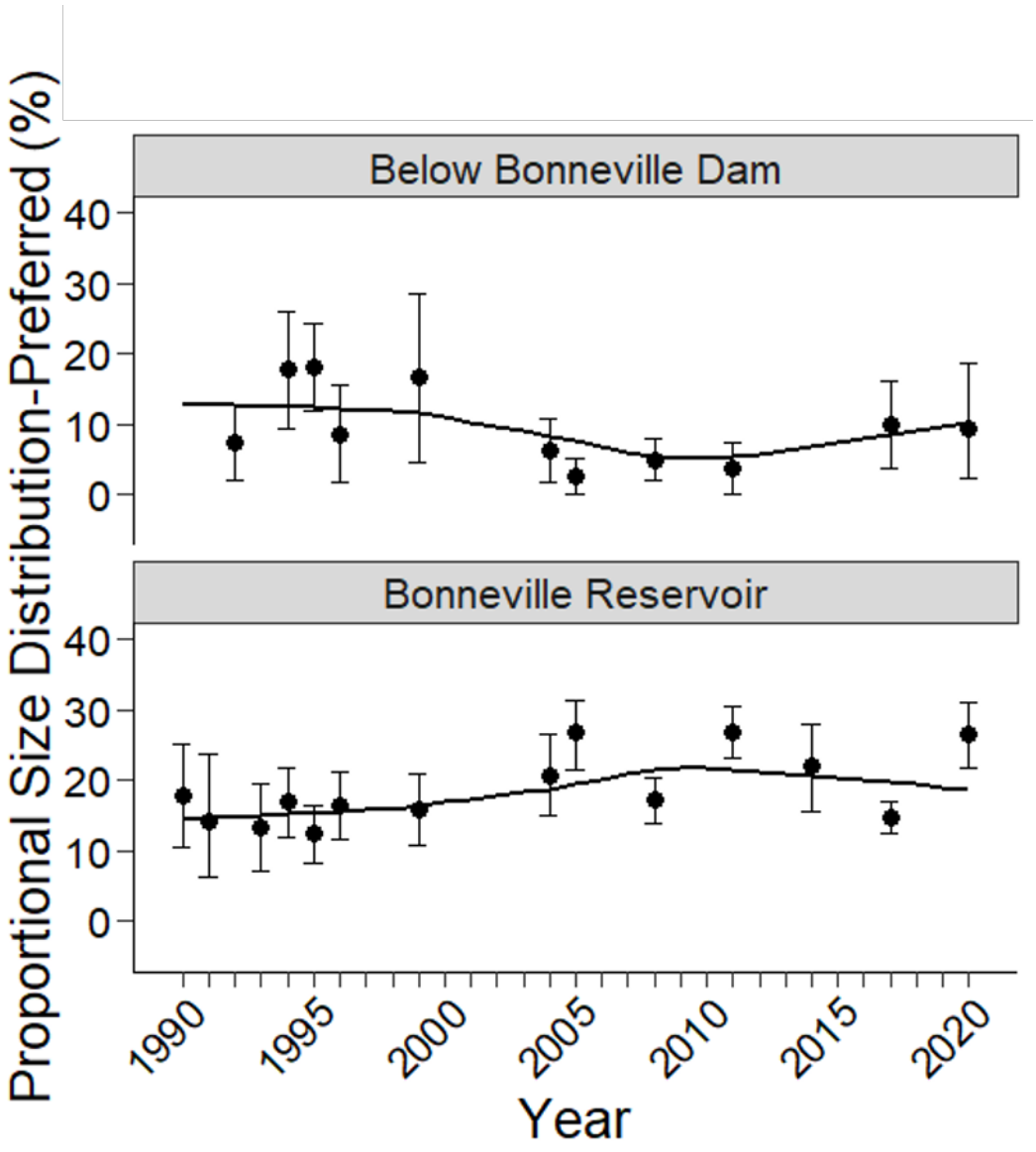

Figure 13. Estimates of proportional size distribution of preferred-length (PSD – P, %) Smallmouth Bass collected during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves. Years without data indicate sampling was not conducted or sample sizes were insufficient for analysis ($n_s < 20$).

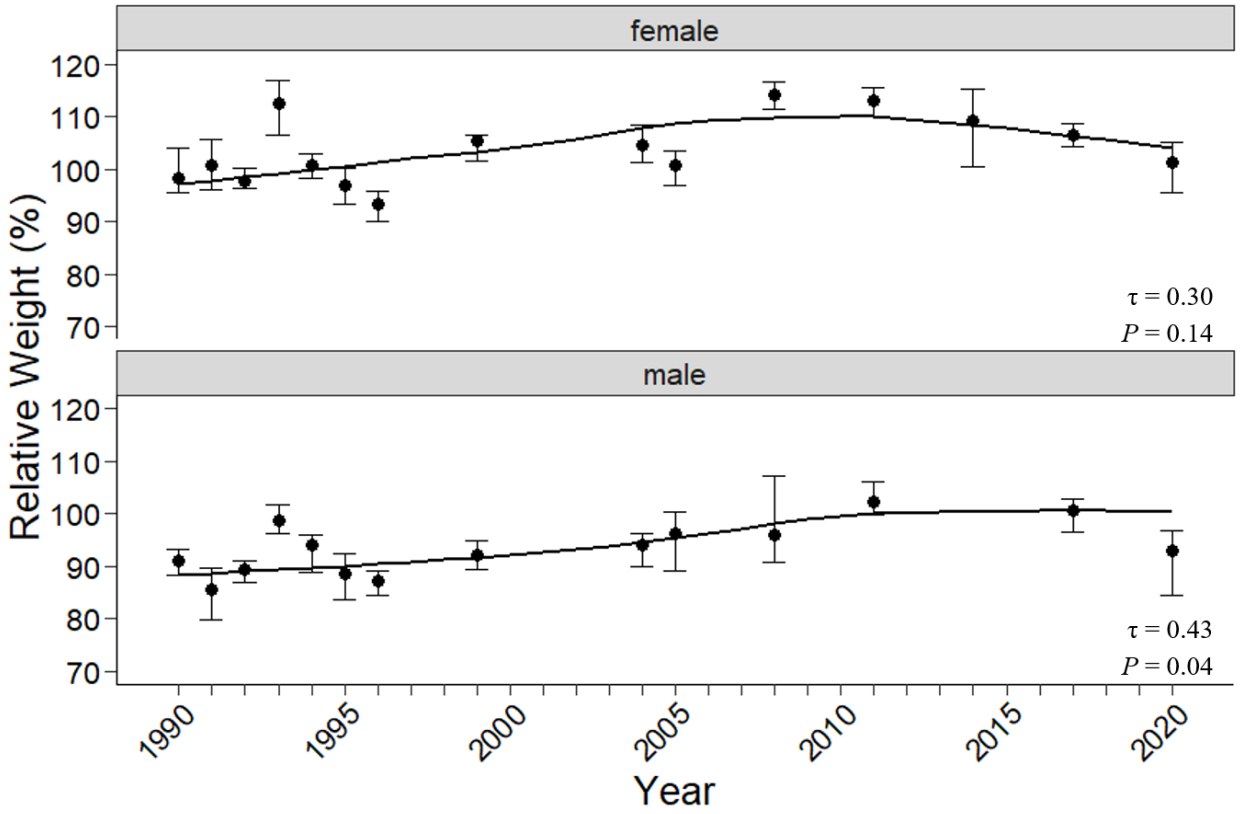

Figure 14. Median relative weight (W_r, %) of female and male Northern Pikeminnow collected during biological evaluation below Bonneville Dam, 1990–2020. Error bars represent 95% bootstrap (percentile) confidence intervals. Results from a Mann-Kendall test of monotonic trend are presented for each time-series. Years without data indicate that sampling was not conducted or sample sizes were insufficient for analyses (n < 5).

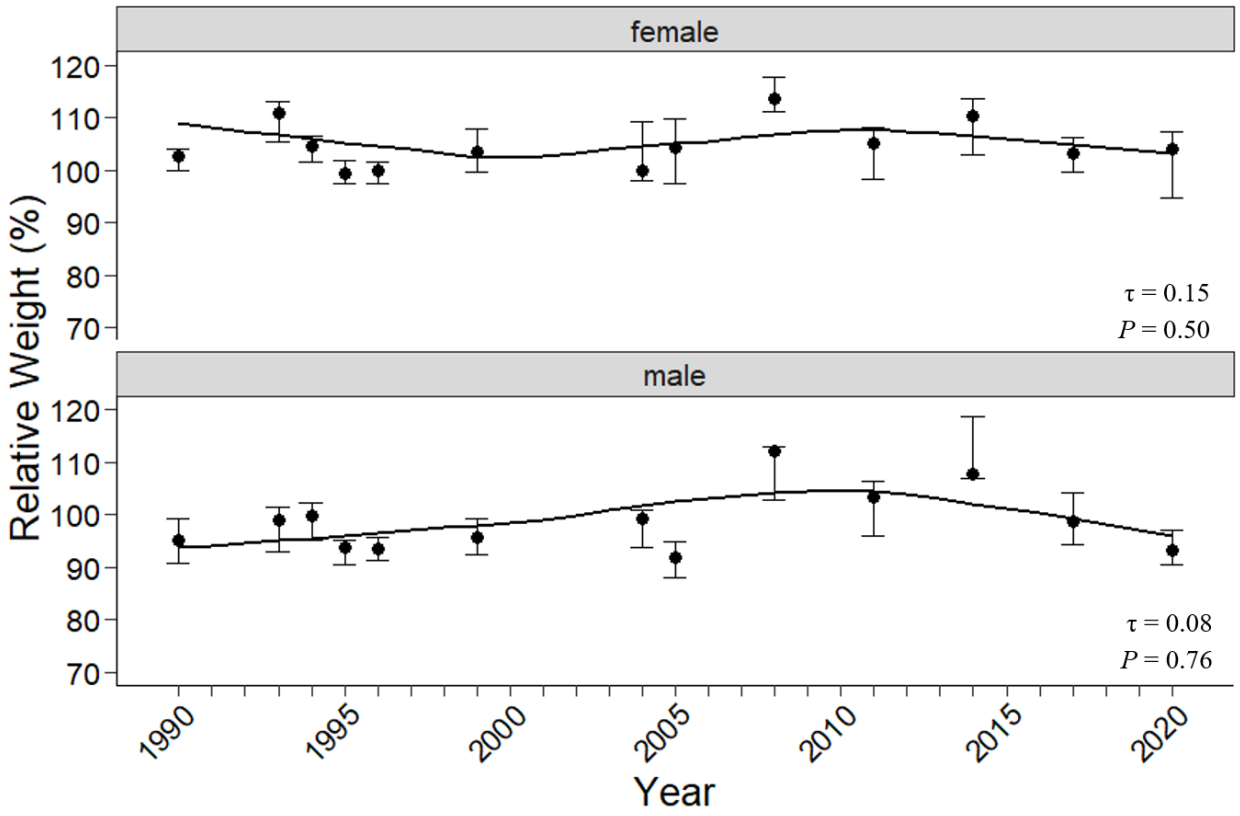

Figure 15. Median relative weight (W_r, %) of female and male Northern Pikeminnow collected during biological evaluation in Bonneville Reservoir, 1990–2020. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic 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).

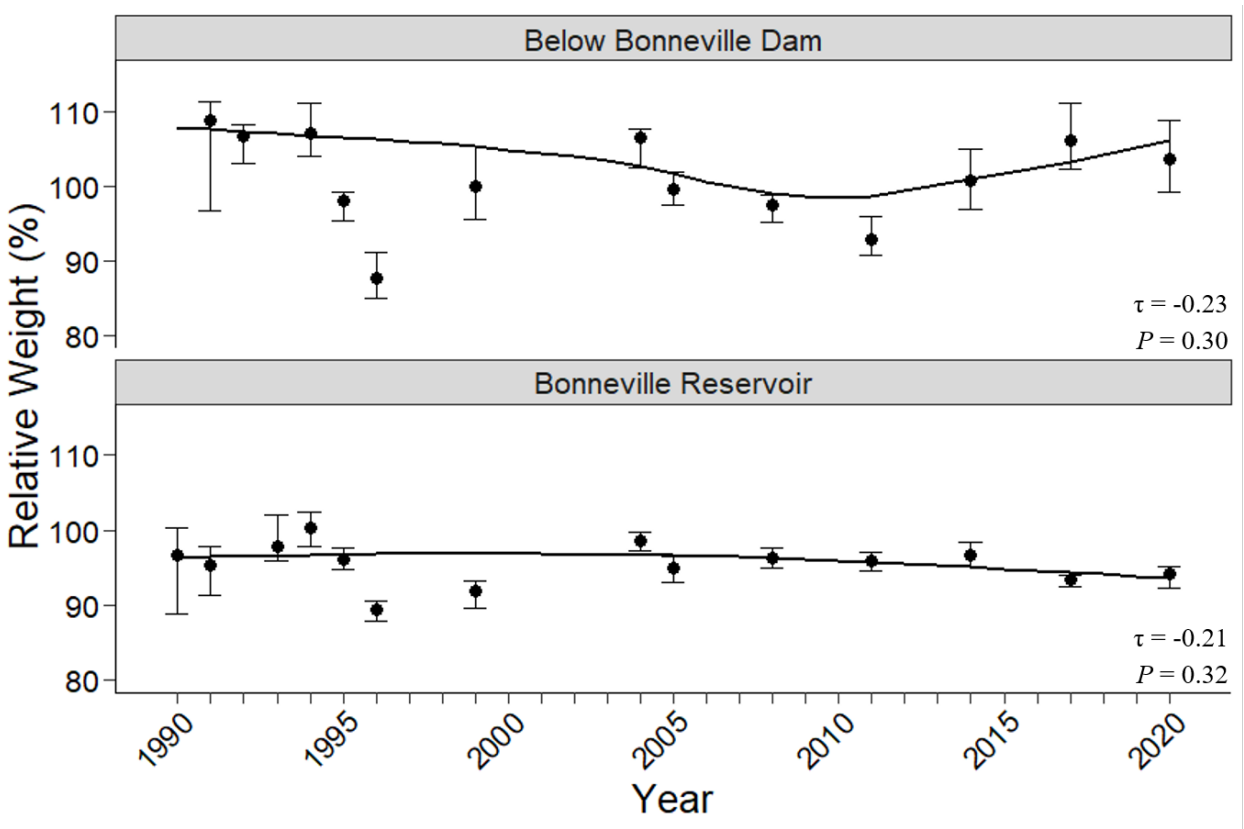

Figure 16. Median relative weight (W_r, %) of Smallmouth Bass collected during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of 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).

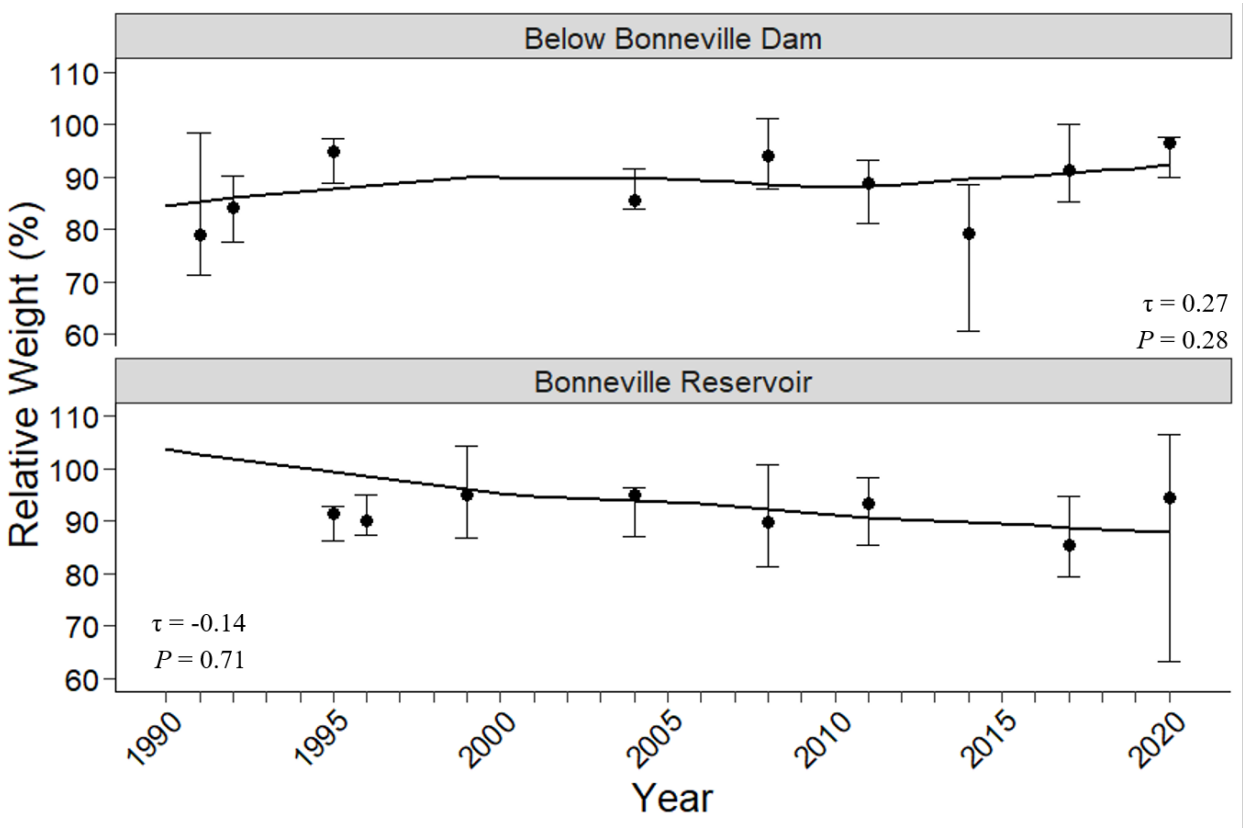

Figure 17. Median relative weight (W_r, %) of Walleye collected during biological evaluation below Bonneville Dam and in Bonneville Reservoir, 1990–2020. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic 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).

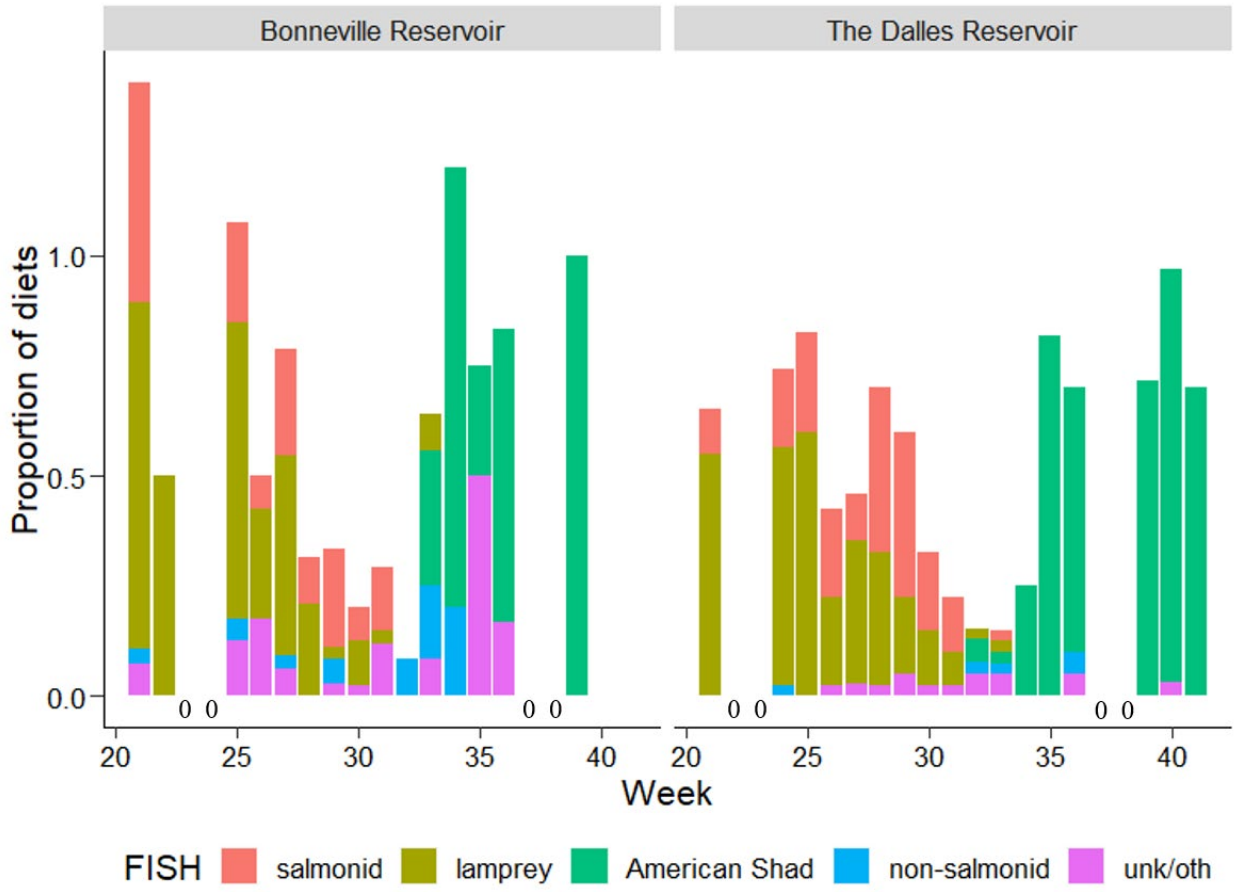

Figure 18. Proportion of all Northern Pikeminnow diet samples containing prey fish collected during the Dam Angling Fishery from the powerhouse tailraces of Bonneville (fishing from The Dalles Dam) and The Dalles (fishing from John Day Dam) reservoirs, May–October 2020 (statistical week 21–41). All Northern Pikeminnow diet samples collected, including empty and diets that did not contain fish, were included in this analysis. Multiple fish groups may be represented in individual Northern Pikeminnow diets. Note: due to COVID-19 and staffing restrictions that no samples were taken in Bonneville during weeks 23–24, The Dalles weeks 22–23, or in either reservoir weeks 37–38 (represented with zeros above the x-axis).

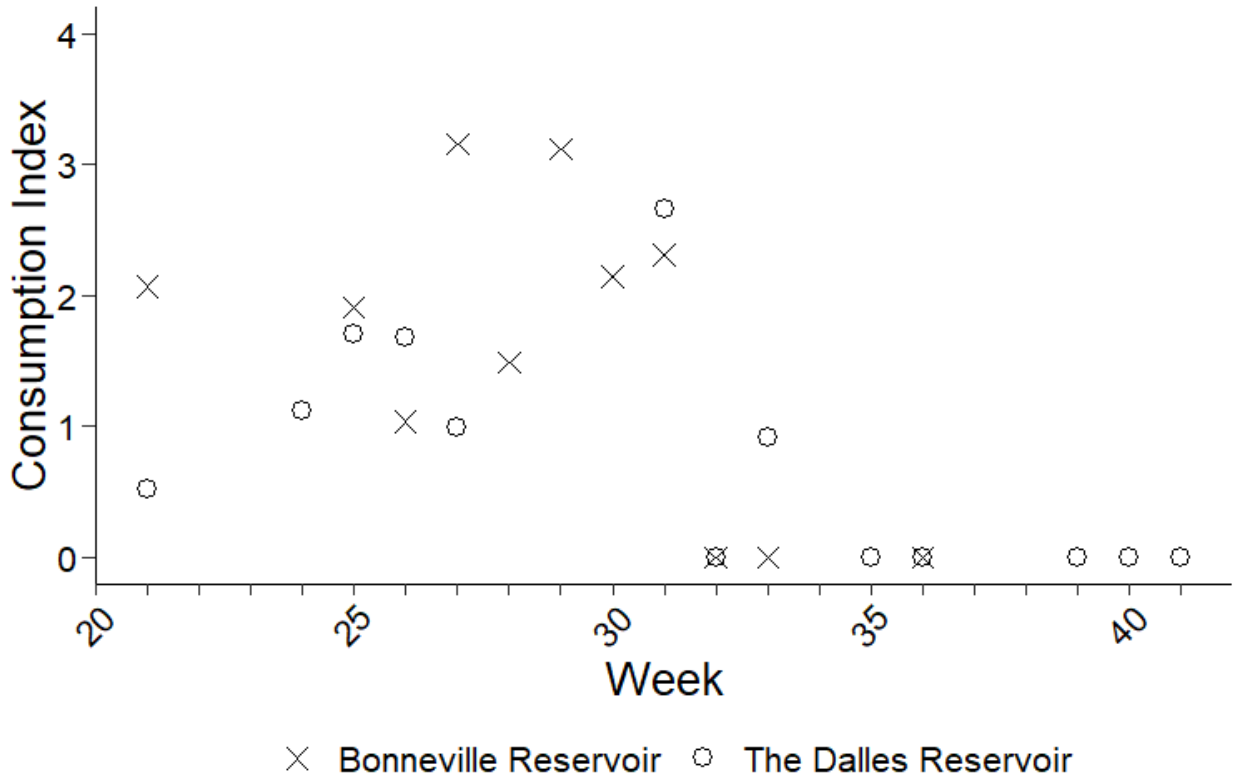

Figure 19. Mean weekly juvenile salmon consumption index for Northern Pikeminnow captured from the Dam Angling Fishery in Bonneville (crosses) and The Dalles (circles) reservoirs, 2020. Weeks without data indicate that sampling was not conducted or sample sizes were insufficient for analyses ($n < 6$).

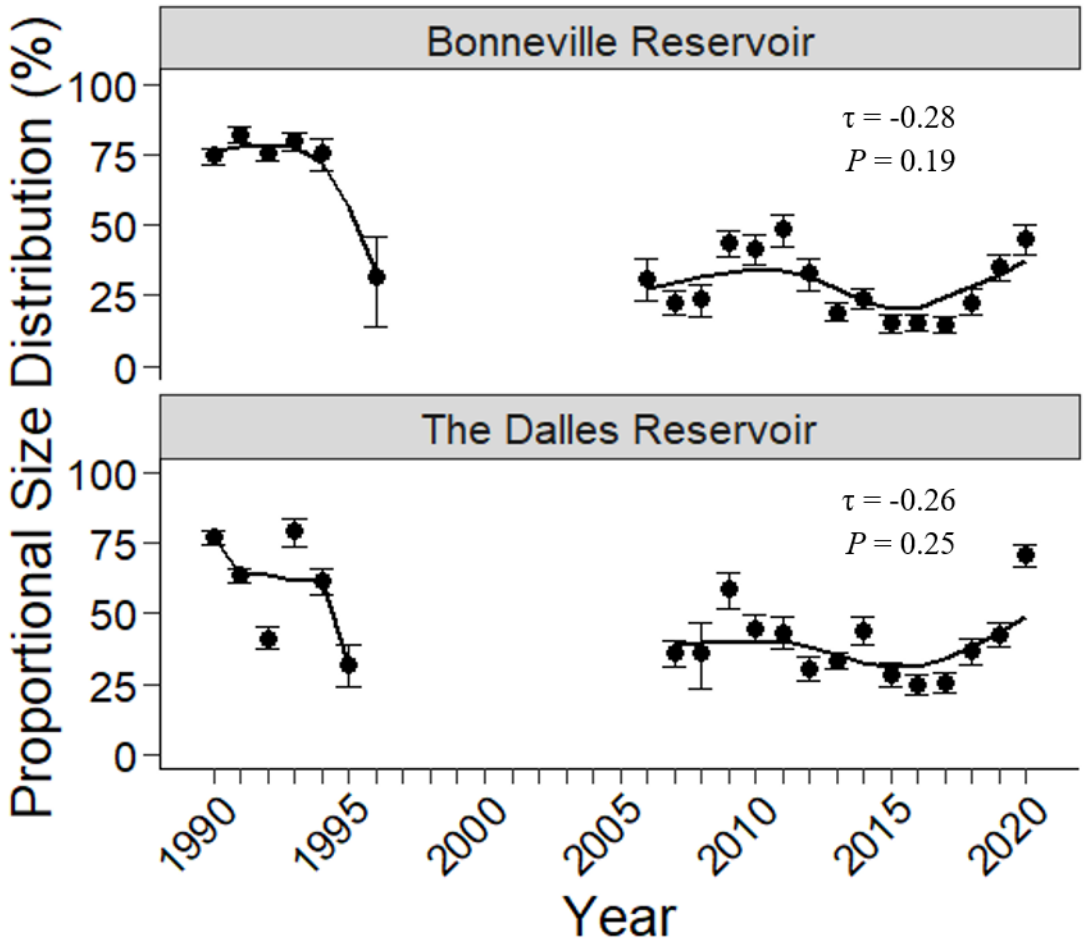

Figure 20. Estimates of proportional size distribution (PSD, %) of Northern Pikeminnow sampled in Bonneville and The Dalles reservoirs during the Dam Angling Fishery, 1990–2020. Error bars represent 95% bootstrap confidence intervals. Data are fit with LOWESS curves for two different time series: early (1990–1996) and late (2006–2020), due to the large data gap between them. Years without data indicate sampling was not conducted or sample sizes were insufficient for analyses ($n_s < 20$).

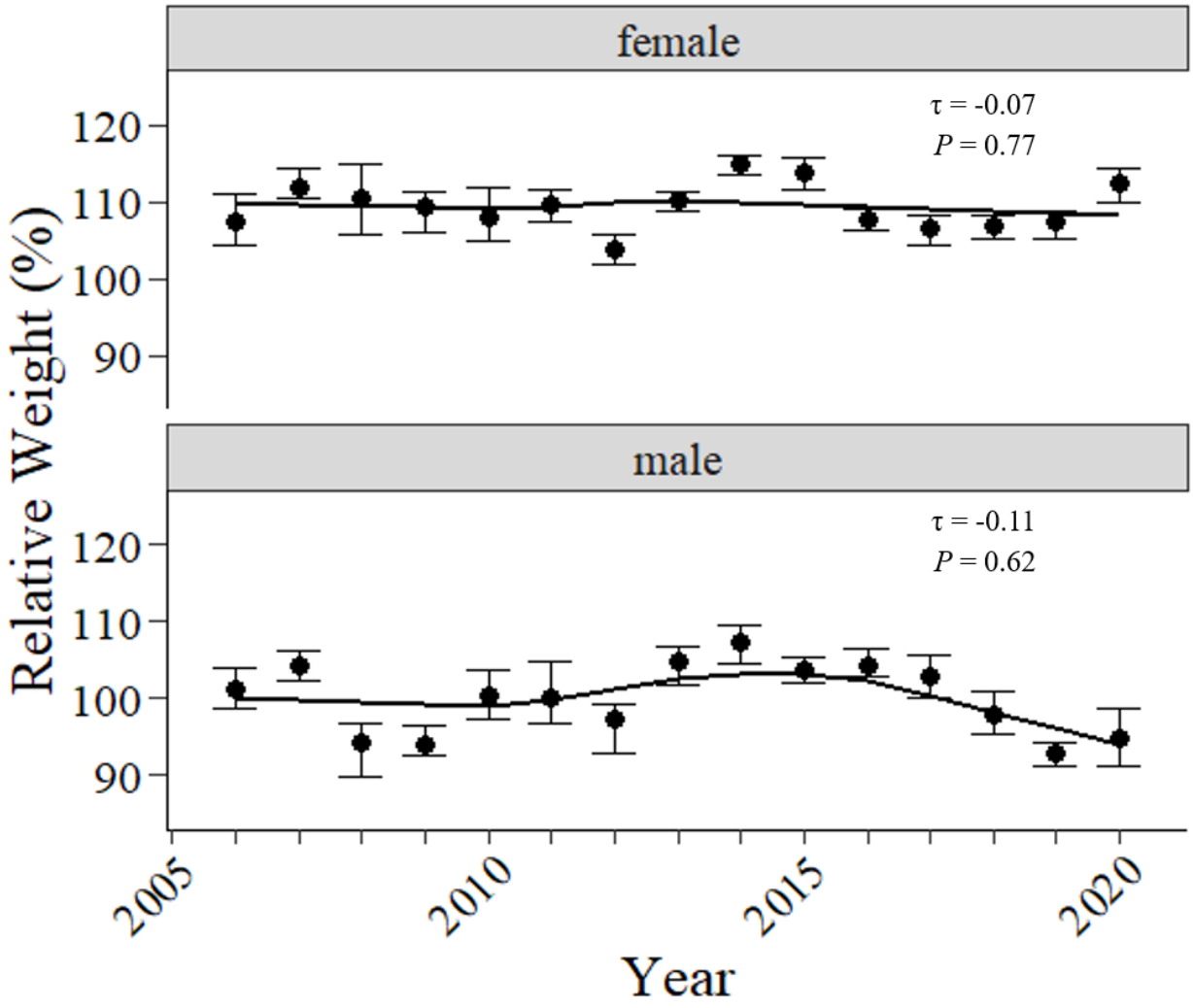

Figure 21. Median relative weight (*Wr*, %) for female and male Northern Pikeminnow collected in Bonneville Reservoir during the Dam Angling Fishery, 2006–2020. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each reservoir.

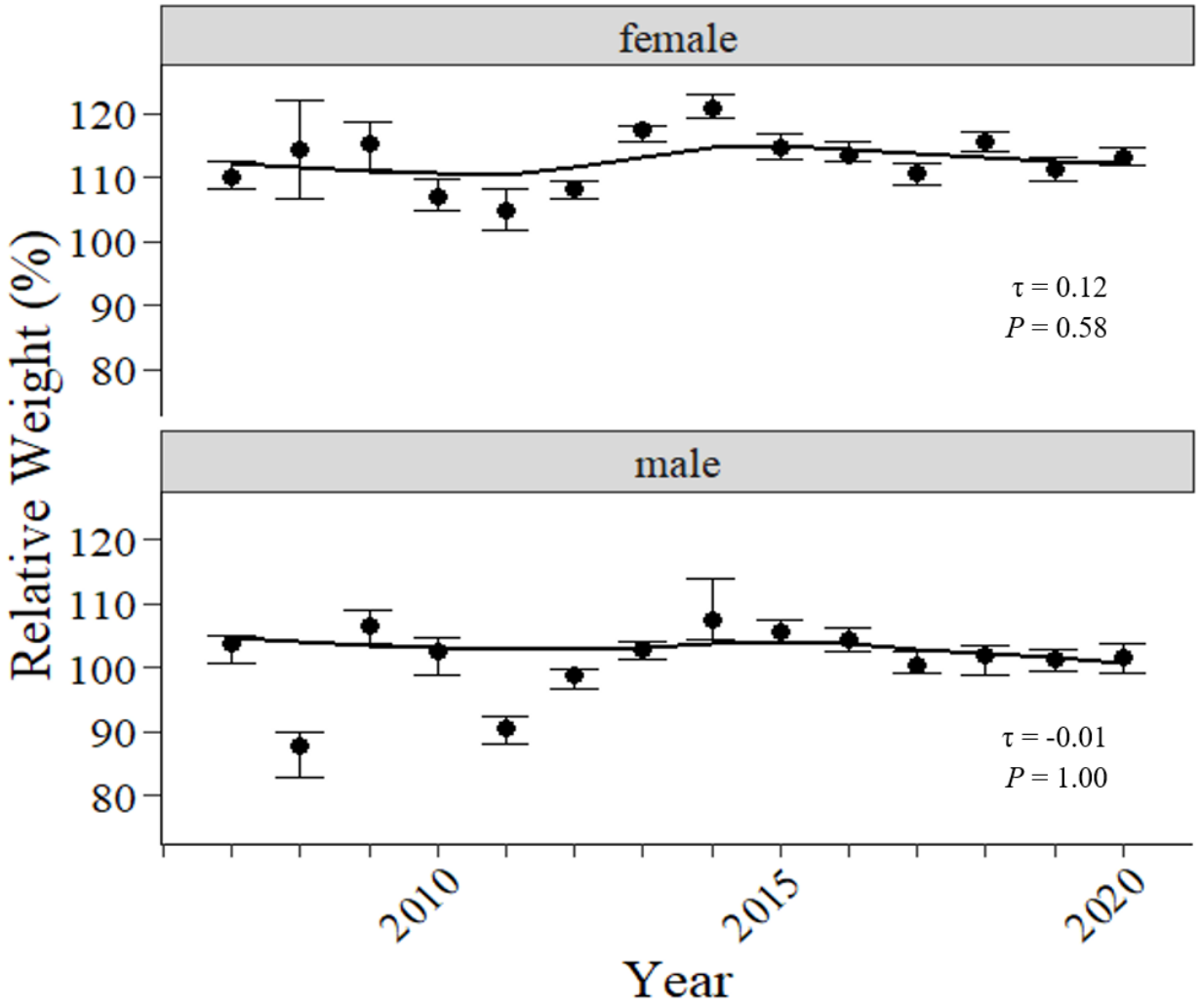

Figure 22. Median relative weight (*Wr*, %) for female and male Northern Pikeminnow collected in The Dalles Reservoir during the Dam Angling Fishery, 2007–2020. Error bars represent 95% bootstrap (percentile) confidence intervals. Data are fit with LOWESS curves. Results from a Mann-Kendall test of monotonic trend are presented for each reservoir.

REPORT D

Northern Pikeminnow Dam Angling on the Columbia River

2020 Annual Report

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We appreciate the efforts of Scott Mengis as the Pikeminnow Dam Angling crew leader, along with Kyle Beckley, Cole Shirley and John Paul Viviano who served as our 2020 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 2020 season.

ABSTRACT

We are reporting on the 2020 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 21 weeks from May 19th through October 12th 2020. 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 2020 Dam Angling crew.

A Dam Angling crew of four anglers harvested a total of 2,790 Northern Pikeminnow during the 2020 season. Of those, 980 Northern Pikeminnow were harvested at The Dalles Dam and 1,810 were harvested at the John Day Dam. The crew fished a total of 1,294.3 hours during the 21 week fishery, averaging 133 fish per week and for a combined overall average catch per angler hour (CPUE) of 2.2 Northern Pikeminnow. At The Dalles Dam, the crew averaged 1.8 fish per angler hour, and cumulatively 19 Northern Pikeminnow per day. At the John Day Dam, the crew averaged 2.4 fish per angler hour with a cumulative crew total of 31 fish per day.

Based on the previous success of the WDFW Dam Angling Crew in implementing the Dam Angling component of the NPMP from 2010-19, the 2020 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 2020 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 2020 marked the eleventh 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 2020.

The objectives of the 2020 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 2020 Dam Angling crew.

METHODS

Project Area

In 2020, 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 2020 were planned for approximately a five month season scheduled to be from May through September. At both The Dalles, and John Day Dams, all angling activities were conducted within the tailrace BRZs where no public angling was permitted. At The Dalles Dam, the Dam Angling crew fished primarily along the turbine deck (Figure 2). At the John Day Dam, the crew fished exclusively along the turbine deck (Figure 3).

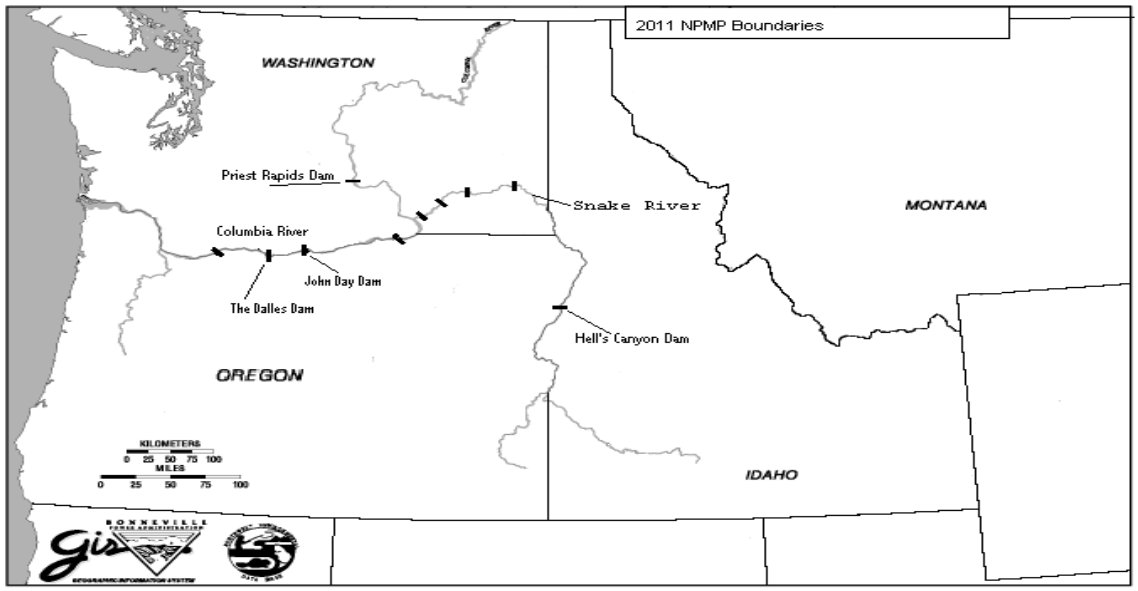

Figure 1. Northern Pikeminnow Management Program boundaries, including 2020 Dam Angling sites.

Figure 2. Angling locations for 2020 Dam Angling at The Dalles Dam

Figure 3. Angling locations for 2020 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 2020, the WDFW Dam Angling crew continued to use the Dam Angling Strategy (DAS) established in 2011 (Dunlap et al. 2012), which 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 2020 season (Figure 4). Angling start times in the morning varied from approximately 4:30 am to 6:00 am at The Dalles Dam and from 5:00 am to 6:00 am at the John Day Dam. Evening times ranged from 6:00 pm to 1:00 am. As part of the four person angling crew, a crew leader was present each day to ensure angler safety and supervision, to collect, record and compile data on Northern Pikeminnow harvest, other fish species caught, and so that NPMP project protocols and Corps of Engineers (USACE) rules were adhered to.

Figure 4. The Dam Angling Crew at John Day Dam

Angling Gear

Dam Anglers used Berkley Air IM8 Graphite 10'6" (2-8 oz. extra heavy casting) rods equipped with either Daiwa 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.

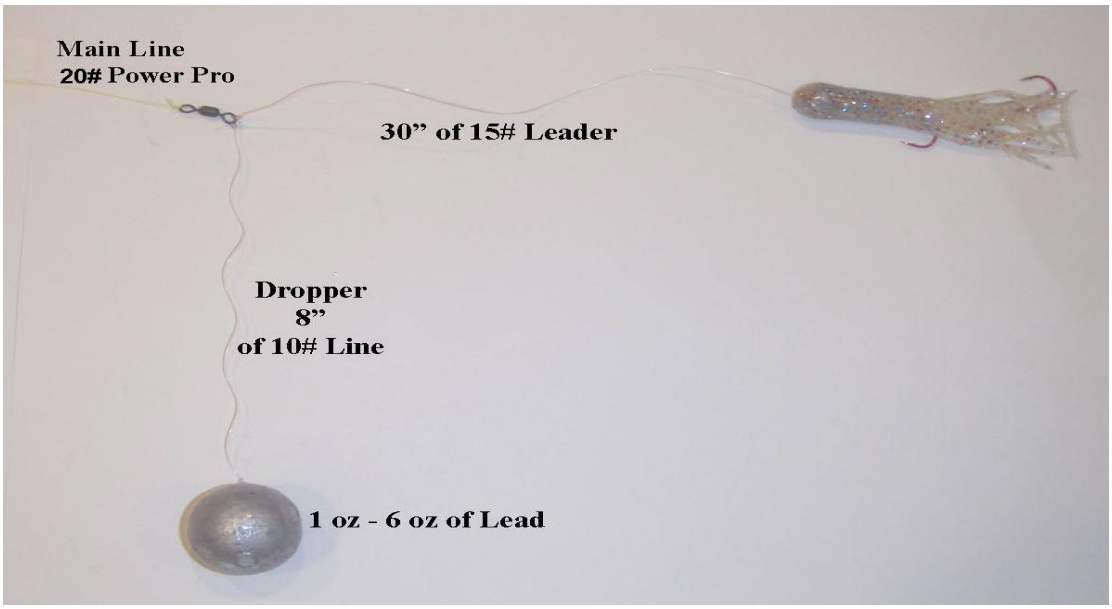

Figure 5. Example of typical rigging used by 2020 NPMP Dam Anglers

Figure 6. Examples of soft plastic tube lures used by 2020 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 2020 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). 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 salmonids. Scanning began on the first day of angling and continued throughout the duration of Dam Angling activities. Technicians individually scanned all Northern Pikeminnow for PIT tag presence, and complete biological data were recorded from all Northern Pikeminnow with positive readings. All Northern Pikeminnow with PIT tags were labeled and preserved for later dissection and tag recovery. All PIT tag data were verified after recovery of PIT tags by WDFW Tag Lead Biologist, entered into the PIT Tag Information System (PTAGIS) and provided to ODFW as requested.

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

2020 Dam Angling Season

The 2020 Dam Angling Season took place from May 19th through October 12th. The later start compared to recent years was due to State and Federal safety precautions related to the 2020 Covid-19 pandemic. Total harvest for The Dalles and John Day dams combined was 2,790 Northern Pikeminnow in 1,294.3 angling hours, with a combined CPUE of 2.2 fish per angler hour. The Dam Angling crew exceeded the CPUE goal of 2.0 fish/angler hour (for the first time during the 2020 season) in week 24 and results were mixed through the core harvest period ending in week 31 during the 2020 season (Figure 8). Per our DAS protocol (Dunlap et al. 2012), weeks when CPUE was under the 2.0 fish/angler hour goal (outside core harvest weeks 23-31) 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 were present and/or available.

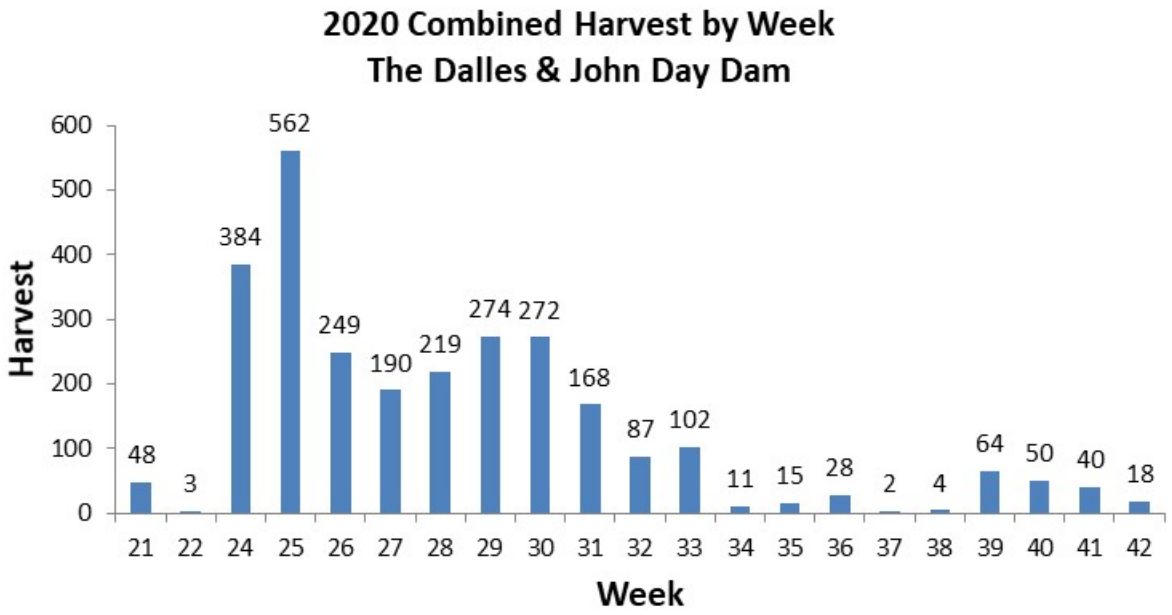

Figure 7. 2020 Weekly harvest of The Dalles (TD) and John Day (JD) Dams combined

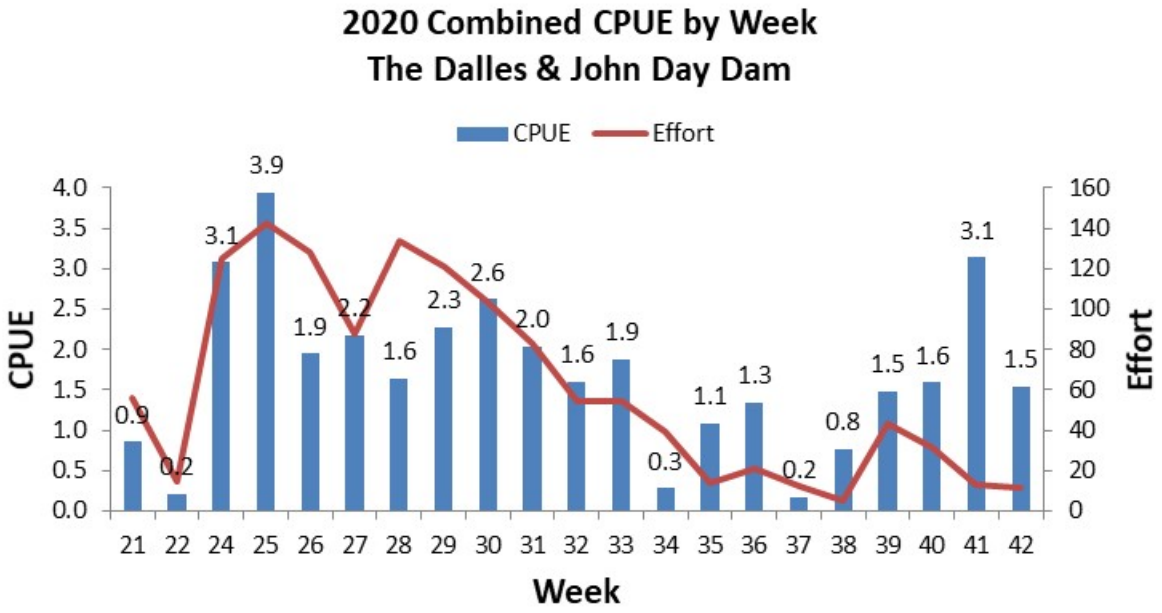

Figure 8. 2020 Weekly CPUE (fish/angler hour) of The Dalles (TD) and John Day (JD) Dams combined

Angling Gear and Technique

The 2020 Dam Angling crew primarily targeted fishing areas and fishing times at each dam that had been productive in past years (Winther et al. 2020). Our top producing lure in 2020 was the 3.75" Gitzit tube (a soft plastic lure) in Smoke/Black Copper Glitter color. This size and color lures was back bounced off the turbine decks and accounted for 1,439 harvested Northern Pikeminnow. A list of the top 5 most productive soft plastic lures used by the Dam Angling crew in 2020 is presented in Table 1.

Table 1. Top 5 Northern Pikeminnow Lures used by 2020 WDFW Dam Angling Crew

Northern Pikeminnow Lures

Brand/style	Size	Color	# N. Pikeminnow Caught
Canyon/ tube bait	3.75"	Smoke/Black Copper Glitter	1,439
Gitzit/ tube bait	3.50"	Pearl/Black Smoke Purple	376
Canyon/ tube bait	3.75"	Smoke/Black Red Glitter	310
Gitzit/ tube bait	3.50"	Smoke Sparkle	145
Canyon/ tube bait	3.75"	Pearl White/Black Back	145

Angling Times

Time of day continued to make a difference in harvest success during the 2020 season. Dam Angler catch data from previous seasons had indicated that morning hours prior to noon were consistently the most productive times for harvesting Northern Pikeminnow (Winther et al. 2020). Results for the 2020 season indicated that 53% of the Dam Angler harvest of Northern Pikeminnow occurred prior to noon (Table 2). Evening hours also continued to be productive at The Dalles Dam in 2020 with 47% of harvest occurring after noon) (Table 3).

Table 2. Combined 2020 WDFW Dam Angler hourly harvest totals for The Dalles (TD) and John Day (JD) dams

Hourly Northern Pikeminnow Harvest (combined TD and JD totals)

Time of day	Harvest	% of Harvest (rounded)
4:30 a.m. – 6:00 a.m.	200	7%
6:00 a.m. – 7:00 a.m.	160	6%
7:00 a.m. – 8:00 a.m.	300	11%
8:00 a.m. – 9:00 a.m.	243	9%
9:00 a.m. – 10:00 a.m.	206	7%
10:00 a.m. – 11:00 a.m.	203	7%
11:00 a.m. – 12:00 p.m.	175	6%
12:00 p.m. – 1:00 p.m.	145	5%
1:00 p.m. – 6:00 p.m.	175	6%
6:00 p.m. – 7:00 p.m.	51	2%
7:00 p.m. – 8:00 p.m.	118	4%
8:00 p.m. – 9:00 p.m.	217	8%
9:00 p.m. – 10:00 p.m.	207	7%
10:00 p.m. – 11:00 p.m.	134	5%
11:00 p.m. – 12:00 a.m.	143	5%
12:00 a.m. – 1:00 a.m.	110	4%
1:00 a.m. – 4:00 a.m.	3	0%

Table 3. 2020 WDFW Dam Angler hourly Northern Pikeminnow Harvest comparison (TD vs JD, rounded)

	The Dalles Dam		John Day Dam	
Time of day	Harvest	% of Harvest	Harvest	% of Harvest
4:30 a.m. – 6:00 a.m.	114	12%	86	5%
6:00 a.m. – 7:00 a.m.	71	7%	89	5%
7:00 a.m. – 8:00 a.m.	69	7%	231	13%
8:00 a.m. – 9:00 a.m.	62	6%	181	10%
9:00 a.m. – 10:00 a.m.	58	6%	148	8%
10:00 a.m. – 11:00 a.m.	59	6%	144	8%
11:00 a.m. – 12:00 p.m.	24	2%	151	8%
12:00 p.m. – 1:00 p.m.	23	2%	122	7%
1:00 p.m. – 6:00 p.m.	28	3%	147	8%
6:00 p.m. – 7:00 p.m.	2	0%	49	3%
7:00 p.m. – 8:00 p.m.	26	3%	92	5%
8:00 p.m. – 9:00 p.m.	40	4%	177	10%
9:00 p.m. – 10:00 p.m.	78	8%	129	7%
10:00 p.m. – 11:00 p.m.	97	10%	37	2%
11:00 p.m. – 12:00 a.m.	123	13%	20	1%
12:00 a.m. – 1:00 a.m.	103	11%	7	0%
1:00 a.m. – 4:00 a.m.	3	0%	0	0%
Total	980	100%	1,810	100%

Incidental Catch

The Dam Angling crew incidentally caught the fish species listed in Table 4 while targeting Northern Pikeminnow at The Dalles and John Day dams in 2020. All incidentally caught fish species were released in 2020. 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 caught at The Dalles Dam and John Day Dam during May and June.

Table 4. 2020 WDFW Dam Angler incidental catch by project

Incidental Catch

Species	The Dalles Dam	John Day Dam
Smallmouth Bass	116	633
Walleye	15	241
Sculpin	19	12
American Shad	21	36
Channel Catfish	1	19
White Sturgeon	0	5
Peamouth	0	1
Sucker	0	3

Tag Recovery

All Northern Pikeminnow harvested by Dam Anglers in 2020 were visually examined for the presence of external spaghetti or Floy tags and 100% were individually scanned with PIT tag readers for the presence of PIT tags. There were no Northern Pikeminnow retaining both ODFW spaghetti and PIT tags recovered by the Dam Angling crew in 2020 (Figure 9), which was four less than that in 2019 (Winther et al. 2020). In addition, there were a total of 11 Northern Pikeminnow recovered that had lost the spaghetti or Floy ODFW tags, but retained PIT tags (tag-loss) implanted by ODFW as a secondary tag mark as part of ODFW's biological evaluation of the NPMP (Barr et al. 2021). The 2020 Dam Angling crew also recovered Northern Pikeminnow with 2 PIT tags from ingested juvenile salmonids (both were hatchery summer Chinook) at The Dalles Dam. There were no recoveries of PIT tags from ingested salmonids at the John Day Dam (Figure 10). There was one less total recovery of ingested salmonids from Northern Pikeminnow than in 2019 (Winther et al. 2020). The overall occurrence rate for ingested PIT tagged salmonids recovered from Northern Pikeminnow caught by Dam Anglers in 2020 was 1:1,395 Northern Pikeminnow, which was an increased occurrence compared to 1:1,625 for the Dam Angling crew in 2019 (Winther et al. 2020) and 1:4,902 for the 2020 Northern Pikeminnow Sport-Reward Fishery (Hone et al. 2021).

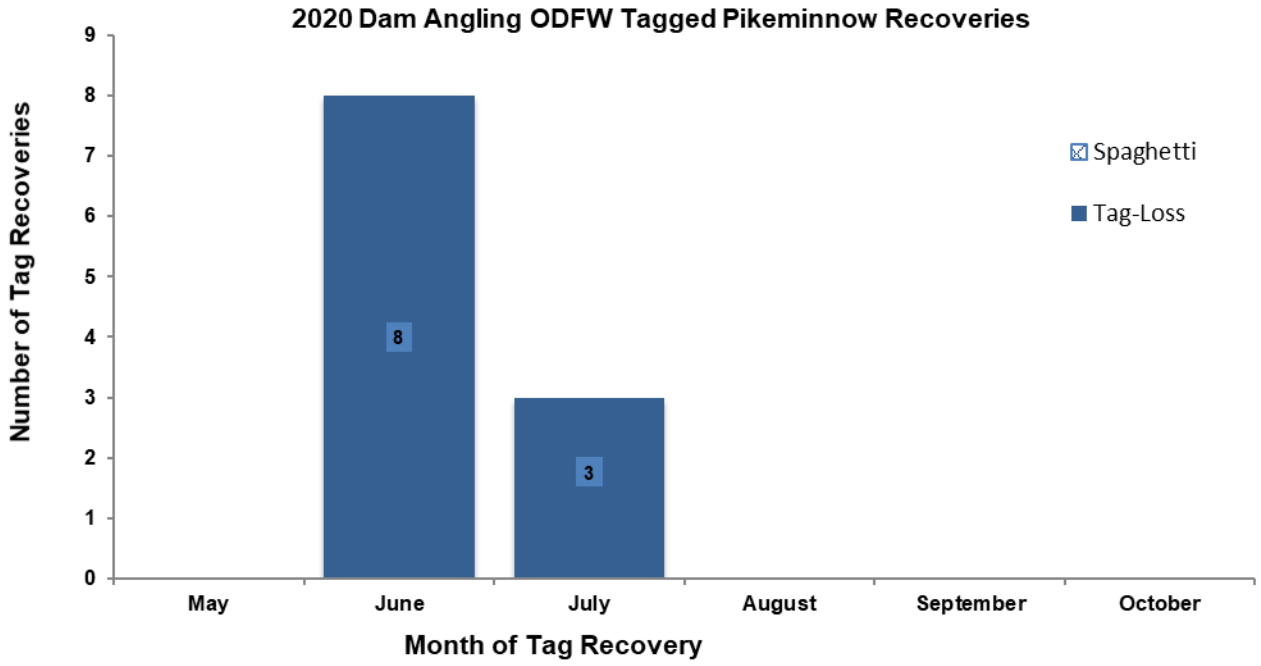

Figure 9. Recoveries of Spaghetti Tagged and Tag-Loss fish from 2020 Dam Angling

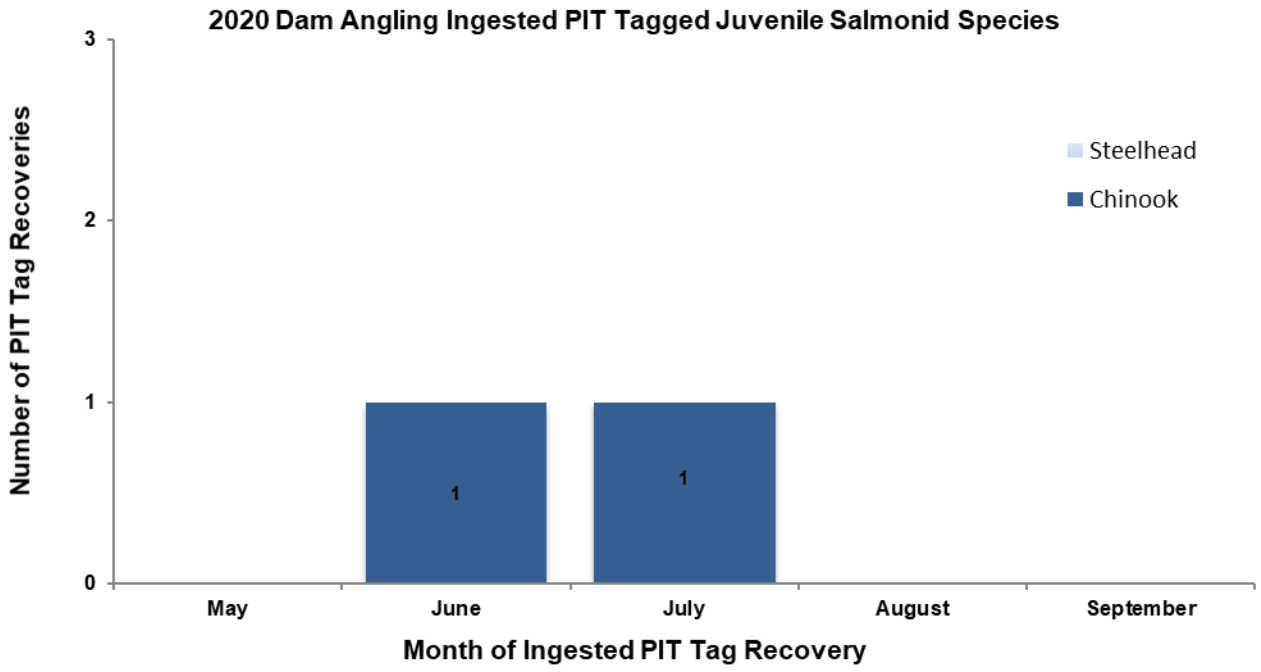

Figure 10. Recoveries of ingested salmonid PIT Tags from 2020 Dam Angling

The Dalles Dam

Harvest

The Dam Angling crew harvested 980 Northern Pikeminnow in 20 weeks of Dam Angling at The Dalles Dam in 2020. Weekly harvest for the Dam Angling crew averaged 52 fish per week and ranged from peak harvest of 183 Northern Pikeminnow in week 29 (July 13 – July 19) to 0 fish in weeks 37, 38 & 40 (no effort was spent during week 23) (Figure 11). Overall Dam Angling harvest at The Dalles Dam was less than half of 2019 (Winther et al. 2020), possibly related to the late season start due to Covid-19 concerns and peak harvest for Dam Angling occurred in week 29, four weeks later than in the 2020 Sport-Reward Fishery (Hone et al. 2021).

The 980 Northern Pikeminnow harvested at The Dalles Dam in 2020 included no external tags, but did include five tag-loss Northern Pikeminnow from ODFW's biological evaluation of the NPMP which was 2 tag-loss more than in 2019 (Winther et al. 2020). The 2020 Dam Angling crew also recovered two Northern Pikeminnow from The Dalles Dam with ingested juvenile salmonids with PIT tags.

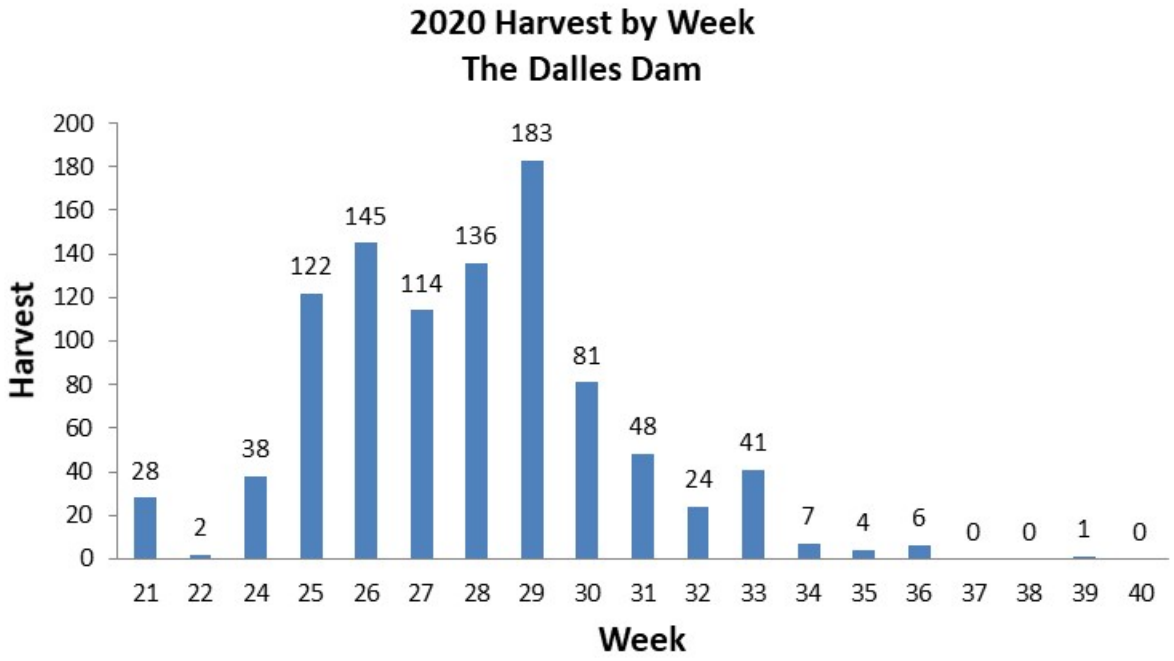

Figure 11. 2020 Weekly Dam Angler harvest of Northern Pikeminnow at The Dalles Dam

As was the case in past Dam Angling seasons, certain areas and/or turbines at The Dalles Dam were better producers than others in 2020. The angling between Turbine #7 (T7) and Turbine #14 (T4) accounted for 44% of total harvest at The Dalles Dam in 2020, up from 40% in 2019 (Winther et al. 2020) (Figure 12). The area between the Fishway (F) and Turbine 4 (T4) accounted for 49% of total harvest. Per USACE instructions, the 2020 Dam Angling crew was not allowed to fish the rock shore above the ice trash sluiceway which historically contributes

25% of the total Dam Angler harvest of Northern Pikeminnow harvest at The Dalles Dam (Dunlap et al. 2018).

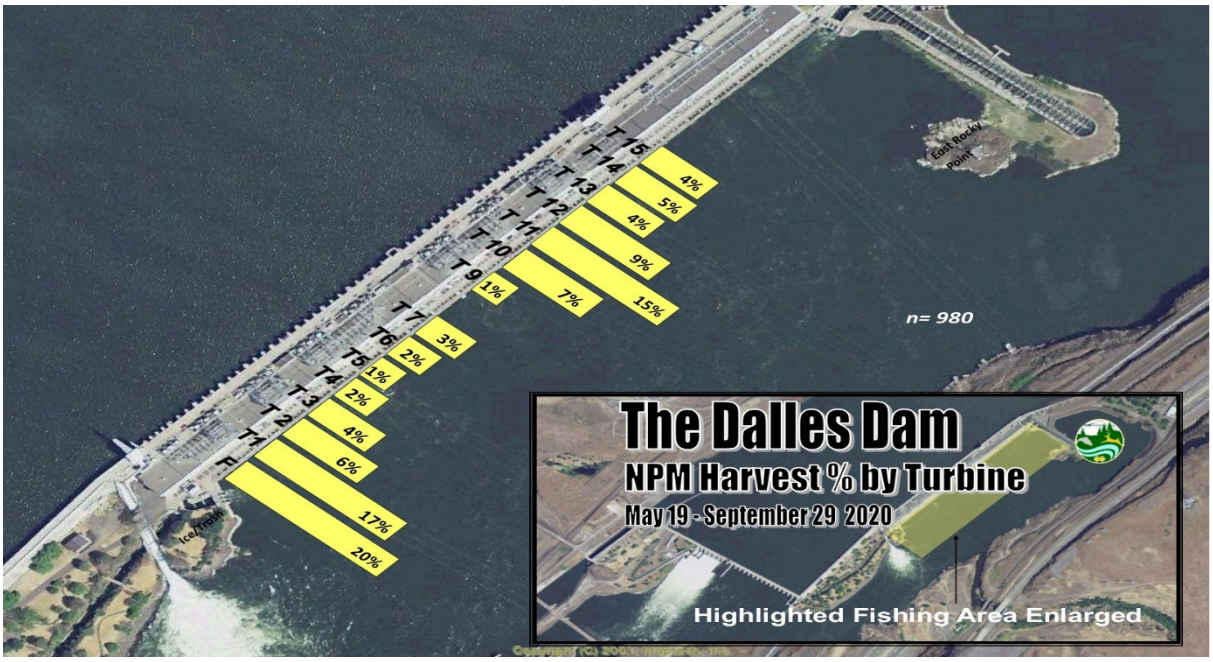

Figure 12. 2020 Overall percent of Northern Pikeminnow harvest by area (T=turbine #, F = fishway)

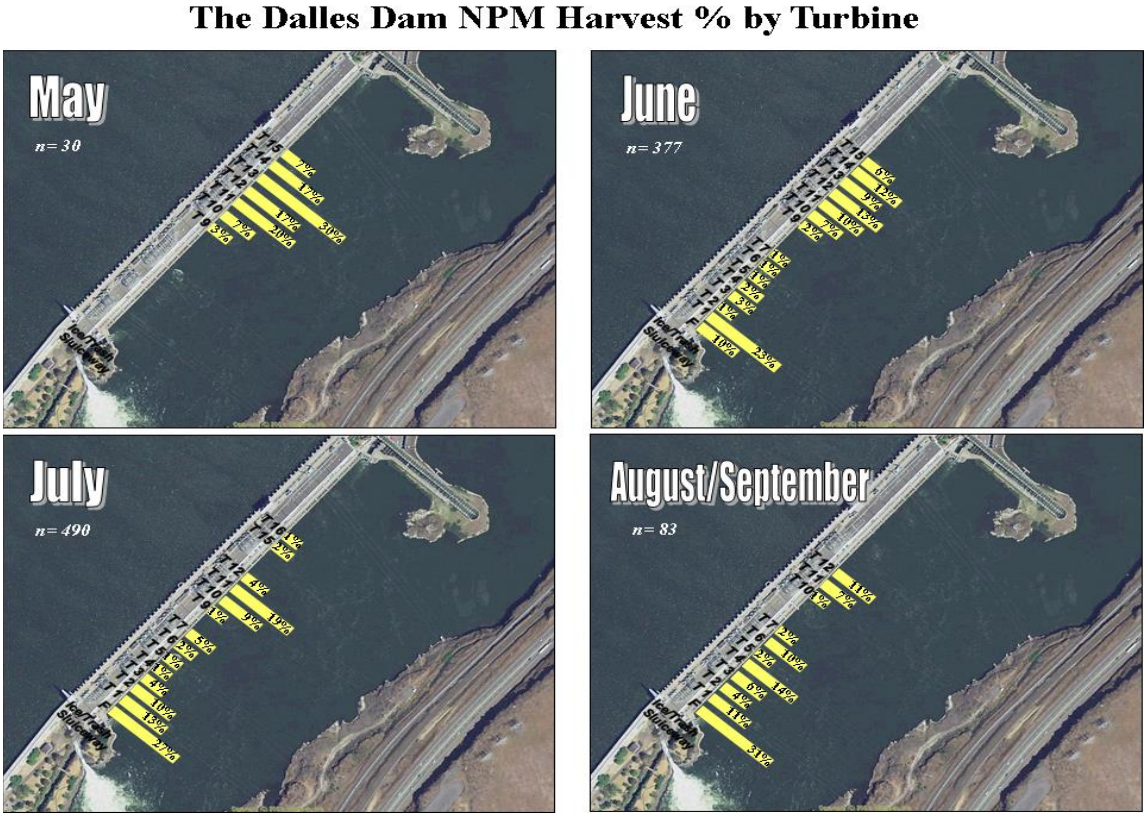

Figure 13. 2020 Monthly harvest percent (*rounded) by area at The Dalles Dam (T=turbine#, F = fishway)

When we look at Northern Pikeminnow harvest at The Dalles Dam during the 2020 Dam Angling season, our harvest data showed some variability in productivity over the course of the May-September Dam Angling season (Figure 13). In general, 2020 data continued to show the highest concentrations of Northern Pikeminnow were harvested near Turbine 1 (T1) in June and July, then more scattered harvest during the rest of the season.

Incidental Catch

While the Dam Angling crew did not target fish species other than Northern Pikeminnow in 2020, they did catch 116 Smallmouth Bass and 15 Walleye at The Dalles Dam in 2020 (Figure 14). Turbine 1/ Fishway locations had the highest catches of Smallmouth Bass (Figure 16) and all Smallmouth Bass and Walleye caught were scanned for PIT tags and released. No PIT tags from ingested salmonids were recovered from Smallmouth Bass or Walleye at The Dalles Dam in 2020.

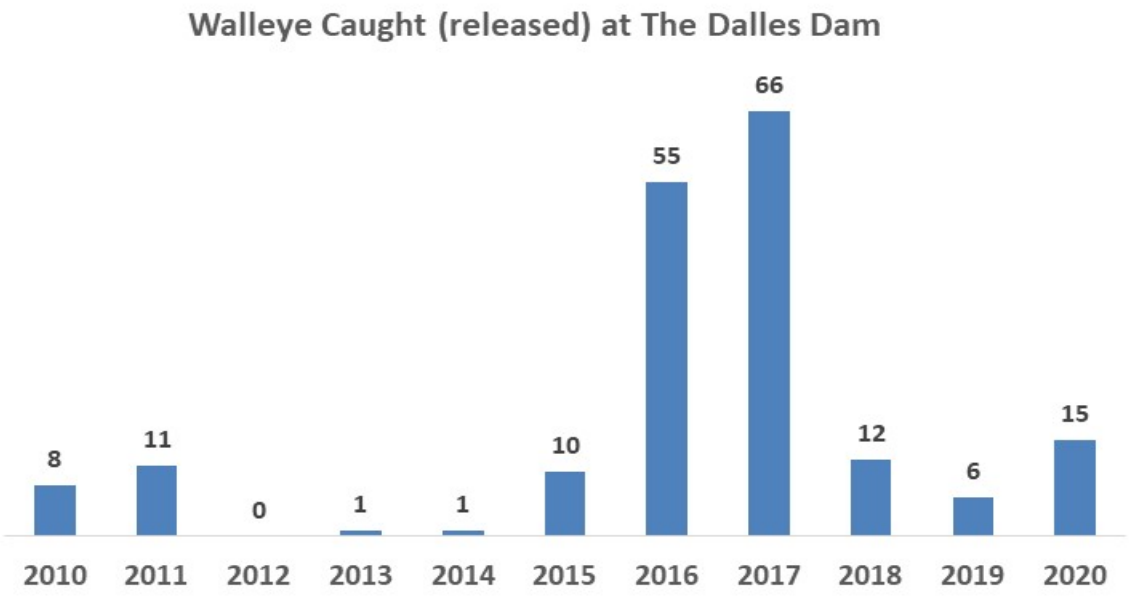

Figure 14. 2020 Annual Dam Angler catch of Walleye at The Dalles Dam

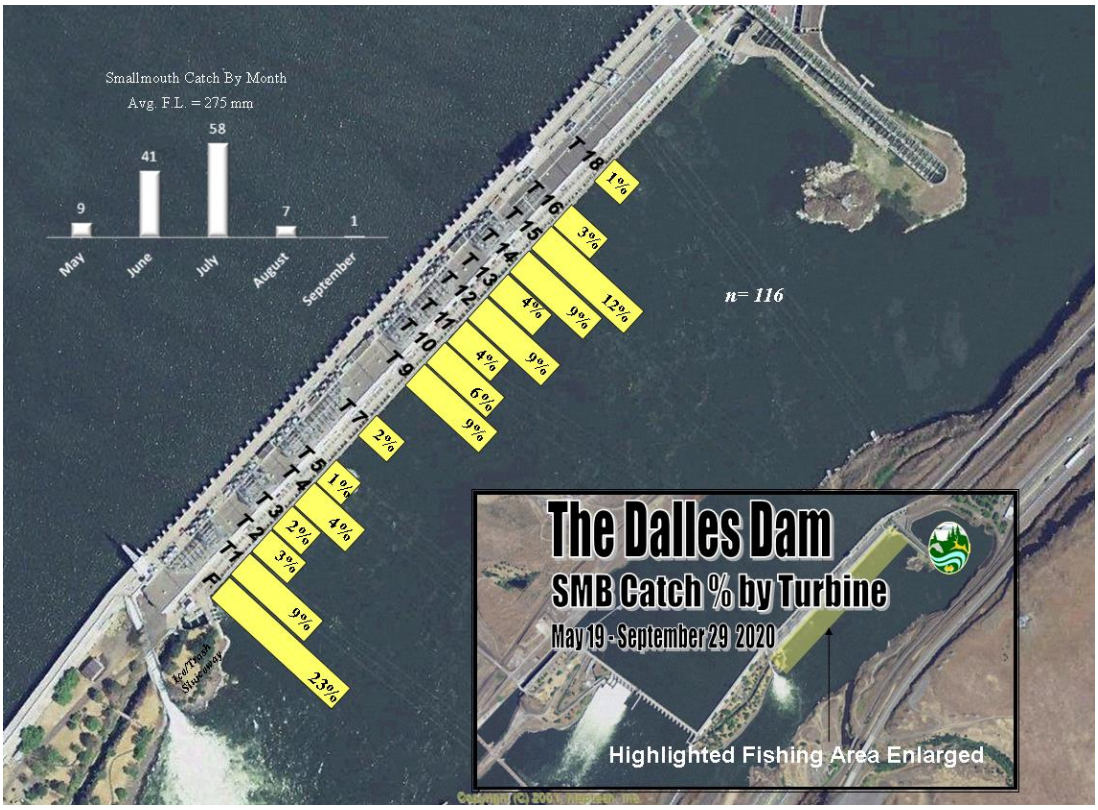

Figure 15. 2020 Incidental catch of Smallmouth Bass (*rounded) by Dam Angling Crew at The Dalles Dam

Effort

Total angler hours of effort at The Dalles Dam decreased to 538.8 hours in 2020 from 620.4 hours in the 2019 Dam Angling season (Winther et al. 2020). The Dam Angling crew fished 51 days at The Dalles Dam over 20 weeks and spent 42% of total Dam Angling effort at The Dalles Dam in 2020.

CPUE

The Dam Angling crew harvested 980 Northern Pikeminnow in 538.8 angler hours at The Dalles Dam in 2020 for an overall average CPUE of 1.8 fish/angler hour, down from 3.6 in 2019 (Winther et al. 2020). Peak weekly CPUE at The Dalles Dam occurred during week 25 (Figure 16). Unfortunately, **c**hallenging conditions related to the Covid-19 pandemic early in the year and typical unfavorable river conditions late in the 2020 season resulted in overall CPUE at The Dalles Dam exceeding the 2.0 fish/angler hour goal for only 6 of the 20 weeks fished (no effort was spent in week 23).

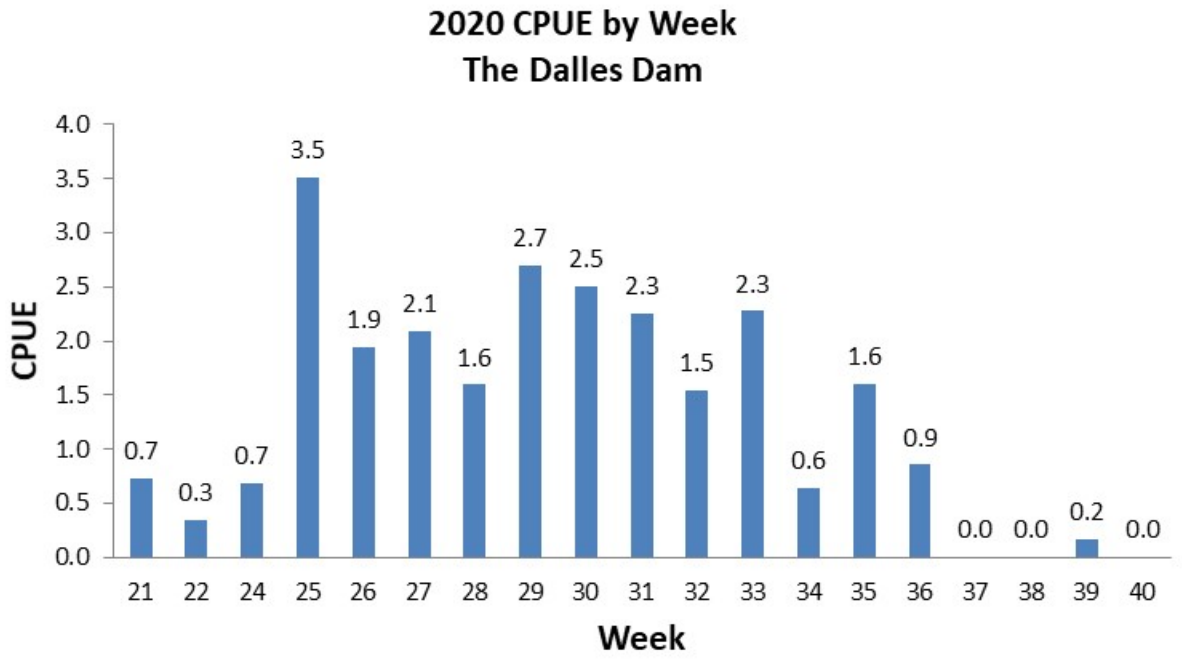

Figure 16. 2020 Weekly Dam Angler CPUE at The Dalles Dam

Fork Length Data

Fork lengths were recorded from 980 (100%) Northern Pikeminnow harvested by the Dam Angling crew at The Dalles Dam during the 2020 Season. The length frequency distribution of Northern Pikeminnow harvested at The Dalles Dam in 2020 is presented in Figure 17. Mean fork length for Northern Pikeminnow caught by the Dam Angling crew at The Dalles Dam in 2020 was 395 mm (SD=61.2), up from 373 mm in 2019 (Winther et al. 2020). By comparison, the mean fork length for the 2020 NPSRF was 290 (Hone et al. 2021).

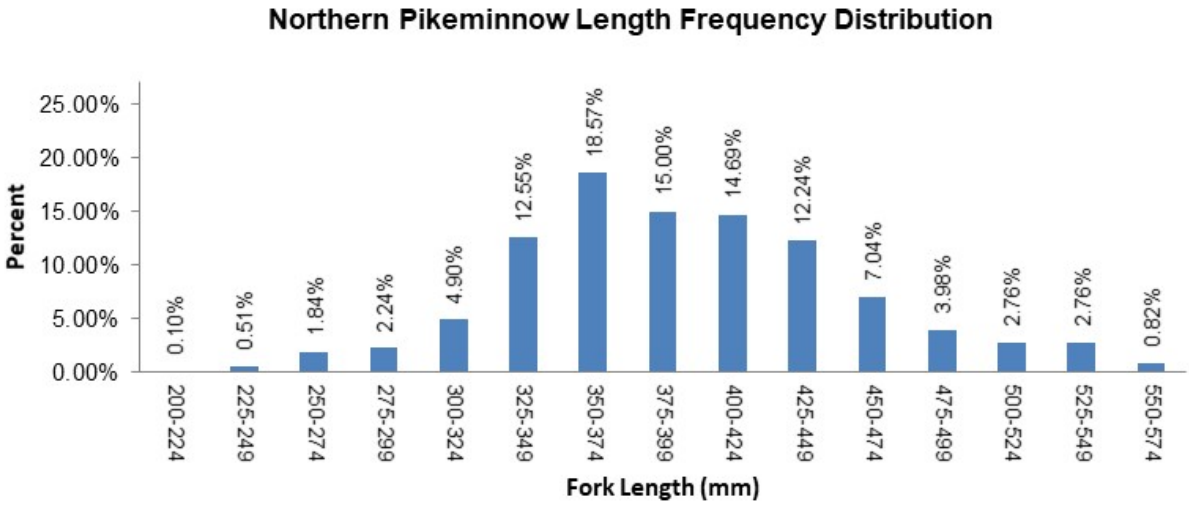

Figure 17. Northern Pikeminnow length frequency distribution at The Dalles Dam in 2020

John Day Dam

Harvest

The Dam Angling crew harvested 1,810 Northern Pikeminnow over 21 weeks at the John Day Dam in 2020. Weekly harvest averaged 86 fish per week and ranged from one fish in week 22 (no effort in week 23) to a peak of 440 in week 25 (June 15 – June 21) (Figure 18). Peak weekly harvest at the John Day Dam occurred in week 25 which was two weeks later than in 2019 (Winther et al. 2020) and the same week as for the 2020 Sport Reward Fishery (Hone et al. 2021). The 1,810 harvested Northern Pikeminnow included no external tags, but did include six tag-loss Northern Pikeminnow from ODFW's biological evaluation of the NPMP (Barr et al. 2021). We recovered 0 PIT tags from juvenile salmonids ingested by a Northern Pikeminnow at the John Day Dam in 2020.

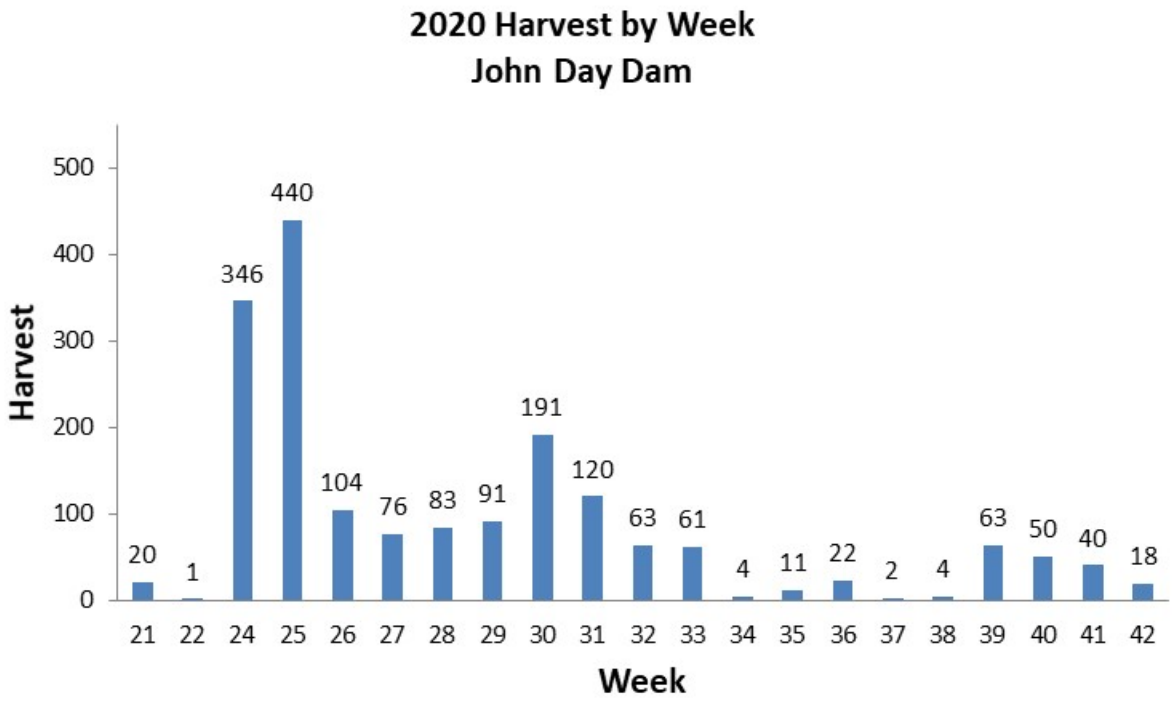

Figure 18. 2020 Weekly Dam Angler harvest of Northern Pikeminnow at the John Day Dam

Turbine #11 (T11) was the single best producing area at the John Day Dam in 2020 accounting for 21% of the total Northern Pikeminnow harvest (Figure 19). Harvest of Northern Pikeminnow peaked during week 25 in June and was best between T8 and T11 with 48% of total (Figure 20).

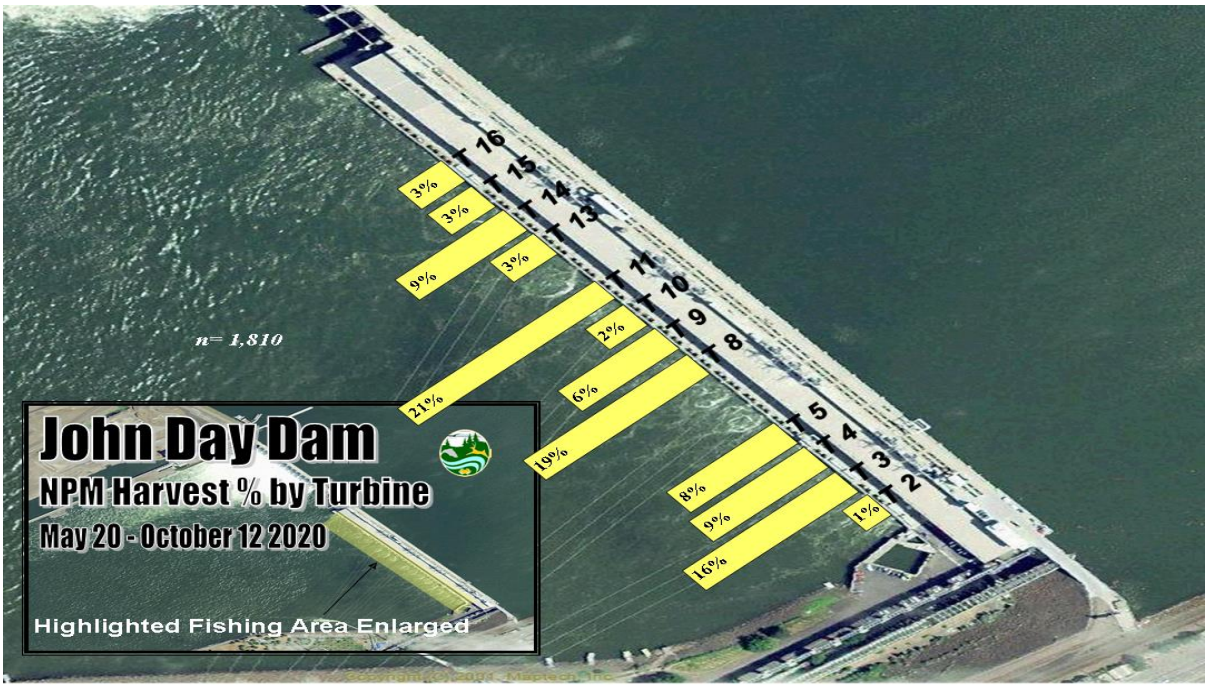

Figure 19. 2020 Overall percent of Northern Pikeminnow harvest by area (T=turbine#)

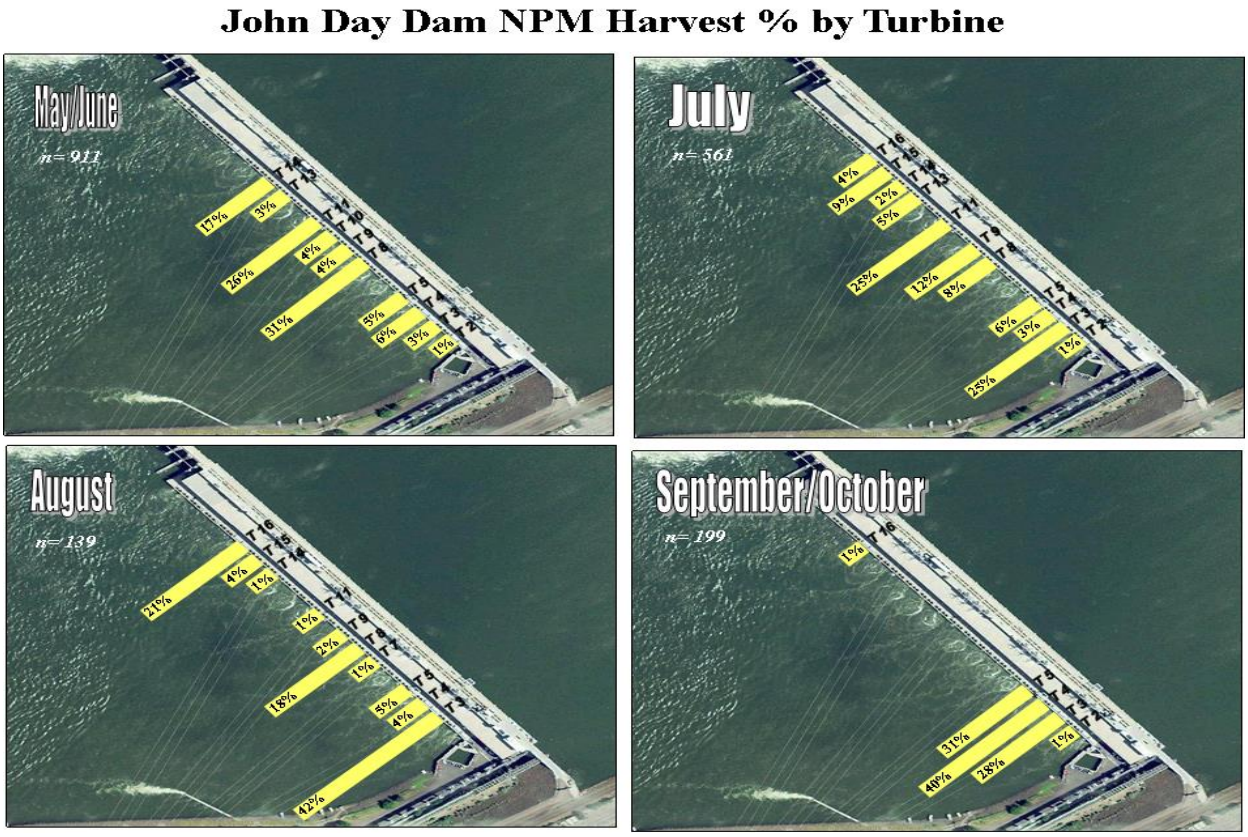

Figure 20. 2020 Monthly percent (*rounded) of Northern Pikeminnow harvest by area (T=turbine#)

Incidental Catch

The Dam Angling crew did not target fish species other than Northern Pikeminnow, but did catch and release 241 Walleye at the John Day Dam in 2020. (Figure 21). The Dam Angling crew also caught and released 633 Smallmouth Bass (smb) at the John Day Dam in 2020. All Walleye and Smallmouth Bass were scanned for PIT tags from ingested salmonids and two PIT tags were found from ingested juvenile salmonids recovered from two of the Smallmouth Bass. There were no recoveries from Walleye. Through PTAGIS queries, we were able to determine that this PIT tag was from a Hatchery Summer Chinook and a Hatchery Fall Chinook.

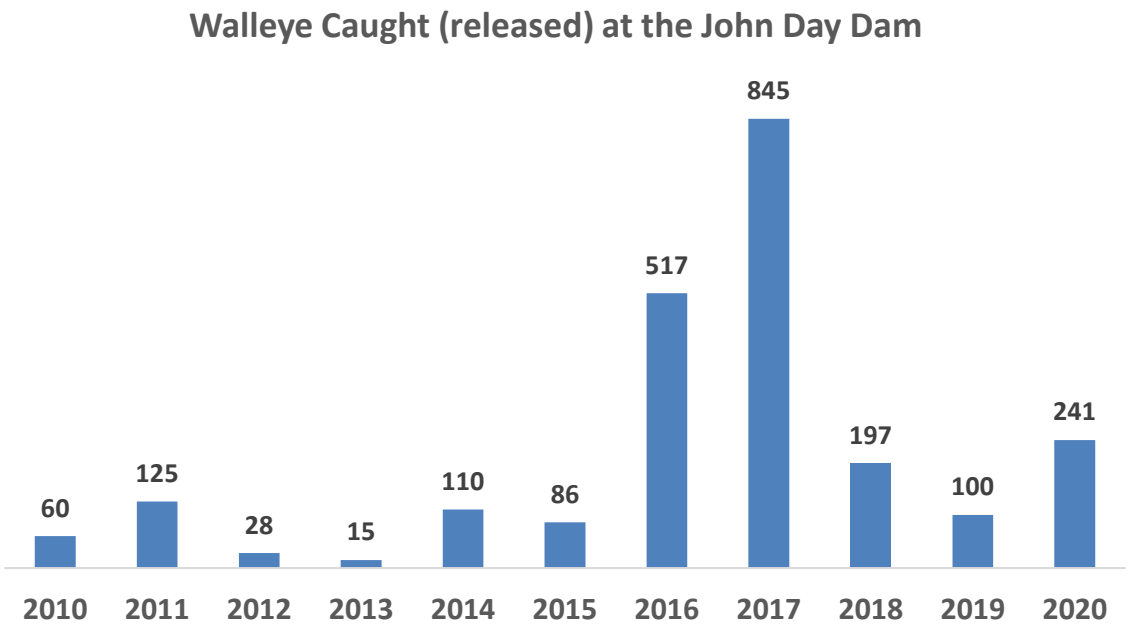

Figure 21. 2020 Annual Dam Angler catch of Walleye at the John Day Dam

Effort

Total effort at the John Day Dam was 755.5 angler hours in 2020, down from 760.5 hours in 2019 (Winther et al. 2020). The crew averaged a combined 36 angler hours of effort per week and 13 angler hours of effort per day at the John Day Dam in 2020. The Dam Angling crew spent 58% of total Dam Angling effort (58 days over 22 weeks) at the John Day Dam in 2020.

CPUE

The Dam Angling crew harvested 1,810 Northern Pikeminnow in 755.5 angler hours at the John Day Dam in 2020 for an overall average CPUE of 2.4 fish/angler hour, slightly down from the 2.5 CPUE in 2019 (Winther et al. 2020). Peak weekly CPUE at the John Day Dam occurred during week 24 and there was no effort spent at the John Day Dam in week 23 (Figure 22). Peak

weekly CPUE at the John Day Dam occurred 1 week earlier than at The Dalles Dam and the overall CPUE goal of 2.0 fish/angler hour was met or exceeded 7 of the 22 weeks fished.

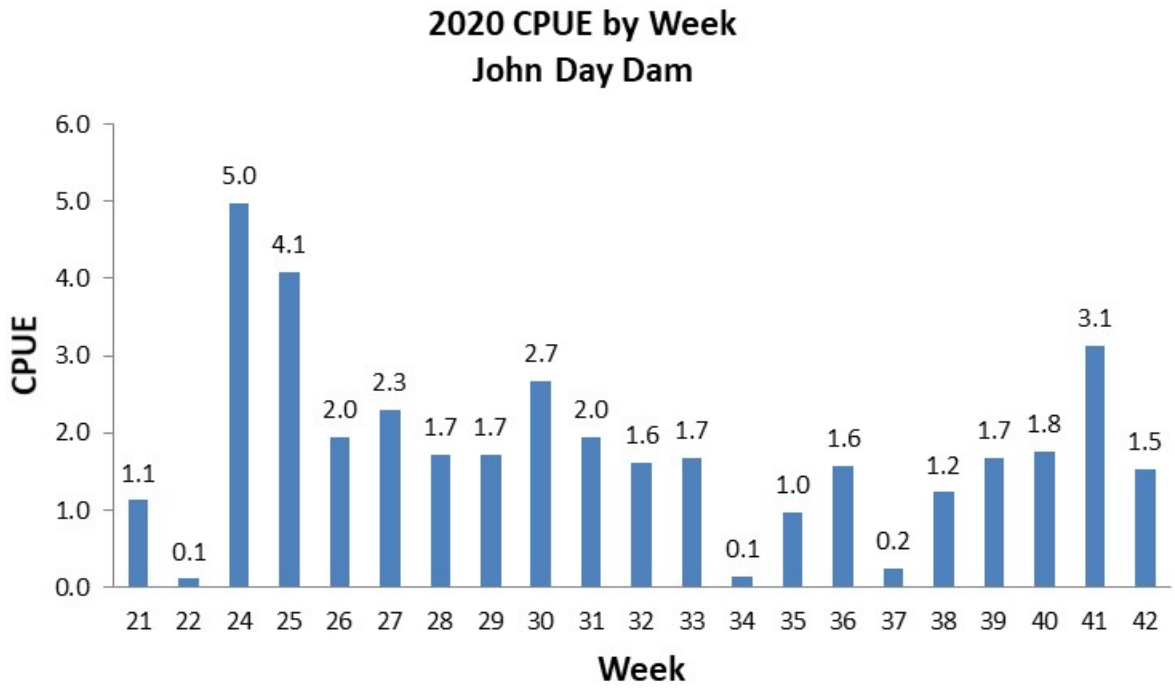

Figure 22. 2020 Weekly Dam Angling CPUE at John Day Dam

Fork Length Data

Fork lengths were recorded from 1,810 Northern Pikeminnow (100% of harvest) at the John Day Dam during the 2020 Dam Angling Season. The length frequency distribution of harvested Northern Pikeminnow from the John Day Dam in 2020 is presented in Figure 23. Mean fork length for Northern Pikeminnow from the John Day Dam in 2020 was 413 mm (SD=49) compared to 379 mm in 2019 (Winther et al. 2020). By comparison, 2020 mean FL for The Dalles Dam was 395 mm (SD=61.2) and for the 2020 NPSRF was 290 mm (Hone et al. 2021).

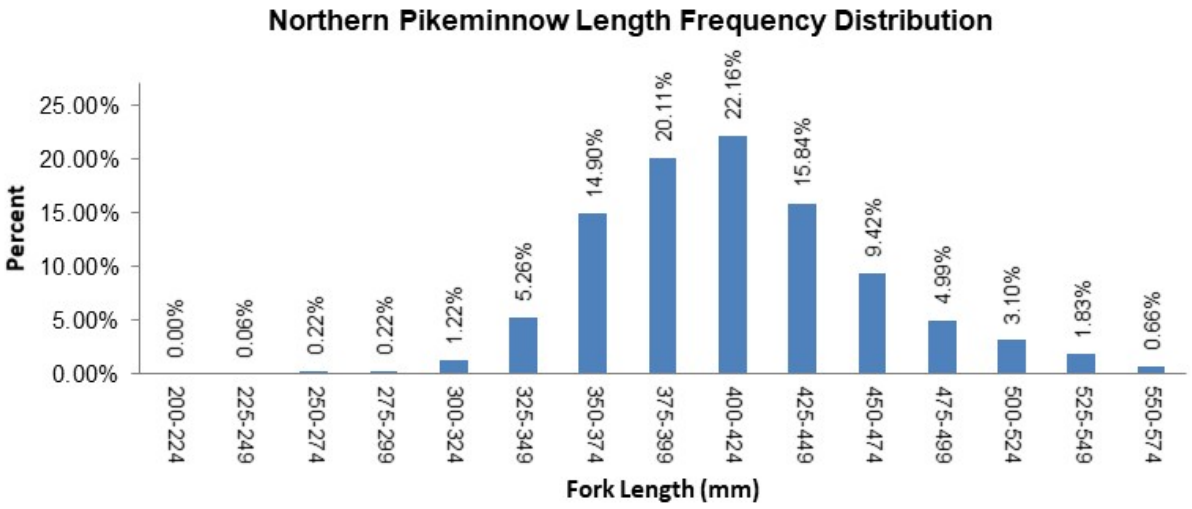

Figure 23. Northern Pikeminnow length frequency distribution at the John Day Dam in 2020

SUMMARY

The uncertainties surrounding the Covid-19 pandemic definitely had a negative impact on the 2020 Dam Angling season as crew only harvested 2,790 Northern Pikeminnow between The Dalles and John Day Dams combined, with 980 coming from The Dalles Dam and 1,810 from the John Day Dam. Overall harvest was lower than 2019 (Winther et al. 2020), and was the lowest total since WDFW began Dam Angling in 2010. Dam Angling was conducted for a 21 week season implemented from May 19th through October 12th 2020 and the loss of harvest during weeks 18-20 made it likely that harvest would be below average.

During the 2020 season, the Dam Angling crew spent 58% of their effort fishing at the John Day Dam and exceeded the 2.0 CPUE goal for only 7 of the 21 weeks of the 2020 Dam Angling season. Angling hours prior to 1:00 pm continued to be the most productive harvest times and the top producing lure for 2020 was the 3.75" Gitzit tube in Smoke/Black Copper Glitter color.

Fork lengths for Northern Pikeminnow harvested by the 2020 Dam Angling Crew at The Dalles and John Day dams were considerably larger than the mean fork length for the NPSRF (395 mm at The Dalles Dam, 413 mm at John Day, and 290 mm from the 2020 NPSRF). The Dam Angling Crew recovered no spaghetti tagged, and 11 tag-loss Northern Pikeminnow in 2020. We recovered two PIT tags from salmonids ingested by harvested Northern Pikeminnow and the occurrence rate for ingested PIT tags 1:1,395. There were 2 salmonid PIT tags recovered from incidentally caught Smallmouth Bass.

While targeting Northern Pikeminnow, the 2020 Dam Angling crew incidentally caught a combined total of 749 Smallmouth Bass, 256 Walleye, 57 American Shad, 31 Sculpin, and 20 Channel Catfish between the two projects.

RECOMMENDATIONS FOR 2021

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

2.) 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. Consider offering Dam Angler assistance to other research projects wishing to obtain Northern Pikeminnow and other fishes from BRZ areas in order to determine feasibility and as a possible initial step to adding additional dams to the DA project.

3.) Plan for 2021 Dam Angling activities to conduct the standard May-September Dam Angling season with a focus on maximizing effort during peak harvest weeks.

4.) Continue to utilize the 2.0 CPUE goal to determine and allocate Dam Angler effort between projects in order to maximize 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 2021.

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

7.) Continue to investigate and further develop Northern Pikeminnow angling techniques in 2021 (such as “heavying up” effort) in order to improve Dam Angler CPUE and/or allow exploitation of Northern Pikeminnow in areas not currently fishable.

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

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APPENDIX A
Top 5 lures used by 2020Dam Angler

Type- Canyon Plastic 3 3/4" Original Gitzit Tube

Color- Smoke/Black & Copper Glitter

#1

Type- Gitzit Incorporated 3.5" Injected Molded Tube

Color– Pearl/Black Smoke Purple Sparkle

#2

Type- Canyon Plastic 3 3/4" Original Gitzit Tube

Color- Smoke/Black Red Glitter

#3

Type- Gitzit Incorporated 3.5" The Original Fat Gitzit

Color- Smoke Sparkle

#4

Type- Canyon Plastic 3 3/4" Original Gitzit Tube

Color– Pearl White/Black Back

#5