Grant County
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March 30, 2020

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
Mail Code: DHAC, PJ-12
888 First Street, N.E.
Washington, D.C. 20426

RE: Priest Rapids Hydroelectric Project No. 2114-192
License Compliance Filing – Article 401(a)(11) – 2019 White Sturgeon Management Plan Annual Report

Dear Secretary Bose,

Please find enclosed Public Utility District No. 2 of Grant County, Washington (Grant PUD) 2019 White Sturgeon Management Plan (WSMP) Annual Report consistent with the requirements of Article 401(a)(11) of the Priest Rapids Project License[1] and the Washington State Department of Ecology (Ecology) 401 Water Quality Water Quality Certification Condition of 6.2(5)(b) and 6.2(5)(d) for the Priest Rapids Project (Project).

The study objectives and tasks which were completed under the 2019 Monitoring and Evaluation program (FERC License Year 12) were as follows:

1). Develop and implement a tagging, marking, and release plan for the 2018 Brood Year (BY) juvenile White Sturgeon based on the annual release target objectives as determined by the Priest Rapids Fish Forum (PRFF), and in accordance with stocking targets outlined in the Priest Rapids White Sturgeon Stocking Statement of Agreement (SOA) dated March 11, 2016. Under the SOA, revised hatchery juvenile White Sturgeon annual stocking targets were established for years 2017 (FERC License Year 10 of the WSMP) to 2020 (Year 13). The release numbers, locations, and strategies used in 2019 (Year 12) during the 2018BY release are provided.

2). Collect broodstock from John Day Reservoir downstream of McNary Dam. This work was conducted directly by Grant PUD and Public Utility District No. 1 of Chelan County, Washington (Chelan PUD), with coordination and data collection conducted by Blue Leaf Environmental (BLE). A summary of 2019 broodstock collection efforts is provided in Appendix A. Spawning of the broodstock captured in 2018 and subsequent rearing of the 2018BY progeny were conducted by personnel at the Yakama Nation Sturgeon Hatchery (YNSH) under contract to Grant PUD. This

[1] 123 FERC ¶ 61,049 (2008)

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2019 Grant PUD report summarizes the 2018 and 2019 hatchery activities as they pertain to the objectives of the 2019 M&E program.

3). Conduct a juvenile White Sturgeon mark and recapture program in September 2019 to estimate survival rate and the population abundance of hatchery juvenile sturgeon released to date. These data are needed to inform future annual release numbers in response to brood year specific abundance and survival estimates. Baited small-hook set line gear have been used since 2014 to capture hatchery juvenile White Sturgeon in the PRPA to estimate their survival and abundance (Golder 2015–2019). Sampling methods were standardized in 2016 and the same methodology was used in all subsequent years.

In 2019, Grant PUD fulfilled a licensing obligation to maintain an acoustic receiver array from License Year 2 to Year 11 to monitor the movement of acoustic-tagged juvenile and adult White Sturgeon in the Project area. During the 2019 M&E program, the acoustic telemetry monitoring study component was limited to the decommissioning of the telemetry array. Juvenile movement data have been summarized and reported on an annual basis since 2014; however, a comprehensive summary of adult movement data has not been conducted to date. From 2010 to 2015, adult White Sturgeon were implanted with acoustic tags to monitor movements during the spawning season and movements to overwintering areas. To fulfill adult movement monitoring objectives, as prescribed under the WSMP, adult White Sturgeon telemetry recorded since 2010 were summarized in this report.

On February 6, 2020, Grant PUD prepared and disseminated the draft 2019 WSMP Annual Report for a thirty day comment period to members of the PRFF, which includes Ecology, U.S. Fish & Wildlife Service (USFWS), Washington Department of Fish & Wildlife, Colville Confederated Tribes, Yakama Nation, the Columbia River Inter-Tribal Fish Commission, Bureau of Indian Affairs, Wanapum Indians, and the Confederated Tribes of the Umatilla Indian Reservation. Comments were received by the Yakama Nation and incorporated into the executive summary of the 2019 WSMP Annual Report. On March 19, 2020 Ecology approved the 2019 WSMP Annual Report (found in Appendix B of the WSMP Report).

FERC staff with any questions should contact Tom Dresser at 509-754-5088, ext. 2312, or at tdresse@gcpud.org.

Sincerely,

Ross Hendrick

Ross Hendrick
Senior Manager – Environmental Affairs

Cc: Breean Zimmerman – Ecology
Priest Rapids Fish Forum

2019
White Sturgeon Management Plan
Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

Prepared for:

Public Utility District No.2 of Grant County
P.O. Box 878
Ephrata, WA 98823

Prepared by:

Golder Associates Ltd.
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Castlegar, British Columbia, CA

March 2020

Thanks are extended to our partners and contributors in this project as follows:

Chris Mott	Grant PUD
Paul Grutter	Golder Associates Ltd.
Sima Usvyatsov	Golder Associates Ltd.
Dustin Ford	Golder Associates Ltd.
Corey Wright	Blue Leaf Environmental
Julie Harper	Blue Leaf Environmental

We wish to specifically acknowledge and thank Chris Mott and his staff for coordinating and fabricating the adult and juvenile White Sturgeon sampling gear used in this study.

List of Abbreviations

401 Certification	Washington Department of Ecology Section 401 Water Quality Certification for the Priest Rapids Project
BY	Brood Year
Chelan PUD	Public Utility District No. 1 of Chelan County, Washington
CPUE	Catch-Per-Unit-Effort
CRITFC	Columbia River Intertribal Fisheries Commission
CBH	Columbia Basin Hatchery
Ep	Proportion of Positive Catch
FERC	Federal Energy Regulatory Commission
FL	Fork Length
Grant PUD	Public Utility District No. 2 of Grant County, Washington
GRTS	Generalized Random-Tessellation Stratified
YNSH	Yakama Nation Sturgeon Hatchery
M&E	Monitoring and Evaluation
PI	Egg Polarization Index
PIT	Passive Integrated Transponder
PRPA	Priest Rapids Project area (Project area)
PRFF	Priest Rapids Fish Forum
PTAGIS	PIT-tag Information System
RISFWC	Rock Island Forebay Waterbird Colony
RM	River Mile
SOA	Statement of Agreement
UCWSRI	Upper Columbia White Sturgeon Recovery Initiative
UTM	Universal Transverse Mercator
WSMP	White Sturgeon Management Plan

Executive Summary

Wanapum Dam and Priest Rapids Dam are located in the mid-Columbia River region in the Priest Rapids Project area (PRPA or the "Project area") and are owned by Public Utility District No. 2 of Grant County, Washington (Grant PUD). On April 17, 2008, the Federal Energy Regulatory Commission (FERC) issued Grant PUD a 44-year license (FERC No. 2114) to operate the Priest Rapids Project. Included in the Washington Department of Ecology Section 401 Water Quality Certification for the Project (401 Certification), Article 401 of the FERC license requires Grant PUD to conduct a Monitoring and Evaluation (M&E) program to evaluate the effect of Project operations on White Sturgeon (*Acipenser transmontanus*) populations within the PRPA and the effectiveness of the supplementation program.

During 2019, (FERC License Year 12 under the 2019 M&E program), conservation aquaculture continued to provide viable hatchery juvenile White Sturgeon for release into the Project area. Adult broodstock collected below McNary Dam in 2018 were spawned, and the resultant juvenile brood were reared at the Yakama Nation Sturgeon Hatchery (YNSH). Due to the detection of autopolyploidy in some fish, which resulted in the culling of two of the five 2018BY maternal families, the number of juvenile fish available for release in 2019 was less than the annual release target of 3,250 fish. Only 2,657 fish from the 2018BY were released in Wanapum Reservoir (1,767 fish) and Priest Rapids Reservoir (890 fish) on May 7, 2019. Similar to previous juvenile brood releases, approximately 31% of the 2018BY (831 fish) had one or more fin deformities. Adult broodstock collection efforts in 2019 captured five females and five males that were spawned at YNSH which produced 24 genetically districted family crosses (four unique crosses and 20 half-sibling crosses) of 2019BY for release in 2020.

Telemetry data from acoustic-tagged adult White Sturgeon, recorded from July 29, 2010 to May 2, 2019, were analyzed to determine the seasonal movements of adult White Sturgeon in Wanapum and Priest Rapids reservoirs. Movement data from 72 individually tagged fish monitored from 2010 to 2019 suggest that a naturally reproducing population of White Sturgeon exists within Wanapum Reservoir, with individuals exhibiting consistent seasonal movements between overwintering and spawning locations on an annual basis. Of the 13 tagged adult White Sturgeon in Priest Rapids Reservoir, seasonal movements within the reservoir were less evident, and most fish maintained long-term residency in the Wanapum Dam tailrace.

The 2019 juvenile population indexing program was based on small hook set line sampling, and the overall study design and sample effort were identical to previous studies conducted since 2016. In total, 316,349 hook-hours of set line sample effort was expended. Overall CPUE in the Project area was 0.20 fish/100 hook-hours, with higher CPUE recorded in Wanapum Reservoir (0.24 fish/100 hook-hours) than Priest Rapids Reservoir (0.09 fish/100 hook-hours). In both reservoirs, the highest CPUEs were recorded in the middle section of each reservoir, followed by the upper section, with the lowest CPUE recorded in the lower section of each reservoir. The proportion of positive catch (Ep) was substantially higher in Wanapum Reservoir (all sections, Ep = 0.70) than in Priest Rapids Reservoir (all sections, Ep = 0.33) due to the high percentage of overnight set lines in Priest Rapids Reservoir that resulted in no catch (66.7%) compared to Wanapum Reservoir (30.1%).

In Wanapum Reservoir, 566 fish were captured, with the 2013BY (n = 166 of 566 fish) and 2014BY (n = 132) the dominant brood years caught, followed by 2012BY (n = 71), 2017BY (n = 62), 2015BY (n = 43), 2010BY (n = 37), 2018BY (n = 14), 2016BY (n = 11), and hatchery fish

of unknown origin (n = 16). The remainder of the Wanapum catch consisted of low numbers of wild juvenile White Sturgeon (n = 6) and 2002BY (n = 8). In Priest Rapids Reservoir, only 73 fish were captured, with slightly higher numbers of 2013BY (n = 19), 2012BY (n = 15), and 2014BY (n = 13) captured and low numbers of 2010BY (n = 5), 2015BY (n = 5), 2017BY (n = 5), 2018BY (n = 4), 2016BY (n = 3), and hatchery fish of unknown origin (n = 4). Wild fish and 2002BY fish were not captured in Priest Rapids Reservoir in 2019.

Of fish captured, fork length (FL) ranged from 31.0 to 147.5 cm FL (mean = 65.3 cm FL; n = 548) in Wanapum Reservoir and from 33.0 to 99.0 cm FL (mean = 59.6 cm FL; n = 72) in Priest Rapids Reservoir. In Wanapum Reservoir, fish weight ranged from 185 to 13,240 g (mean = 1,994 g; n = 619). In Priest Rapids Reservoir, the range was smaller, with the smallest fish at 230 g and the largest at 8,700 g (mean = 1,620 g; n = 76). The difference in size range between the two reservoirs was due, in part, to low numbers of larger 2002BY in Wanapum Reservoir. Overall, the length-frequency histograms of brood years 2010BY through 2018BY captured in Wanapum and Priest Rapids reservoirs were similar, and size ranges of hatchery brood year releases overlapped. A substantial increase in growth of all brood years of hatchery juvenile White Sturgeon was evident in 2019 compared to previous indexing studies. The higher growth rates recorded in 2019 were likely attributed to either lower energetic requirements or better feeding opportunities due to below average flows in 2019.

The 2019 catch of hatchery fish that were at-large for one or more years (i.e. the 2010BY through 2017BY releases) was sufficient to model first year and post-first year survival and recapture probabilities and provide estimates of total juvenile hatchery White Sturgeon abundance for both Wanapum and Priest Rapids reservoirs. The highest mean survival estimates were recorded for the 2013BY (in Priest Rapids – 0.463 first year, 0.819 all subsequent years), with slightly lower survival estimates recorded for the 2010BY (0.461, 0.817) and 2012BY (0.389, 0.769). For brood years released from 2015 to present, a notable decline in survival was evident, with survival estimates for the 2014BY (0.300, 0.691), 2015BY (0.259, 0.645), and 2016-2017 brood years (0.178, 0.818; combined due to low catch) releases substantially lower than the preceding brood years. With the release of the 2018BY, the 2019 hatchery fish abundance estimate in Wanapum Reservoir was 5,262 (95% CI = 4,164 – 6,360) or 19.4% of total hatchery releases to date (n = 27,132 fish). In Priest Rapids Reservoir, the 2019 hatchery fish abundance estimate was 2,239 fish (95% CI = 1,737– 2,741) or 19.6% of total hatchery releases to date (n = 11,446 fish).

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1.0 Introduction

Wanapum Dam and Priest Rapids Dam are located in the mid-Columbia River region in the Priest Rapids Project area (PRPA or the "Project area") and are owned by Public Utility District No. 2 of Grant County, Washington (Grant PUD). On April 17, 2008, the Federal Energy Regulatory Commission (FERC) issued Grant PUD a 44-year license (FERC No. 2114) to operate the Priest Rapids Project. As part of the Washington Department of Ecology Section 401 Water Quality Certification for the Project (401 Certification), Article 401 of the FERC license requires Grant PUD to conduct a Monitoring and Evaluation (M&E) program to evaluate the effect of Project operations on White Sturgeon (*Acipenser transmontanus*) populations within the PRPA.

In response, Grant PUD developed a White Sturgeon Management Plan (WSMP), with the overarching goal to restore and maintain White Sturgeon populations to levels commensurate with the available aquatic habitat in the PRPA. Restoration of the White Sturgeon population was to be achieved primarily through conservation aquaculture and the annual release of hatchery-raised juvenile White Sturgeon into the Project area over a 25-year supplementation period. As identified in the WSMP, the main objectives and timeline of studies to be conducted under the M&E program were a determination of the following: 1) the effectiveness of the supplementation program; 2) the carrying capacity of habitat in the Project; and 3) the level of natural recruitment of White Sturgeon in the Project area. On an annual basis, the M&E program study results are reviewed and, if needed, programs are modified under the auspice of adaptive management, based on the best available information and consensus with stakeholders and regulators. This report summarizes the 2019 M&E program developed as part of this ongoing evaluation effort.

The study objectives and tasks which were completed under the 2019 M&E program (FERC License Year 12) were as follows:

1). Develop and implement a tagging, marking, and release plan for the 2018 Brood Year (BY) juvenile White Sturgeon based on the annual release target objectives as determined by the Priest Rapids Fish Forum (PRFF), and in accordance with stocking targets outlined in the Priest Rapids White Sturgeon Stocking Statement of Agreement (SOA) dated March 11, 2016. Under the SOA, revised hatchery juvenile White Sturgeon annual stocking targets were established for years 2017 (FERC License Year 10 of the WSMP) to 2020 (Year 13). The release numbers, locations, and strategies used in 2019 (Year 12) during the 2018BY release are provided.
2). Collect broodstock from John Day Reservoir downstream of McNary Dam. This work was conducted directly by Grant PUD and Public Utility District No. 1 of Chelan County, Washington (Chelan PUD), with coordination and data collection conducted by Blue Leaf Environmental (BLE). A summary of 2019 broodstock collection efforts is provided in Appendix A. Spawning of the broodstock captured in 2018 and subsequent rearing of the 2018BY progeny were conducted by personnel at the Yakama Nation Sturgeon Hatchery (YNSH) under contract to Grant PUD. This 2019 Grant PUD report summarizes the 2018 and 2019 hatchery activities as they pertain to the objectives of the 2019 M&E program.

3). Conduct a juvenile White Sturgeon mark and recapture program in September 2019 to estimate survival rate and the population abundance of hatchery juvenile sturgeon released to date. These data are needed to inform future annual release numbers in response to brood year specific abundance and survival estimates. Baited small-hook set line gear have been used since 2014 to capture hatchery juvenile White Sturgeon in the PRPA to estimate their survival and abundance (Golder 2015–2019). Sampling methods were standardized in 2016 and the same methodology was used in all subsequent years.

In 2019, Grant PUD fulfilled a licensing obligation to maintain an acoustic receiver array from License Year 2 to Year 11 to monitor the movement of acoustic-tagged juvenile and adult White Sturgeon in the Project area. During the 2019 M&E program, the acoustic telemetry monitoring study component was limited to the decommissioning of the telemetry array. Juvenile movement data have been summarized and reported on an annual basis since 2014; however, a comprehensive summary of adult movement data has not been conducted to date. From 2010 to 2015, adult White Sturgeon were implanted with acoustic tags to monitor movements during the spawning season and movements to overwintering areas. To fulfill adult movement monitoring objectives, as prescribed under the WSMP, adult White Sturgeon telemetry recorded since 2010 were summarized in this report.

The Priest Rapids Project Area

The PRPA is approximately 99 km long (61.5 miles), with the upstream boundary defined by Rock Island Dam (River Mile [RM] 453.0 and downstream boundary defined by Vernita Bar (RM392.0) below Priest Rapids Dam (Figure 1). The Project encompasses two reservoirs, Wanapum and Priest Rapids reservoirs, and a short riverine section of McNary Reservoir below Priest Rapids Dam. Wanapum Reservoir, situated between Rock Island Dam (RM453.0) and Wanapum Dam (RM415.0), is the largest reservoir in the Project area and is approximately 61 km long (38 miles) and has a surface area of 5,904 hectares (14,590 acres). The second reservoir, Priest Rapids Reservoir, is located between Wanapum Dam and Priest Rapids Dam (RM397.0) and is approximately 29 km (18 miles) long with a surface area of 3,067 hectares (7,580 acres). The operation of Wanapum and Priest Rapids dams are coordinated with the operations with other upstream and downstream hydroelectric facilities on the Columbia River to regulate river discharge to provide water for power generation and non-power demands, such as environment, agricultural, recreational, and cultural use of water (Grant PUD 2000). Both dams operate as “run-of-the-river”, with approximately equal inflow and outflow discharge rates through both dams. Due to the large size of Wanapum Reservoir, approximately 138,400 acre-feet of the reservoir’s gross storage volume of 566,400 acre-feet can be used as active storage to opportunistically generate power at Wanapum Dam. During power production at Wanapum Dam, Wanapum Reservoir has a normal operating elevation range between 170.7 and 174.2 m (560.0 and 571.5 feet) and can be surcharged up to 175.3 m (575 feet). Priest Rapids Reservoir has a gross storage volume of 191,000 acre-feet, of which 31,000 acre-feet can be used as active storage. During power production at Priest Rapids Dam, Priest Rapids Reservoir has a normal operating elevation range between 146.8 and 148.7 m (481.5 to 488.0 feet) and can be surcharged up to 149.8 m (491.5 feet). Mean residence time of each reservoir is short (i.e., approximately 24-48 hours) and minimal vertical or longitudinal thermal stratification occurs in either reservoir (Grant PUD 2000).

For the purposed of study design and data analysis, each reservoir was divided into “lower”, “middle”, and “upper” sections (Figure 1). These section boundaries were determined based on coarse approximations of hydraulic and physical characteristics common to each section, which included water velocity, channel confinement, and the amount of inundated area beyond the original river channel confinement after impoundment. The section represented the transition from lotic conditions in the upper reservoir section, a transitional middle section where water velocity is reduced, to lentic conditions in the lower reservoir section where water velocity is low and other environmental factors, such as wind velocity, wind direction, and fetch become more relevant and have a substantial effect on ecosystem processes.

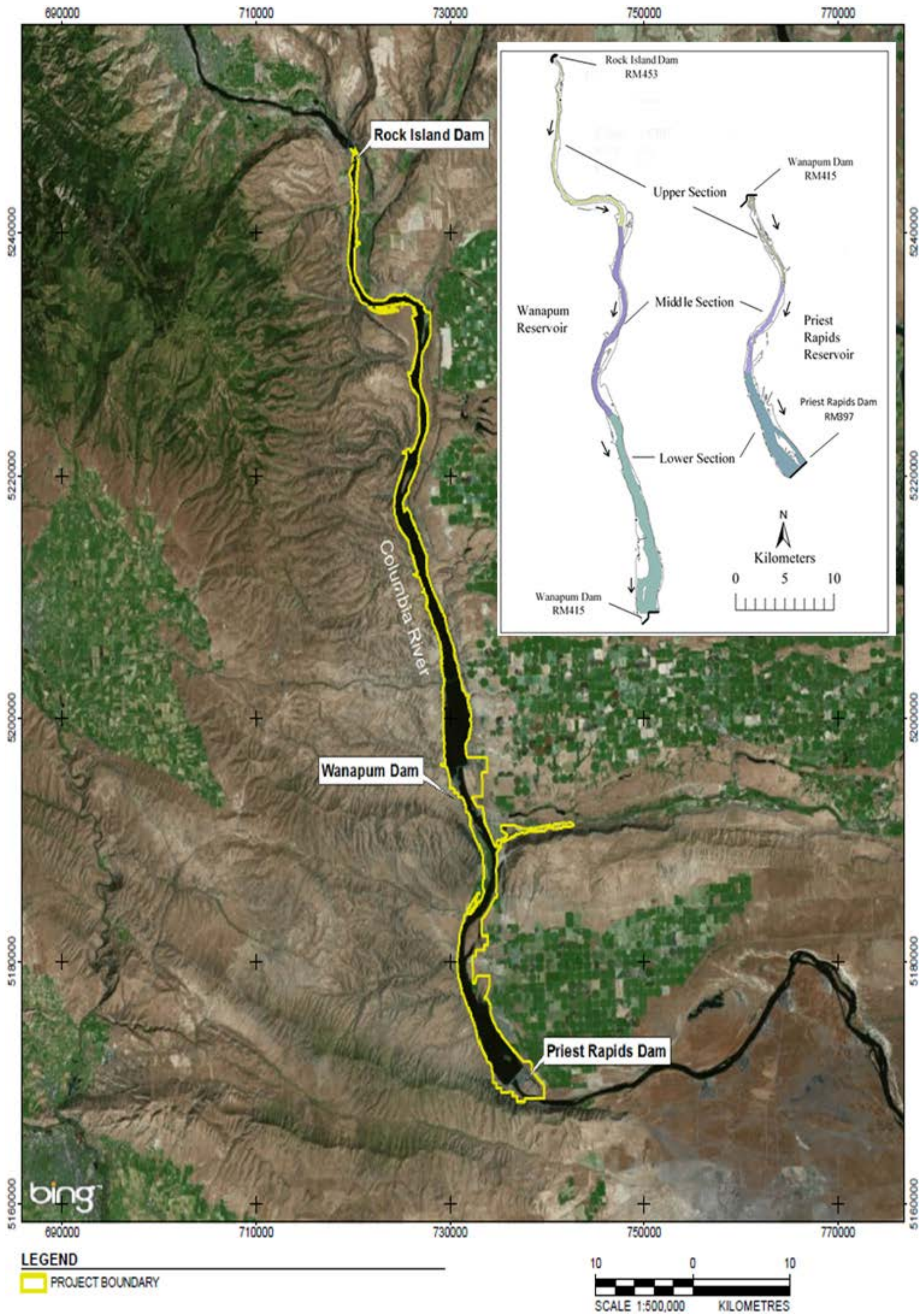


Figure 1 **The Priest Rapids Project area. Inset shows the location of the upper, middle, and lower sections in the Priest Rapids and Wanapum reservoirs.**

1.1 Consultation

Pursuant to the reporting requirements, Grant PUD provided a complete draft of the WSMP 2019 Annual Report to the PRFF on XXXX, 2020 for review. Written comments were received from WDFW and Colville Confederated Tribe on XXXX, 2020. A summary of written comments from the PRFF, as received by Grant PUD on the draft 2019 WSMP Comprehensive Annual Report, have been compiled along with responses from Grant PUD (Appendix X). The summary is based on review comments provided (Appendix X).

2.0 Methods

Study methods used in 2019 were similar to the 2018 study, with a similar approach and level of effort applied for the study components common to both years, which includes hatchery juvenile White Sturgeon tagging and release, and the juvenile White Sturgeon population indexing.

The following sections provide general descriptions of methods used and details where the 2019 methodology deviated from previous studies and where new methods or approaches were applied.

2.1 Environmental Variables

2.1.1 Discharge and Temperature

Total river discharge and temperature data recorded in the tailwater of Rock Island Dam were used to document these environmental variables within the PRPA during each study component. Mean hourly total river discharge and water temperature data from January 1 to December 25, 2019 were obtained from the Columbia River Data Access in Real Time webpage (DART 2019).

2.2 2018BY Rearing and Marking, and Release

Under the SOA; March 11, 2016, the annual release of hatchery White Sturgeon in the PRPA from 2016 to 2020 was established at 3,250 fish per year, with 62% (2,000 fish) released in Wanapum Reservoir and the remaining 38% (1,250 fish) released in Priest Rapids Reservoir. The 2018BY brood to be released were the progeny of a 5Fx5M spawning matrix conducted June 7, 2018 at YNSH. The progeny of each maternal family was kept segregated and grown over winter in five rearing pens. Prior to tagging and release of the 2018BY, each of the five maternal families was tested for the presence of spontaneous autopolyploidy during the week from April 1 to 5, 2019 by YNSH staff and researchers at UC-Davis. White Sturgeon with autopolyploidy have a chromosome count of 12N compared to 8N in natural White Sturgeon populations. Test results provided to the YNSH hatchery manager (Donella Miller) on April 5 confirmed that autopolyploidy was detected in two of the five maternal families (i.e., two families confirmed 12N and three families confirmed 8N). On April 8, after reviewing the test results and in consideration of the long-term genetic implications, a decision was made by the PRFF to not release fish from the two 12N families. The total number of fish produced from the three 8N families was estimated at approximately 2,850 fish. Consequently, the 2018BY release was approximately 400 fish fewer than the 3,250 annual release target as prescribed under the SOA.

All hatchery White Sturgeon received a 12.5 mm, 134.2 kHz ISO full-duplex Passive Integrated Transponder (PIT) tag (Biomark®) inserted on the left side of the fish at the base of the 4th dorsal scute, with the tag oriented with the body axis towards the head of the fish. All fish were externally marked as hatchery fish by removing the three left-lateral scutes anterior of an imaginary vertical line extended downward from the origin of the dorsal fin (Figure 2).

Acoustic-tags were not implanted into hatchery fish and was not required under Grant PUD's FERC license obligations in 2019.

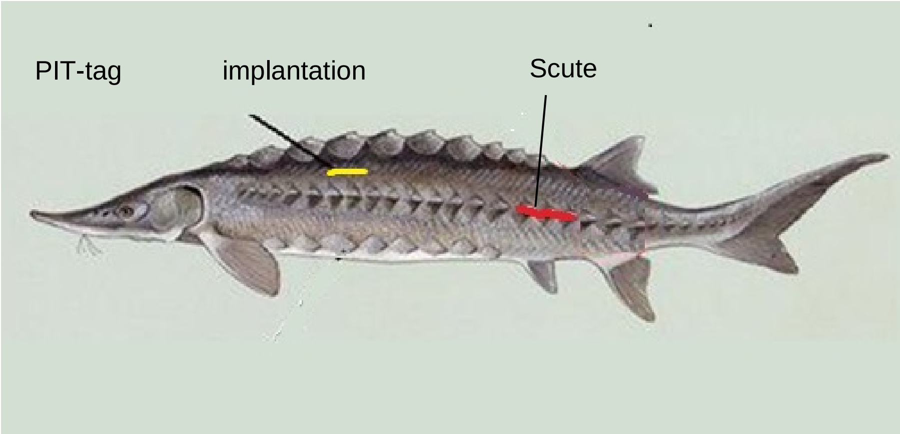


Figure 2 Juvenile white sturgeon tag implantation and mark locations.

Tagging logistics and data collection were coordinated by BLE, with assistance from YNSH staff during PIT-tagging and scute-marking activities. Data were recorded with a Biomark fish processing system and entered electronically into the Biomark P4 data processing program. BLE was responsible for implementing appropriate quality control/quality assurance protocols (e.g., fish handling and processing methods, daily data verification, and data backups) during fish processing and data recording. The data fields recorded were selected to document the genetic origin, holding and rearing conditions, morphometry, fin abnormalities, and the identifying tags and marks applied to each fish (Table 1).

Table 1 Data recorded for the 2018BY white sturgeon tagged and released in the Priest Rapids Project area in 2019.

Data Field	Description
Rec #	Sequential record number
Hatchery (Rearing)	Yakama Nation Sturgeon Hatchery (YNSH)
Proponent	Grant PUD
Tagging Date and Time (mm/dd/yyyy hh:mm)	Date and time when each fish was tagged
PIT-Tag Code	in HEX or DEC format
Species	White Sturgeon
Fork Length (mm)	Measured for all fish; tip of snout to tail fork (nearest 1 mm)
Weight (g)	Measured for all fish (nearest 1 g)
Brood Year Cross	2018
Rearing Pen-Stock Id	Parental Family
Release Pen	Wanapum or Priest Rapids Reservoir
Scute removal	3 left lateral scutes below and anterior to the dorsal fin
PIT-tag placement	left lateral, behind head
Notes	Recorded deformities and if the fish were in poor health

2018BY Releases

In 2019, juvenile White Sturgeon were held in the hatchery for approximately four weeks post-tagging to allow recovery from the tagging process. The release of 2018BY fish into the PRPA was coordinated by Grant PUD biologists and technicians, who worked with staff and equipment provided by YNSH and Grant PUD. Since 2015, fish destined for Wanapum Reservoir have been released at the Frenchman Coulee boat launch (RM424.5), while fish destined for Priest Rapids Reservoir have been released at the Wanapum Dam tailrace launch (RM415.6). Transport of the fish from the YNSH to the release sites was accomplished with a Grant PUD hatchery truck and White Sturgeon transport trailer. Fish were released from the transport vehicle to the river through either a flexible flume or chute to avoid damage to the fish. Buckets of water and nets were used to evacuate any remaining fish from the transport vehicle tanks. An effort was made to scare fish away from the wheels of the transport truck and trailer before they were driven out of the water.

Grant PUD biologists and field staff assisted with fish transfer and transport efforts. During the transfer, staff monitored water temperature and dissolved oxygen levels as follows:

- during fish transfer from holding pens to the transport vehicle at YNSH;
- during transport at a minimum of two scheduled check stops; and,
- during release of the fish.

Transport manifest forms were completed by field staff to record the above information, as well as the date and time of water quality checks and the arrival, release, and departure times during the transfer. Total travel time from the YNSH to the Project release sites was approximately

2 hours, with two water quality checks conducted approximately 40 minutes apart during transport.

2.3 Broodstock Capture

Since 2015, all broodstock capture efforts have been conducted outside of the PRPA, with the majority of effort conducted in John Day Reservoir, immediately downstream of McNary Dam. The 2019 White Sturgeon broodstock capture program was a collective effort of public utilities, government agencies, and consultants in support of the White Sturgeon conservation aquaculture program at YNSH. This capture effort consisted of guide-assisted angling conducted by BLE biologists, Chelan and Grant PUD personnel, and volunteers. Candidate broodstock were transported to YNSH by BLE staff using the Grant PUD's White Sturgeon transport trailer. Following transport to the hatchery, fish were weighed and transferred to a holding pen. Once contained within a holding pen, additional gonad inspections were conducted to determine egg maturity and in preparation for egg collection and fertilization efforts.

2.4 Juvenile White Sturgeon Population Indexing

The methods used during the 2019 juvenile White Sturgeon population indexing program were the same standardized methodology applied during the indexing studies conducted in 2016, 2017, and 2018 (Golder 2019). Juvenile White Sturgeon mark-recapture efforts were conducted with small-hook (2/0 and 4/0) set line sampling gear deployed in Wanapum and Priest Rapids reservoirs. Each set line was 122 m long and was deployed with 40 gangions spaced 3 m apart. Each gangion consisted of a swivel snap, a length of 150# monofilament leader, and either a 2/0 or 4/0 circle hook. Sampling was conducted in Wanapum Reservoir by Golder and BLE using separate research vessels to deploy gear and process fish. Sampling in Priest Rapids Reservoir was conducted by Grant PUD using a Grant PUD research vessel. Set lines were left to sample overnight and were retrieved and reset the following day.

Set line locations in 2019 were selected in an identical manner to previous study years using a single pass, unstratified, unequal probability general random-tessellation stratified (GRTS) sampling design (Stevens and Olsen 2004). The GRTS sample locations were determined with the spsurvey package (Kincaid 2007) developed for the R statistical program (R version 3.6.1; R Core Team 2019). The 2019 survey used the same sample multi-density reservoir categories ("lower", "middle", and "upper" sections) used in previous study years (Golder 2019). The Wanapum Reservoir GRTS sample sites were constrained to sections of the reservoir where water depth was typically 15 m or greater, based on available bathymetric data. In Priest Rapids Reservoir, site selection was constrained to the area encompassed within the ≥6 m bathymetric contour, consistent with previous GRTS sampling effort within Priest Rapids Reservoir. The sample depth criteria for each reservoir were selected to exclude shallow water areas within the lower, middle, and upper reservoir sections that exhibit dense aquatic macrophyte growth.

In Wanapum Reservoir, the spsurvey package specified a GRTS sample draw of 270 sites (with a 50% overdraw) with sites allocated equally among the three reservoir sections (i.e., 90 sites per section). In Priest Rapids Reservoir, the specified GRTS draw was 90 sites (with 50% overdraw) with sites allocated equally among reservoir sections (i.e., 30 sites per section). In both reservoirs, sampling intensity increased from downstream to upstream reservoir sections because the areal extent of each section progressively decreased moving upstream. In 2019, set line deployment and retrieval, catch processing, and data recording were conducted in a manner identical to the previous indexing studies in 2016, 2017, and 2018 (Golder 2019).

The relationship between White Sturgeon fork length (log10 transformed FL) and weight data was estimated via linear regression for each reservoir separately. Sturgeon condition was estimated by calculating relative weight based on the standard weight (Ws) equation for White Sturgeon: Ws = 2.735 E-6 * $FL^{3.232}$ (Beamesderfer 1993). Absolute growth (cm) in FL, and average annual growth rate (cm/year) in FL between tagging and capture was calculated for individual fish. For White Sturgeon caught more than once during the survey, data from the first capture was used in growth calculations. In addition to calculation of catch-per-unit-effort (CPUE) based on hook-hours (i.e., 1 hook set for 1 hour), the proportion of efforts where catch was greater than zero (Ep; Counihan et al. 1999; Bannerot and Austin 1983; Uphoff 1993), also referred to as the proportion of positive catch, was also calculated for comparisons of catch rate between the two reservoirs and reservoir sections within each reservoir.

2.5 Juvenile White Sturgeon Growth, Survival and Abundance Estimation

Mark-recapture data from sampling conducted during the juvenile White Sturgeon sampling programs since 2014 were used to construct a Cormack-Jolly-Seber model that was used to estimate survival of hatchery juveniles released in Wanapum and Priest Rapids reservoirs. The analysis was conducted using the statistical environment R v. 3.6.1 (R Core Team 2019), interfaced with Program MARK (White and Burnham 1999) through the package 'RMark' (Laake 2013). Fish tagged in Wanapum Reservoir that were subsequently captured in Priest Rapids Reservoir were not marked as "emigrated", since the analysis did not take into account reservoir of capture, only reservoir of release. Only hatchery fish released in the PRPA between 2011 and 2018 were included in the analysis. Wild fish and fish that were released elsewhere and entrained into the PRPA (e.g., fish originating in Rocky Reach) were removed from the analysis.

The models did not include any fish length or weight at release data, due to some release length/weight data missing from a subset of fish. The models assumed that all fish were released at age-1. Models were constructed using all combinations of the following survival and recapture specifications:

a) Survival:
    a. as an additive function of brood year and first year post-release and all subsequent years.
    b. as an additive function of release reservoir, brood year, and whether the period was in the first year post release or in all subsequent years.
b) Recapture:
    a. as multiplicative function of release reservoir and age.
    b. as multiplicative function of brood year and age, with an additive effect of release reservoir.
    c. as multiplicative function of brood year and sampling occasion, with an additive effect of release reservoir.
    d. as multiplicative function of release reservoir, brood year, and sampling occasion.

The 2016 and 2017 brood year data were combined into a single dataset, 2016-2017BY, to resolve issues with model convergence. In addition, the recapture of 2016-2017BY in 2019 was fixed to a constant value of 0.107 in Wanapum and 0.034 in Priest Rapids to assist with convergence. These values represent the mean estimates of age-2 recapture probabilities based on the 2018 analysis (Golder 2019).

The candidate models were evaluated using quasi-likelihood-adjusted Akaike's Information Criterion corrected for small sample size (QAICc), where a lower value indicates better support for the model. The full model set was then model-averaged to provide estimates of survival and recapture values. The survival estimates were used to calculate cumulative mean annual population values, with 95% confidence intervals, to describe the abundance of hatchery juvenile White Sturgeon released in the PRPA for each calendar year from 2011 to 2019. Estimation of survival was only possible for brood year releases with one or more years at large and could not be estimated for the 2018BY released in 2019. To account for the 2018BY abundance, the number of 2018BY fish released in 2019 was used as the abundance of that brood year.

2.6 Telemetry Receiver Array Download and Maintenance

Between 2010 and 2019, up to 12 acoustic telemetry receivers (Amirix Vemco model VR2W®) were deployed in the PRPA to monitor the movements of acoustic-tagged adult and hatchery juvenile White Sturgeon (Table 2). With the completion of the last year of juvenile White Sturgeon acoustic tagging and movement monitoring FERC license obligation in 2018, the acoustic telemetry receivers were removed on May 1 and 2, 2019. At stations where an anchored float-mooring system was used to deploy a receiver (i.e., designated LD2 in Table 2), the moorings were serviced and left in place after the receiver was removed. All un-anchored cable shore-based mooring systems and a single mooring located on the Wanapum Dam safety boom were disassembled and removed.

Table 2 The location, initial deployment date, station type, and VR2W serial number of acoustic stations removed from the Priest Rapids Project area as of May 2, 2019.

Station Name	River Mile	Zone	UTM E	UTM N	Reservoir	Deployment Date	Refurbished / Redeployed	Station Type [a]	Station Status	VR2W Serial No.
VRRM395.4	395.4	11	279333	5167991	McNary	5-Apr-17	--	Cable	Active	109733
VRRM398.1	398.1	11	276787	5170822	Priest Rapids	22-Jun-10	15-Apr-15	LD2	Active	122200
VRRM403.0	403.0	11	273078	5177718	Priest Rapids	22-Jun-10	20-Apr-16	LD2	Active	126560
VRRM410.0	410.0	11	276857	5187710	Priest Rapids	20-Jul-17	--	Cable	Active	109731
VRRM413.5	413.5	11	274582	5192231	Priest Rapids	5-Apr-17	--	Cable	Active	109728
VRRM415.5	415.5	11	273975	5195735	Priest Rapids	19-Sep-10	17-Apr-15	LD2	Active	109735
VRRM415.8	415.8	11	273713	5196126	Wanapum	6-Apr-17	--	Sboom	Active	109732
VRRM437.1	437.1	10	726238	5227455	Wanapum	17-May-12	16-Apr-15	LD2	Active	120240
VRRM442.0	442.0	10	725352	5234881	Wanapum	21-Jun-10	16-Apr-15	LD2	Active	109723
VRRM446.9	446.9	10	719591	5237579	Wanapum	29-Jun-11	14-Apr-15	LD2	Active	109737
VRRM452.4	452.4	10	720484	5246202	Wanapum	20-Sep-10	14-Apr-15	LD2	Active	109725

[a] LD2 – float deployment system with the VR2W receiver deployed downward and vertical in the water column at a depth of 4 m. Sboom - deployed on a cable attached to forebay safety boom with the VR2W receiver oriented downward and vertical in the water column at a depth of 4 m. Cable – the VR2W is deployed in a rubberized padded housing at the end of a stainless steel cable bolted to an overhanging or oversteepened rock outcrop.

2.7 Adult Movement

The adult telemetry data were uploaded from the Grant PUD telemetry database and were screened for errors and spurious detections, which were defined as acoustic tag IDs that were detected only once on any given day; these single detections were reviewed separately, and if considered erroneous, were removed from the dataset prior to analysis. The screened telemetry data were analyzed as presence/absence data. If a fish was detected at a receiver more than once in a day (i.e., the detection was defined as non-spurious), it was considered to be present near that receiver on that day. This approach allowed the examination of spatial and temporal patterns of presence/absence of individual fish. Daily presence/absence data were then used to estimate the following: 1) a daily count of fish recorded at each station; and 2) a daily residency, calculated as the number of hours an individual fish was detected at each receiver station in a 24 hour period. Individual residency proportions were then used to calculate daily mean of residency proportions across all fish detected by the receiver. Screening of telemetry data and the presence/absence data analyses were performed in the statistical environment R, v. 3.6.1 (R Core Team 2019). Plots were created in R using the package ggplot2 (Wickham 2009).

2.8 General Data Recording and Analysis

Custom field databases were designed and used to record field data for specific study components. In 2019, three copies of a juvenile White Sturgeon indexing database, with custom data fields specific to the study data requirements, were used by field crews to record indexing data in both Wanapum and Priest Rapids reservoirs. These database copies were merged at the end of the 2019 study into a single database that contained all indexing data recorded in the PRPA from 2014 to 2019. Within and between the various relational databases developed for the M&E studies, queries were used to extract data, screen for errors, and analyze annual and inter-year data to determine movement, growth, and capture history of hatchery juvenile White Sturgeon. Additional post-collection error screening and data proofing was conducted using both Excel® and in the statistical environment R, v. 3.6.1 (R Core Team 2019). Summary tables and simple figures were produced in Excel® using pivot tables and data filters. More complicated figures were created in R using the package ggplot2 (Wickham 2009). Customized datasheets and manifests were used to record information during the juvenile release, and VR2W station removal.

3.0 Results

3.1 Discharge and Temperature During Study Components

In 2019, peak mean daily flows in the PRPA, as measured in Wanapum Reservoir below Rock Island Dam, were recorded on May 19 (5,069 m^3/s; DART 2019). Lowest mean daily discharge was recorded on September 17 (784 m^3/s). Peak mean daily water temperature was recorded on September 10 (20.6°C). The lowest mean daily water temperature was recorded on February 12 (2.2°C; Figure 3).

2018BY Juvenile Release

Hatchery juveniles are typically released into the PRPA in late spring to time the release with the rising hydrograph and when receiving water temperatures range from 8 to 12°C. The 2018BY were released on May 7 on the ascending limb of the spring freshet when mean daily discharge was 2,879 m^3/s. After the release, total river discharge continued to increase and attained a seasonal high on May 19, after which flows reduced gradually from June to August. Mean daily Columbia River water temperature on the day of the 2018BY release was 8.9°C.

2019 Broodstock Collection

Broodstock collection was not conducted within the PRPA in 2019. All broodstock capture efforts in 2019 were conducted in John Day Reservoir over 14 days from May 15 to 24 and from May 31 to June 3. Schedule and duration rationale for the 2019 broodstock capture program, physical conditions during sampling, and collection results are provided in Appendix A.

Juvenile White Sturgeon Indexing

Juvenile White Sturgeon indexing in 2019 was conducted from August 28 to September 26, which coincided with low seasonal flows (Figure 3). During sampling, average mean daily discharge was 1,681 m^3/s and ranged from a low of 785 m^3/s on September 17 to a high of 3094 m^3/s on August 29. During juvenile indexing, load-following by upstream and downstream hydroelectric facilities resulted in large variations in hourly and daily discharge. Mean water temperature during sampling was 19.1°C (SD = ±0.7) and ranged between 18.0°C and 20.6°C.

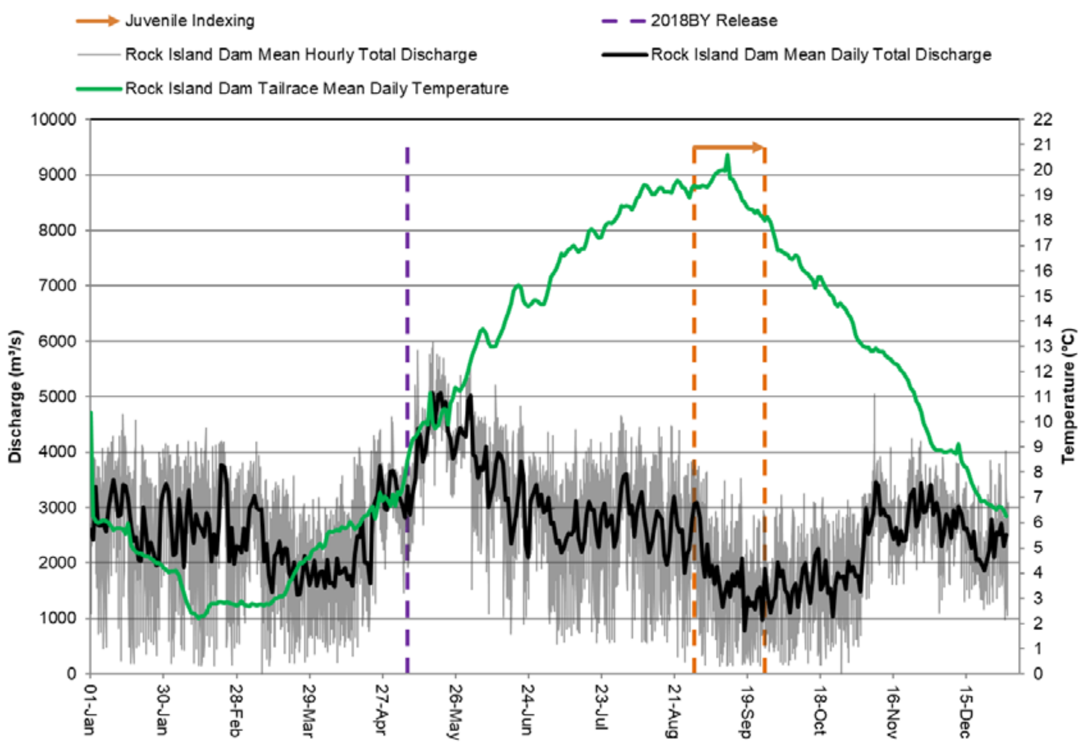


Figure 3 **Mean daily discharge (black line), mean hourly discharge (light gray ribbon), and mean hourly water temperature (green line) of the Columbia River in the Priest Rapids Project area, as measured below Rock Island Dam in 2019. The vertical purple dashed line denotes the 2018BY juvenile white sturgeon release date. The horizontal arrow between the dotted vertical lines indicates the timing of juvenile white sturgeon indexing (orange).**

3.2 2018BY Juvenile Marking and Release

Due to the presence of autopolyploidy 12N fish in two of the five maternal families, the 2019 Grant PUD juvenile White Sturgeon release was limited to the total number of viable candidate fish from the remaining three families. After marking and tagging, conducted from April 9 to 10, the total number of 2018BY fish suitable for release was 2,657 fish or approximately 82% of the annual hatchery juvenile White Sturgeon release prescribed under the Priest Rapids White Sturgeon Stocking SOA (i.e., a maximum of 3,250 fish).

The release proportion by reservoir outlined in the SOA allocated 62% of the release (1,767 fish) in Wanapum Reservoir at the Frenchman Coulee Launch (RM426.5) and 38% (890 fish) in Priest Rapids Reservoir at the Wanapum Dam tailrace launch (RM415.6; Table 3). Mean fork length and weight of the 2018BY when tagged was 267 mm (SD ± 29 mm) and 128 g (SD ± 43 g), respectively. Unlike previous annual releases, acoustic telemetry tags were not surgically implanted in the 2018BY.

All fish were released on May 7, 2019, approximately 27 days after tagging. One shed PIT-tag was found in the rearing tanks, either during a sweep of the tanks with a magnetic wand during the holding period, or after the tanks were drained and cleaned. Mortalities were not recorded during the post-tagging holding period.

During transport of the fish to Wanapum Reservoir, the holding tank oxygen level onboard the Grant Transport hatchery truck was 13.3 mg/L on departure from the hatchery, 11.7 mg/L at the two travel check stops, and 11.6 mg/L upon arrival at the Wanapum Reservoir release site, Frenchman Coulee Launch (RM424.5). At release, water temperature in the holding tanks was 9.8°C and the fish were released into receiving water with a temperature of 9.6°C. During transport of fish to Priest Rapids Reservoir, the holding tank oxygen level onboard the Grant Transport trailer was 11.1 mg/L on departure from the hatchery, 7.6 mg/L at the first travel check stop, 5.8 mg/L at the second travel check stop, and 5.5 mg/L upon arrival at the Priest Rapids Reservoir release site, the Wanapum Dam Tailrace Launch (RM415.6). At release, water temperature in the trailer holding tank was 10.4°C and the fish were released into receiving water with a temperature of 9.0°C. Additional shed PIT-tags were not found in either transport vehicle after release and all fish were released alive.

Table 3 Number of 2018BY juvenile white sturgeon released in Wanapum and Priest Rapids reservoirs and the mean fork length (FL) and mean weight of fish in each release. May 7, 2019.

	2019 White Sturgeon 2018BY Release		
Release Location Reservoir (River Mile)	**No. of Fish (acoustic-tagged)**	**Mean FL (± SD) mm**	**Mean Weight (± SD) g**
Wanapum (424.5)[1]	1,767 (0)	269 (30)	130 (44)
Priest Rapids (415.6)[2]	890 (0)	265 (28)	124 (40)
Total	2,657 (0)	267 (29)	128 (43)

[1] Frenchman Coulee Launch

[2] Wanapum Tailrace Launch

During tagging, fin deformities were recorded for 31% (831 of 2,657 fish) of the 2018BY. Fin deformity, when noted, was primarily associated with the pectoral fins (n = 758), with the majority of these (76.6% or 581 of 758 fish) with only one of two pectoral fins deformed (Table 4).

Table 4 Fin deformity type and occurrence noted during processing of 2018BY juvenile white sturgeon that were released in the Priest Rapids area on May 7, 2019.

2018BY Primary Fin Deformity	Fin Deformity Sub-type	No. of fish with Primary Deformity	No. of fish with Sub-type Deformity
Caudal deformity only		42	
	Deformed, curled, or damaged		42
Both caudal and pectoral deformity		31	
	Two deformed, curled, or damaged fins		20
	One deformed, curled, or damaged fin; one missing fin		1
	Three deformed, curled, or damaged fins		8
	Two deformed, curled, or damaged fins; one missing fin		2
Pectoral deformity only		758	
	One deformed, curled, or damaged fin		581
	One missing fin		48
	Two deformed, curled, or damaged fins		82
	One deformed, curled, or damaged fin; one missing fin		39
	Two missing fins		8
Other deformities		0	
	Deformed rostrum, operculum, other fins		0
Total fish with fin deformities		831 (31%)	
Total fish without fin deformity		1,826 (69%)	
Total 2018BY Release		2,657	

3.3 2018 Broodstock Capture

In 2019, angling for White Sturgeon broodstock took place over 14 days from May 15 to 24 and from May 31 to June 3 (see Appendix A). In total, 147 individual White Sturgeon were captured, with 7 fish captured twice for a total of 156 White Sturgeon landings. Of the individuals captured, 80 were greater than 150 cm FL, and based on size, were considered mature.
The gonads of these fish were surgically inspected to determine stage of maturity and broodstock candidacy. The remaining 67 fish captured were less than 150 cm FL and were immediately released after fish were scanned for PIT-tag, tagged (if necessary), and measured for fork length and weight. In total, five females and six males were transported to YNSH.

3.4 Adult White Sturgeon Movements

Telemetry data from the acoustic-tagged adult White Sturgeon, recorded from July 29, 2010 to May 2, 2019, were analyzed to determine the seasonal movement of adult White Sturgeon in Wanapum and Priest Rapids reservoirs.

Wanapum Reservoir

During the nine years of acoustic telemetry monitoring in Wanapum Reservoir, monitoring station RM437.1 and the stations upstream of it maintained their structural integrity and required less maintenance than downstream stations. This was particularly so for RM442, located at Columbia Cliffs Eddy near a known White Sturgeon overwintering area, which operated uninterrupted for the entire deployment period. The lower integrity of the downstream stations was due to more powerful and frequent wave action, especially at the stations in the Wanapum Dam forebay area (i.e., RM416.1, RM415.8). The stations in the middle and lower reservoir sections were also subject to several instances of vandalism when the acoustic receivers and station components were either stolen or damaged. With the exception of RM432.5, all damaged or lost stations were either repaired, replaced, or moved to a new and more secure location to restore detection coverage and limit data loss. The station at RM432.5 was not replaced after it was lost. In Wanapum Reservoir, acoustic tags were implanted into adult White Sturgeon each year from 2010 to 2015 during spring broodstock capture efforts and fall adult population indexing studies. In total, 72 high gain tags with either a five (10 tags) or ten-year (62 tags) battery life were deployed. As the number of deployed tags increased with each year, the amount of telemetry data recorded at each station increased over time.

White Sturgeon spawn below Rock Island Dam (RM453; Golder 2011) and the RM452.4 telemetry station consistently detected large numbers of tagged adult fish during the known White Sturgeon spawning season (June to July) on an annual basis (Figure 4). After each spawning season, detections at RM452.4 decreased and detections at the main overwintering site near RM442.0 increased, as fish moved downstream after the spawning season. In late October of each year, detections at RM442.0 decreased and a second increase in detections at RM452.4 was recorded. This increase in detections at RM452.4 was possibly related to fish moving upstream to exploit seasonal feeding opportunities below Rock Island Dam (e.g., fall migrating salmon). By the end of December, detections decreased at RM452.4 and increased at RM442.0 as fish moved downstream to the overwintering site.

In the middle reservoir section, the station at RM437.1 was positioned at a narrowing in the reservoir and effectively detected fish either moving upstream from or downstream to another known overwintering and holding habitat near RM426.5 and RM425.9. Although considered a high use area, tag detection frequency at these two downstream stations was lower than at upstream stations and tag detection frequency did not exhibit a regular pattern or fluctuate seasonally. However, a review of individual sturgeon movement plots indicate that adult fish routinely moved between the high use areas near RM442.0 an RM426.5 and that fish in both areas regularly exhibited seasonal upstream spawning movements. Stations at RM416.1 and RM415.8 near Wanapum Dam detected very few fish over the nine year deployment period, which supported the findings of the population indexing studies that captured lower numbers of White Sturgeon in the lower reservoir section compared to the middle and upper reservoir sections. During the emergency drawdown of Wanapum Reservoir from February 27, 2014 to March 16, 2015, the timing and number of tag detections recorded at RM452.4 and RM 442.0 changed substantially compared to the tag detection frequency recorded prior to the reservoir drawdown. After the reservoir was refilled, the tag detection frequency resumed a pattern that was similar to the detection frequency prior to the drawdown. This change in tag detection frequency during the reduction may have been due to a change in adult movement patterns or due to a change in the detection range at these stations

Mean daily residency estimates of fish at each station were calculated and plotted (Figure 5) but were difficult to interpret due to substantial variation of fish residency within each year and over the nine-year monitoring period. Overall, residency was higher in the upper section of Wanapum Reservoir than the middle section, and both were higher than the lower reservoir section. Sustained durations of high residency were recorded each year at RM442.0 and indicated continued use of the adjacent Columbia Cliff Eddy as an overwintering area. Residency estimates near RM426.5 were moderately high, less variable, and remained relatively constant over the entire monitoring period, indicating high use of the adjacent habitat by White Sturgeon.

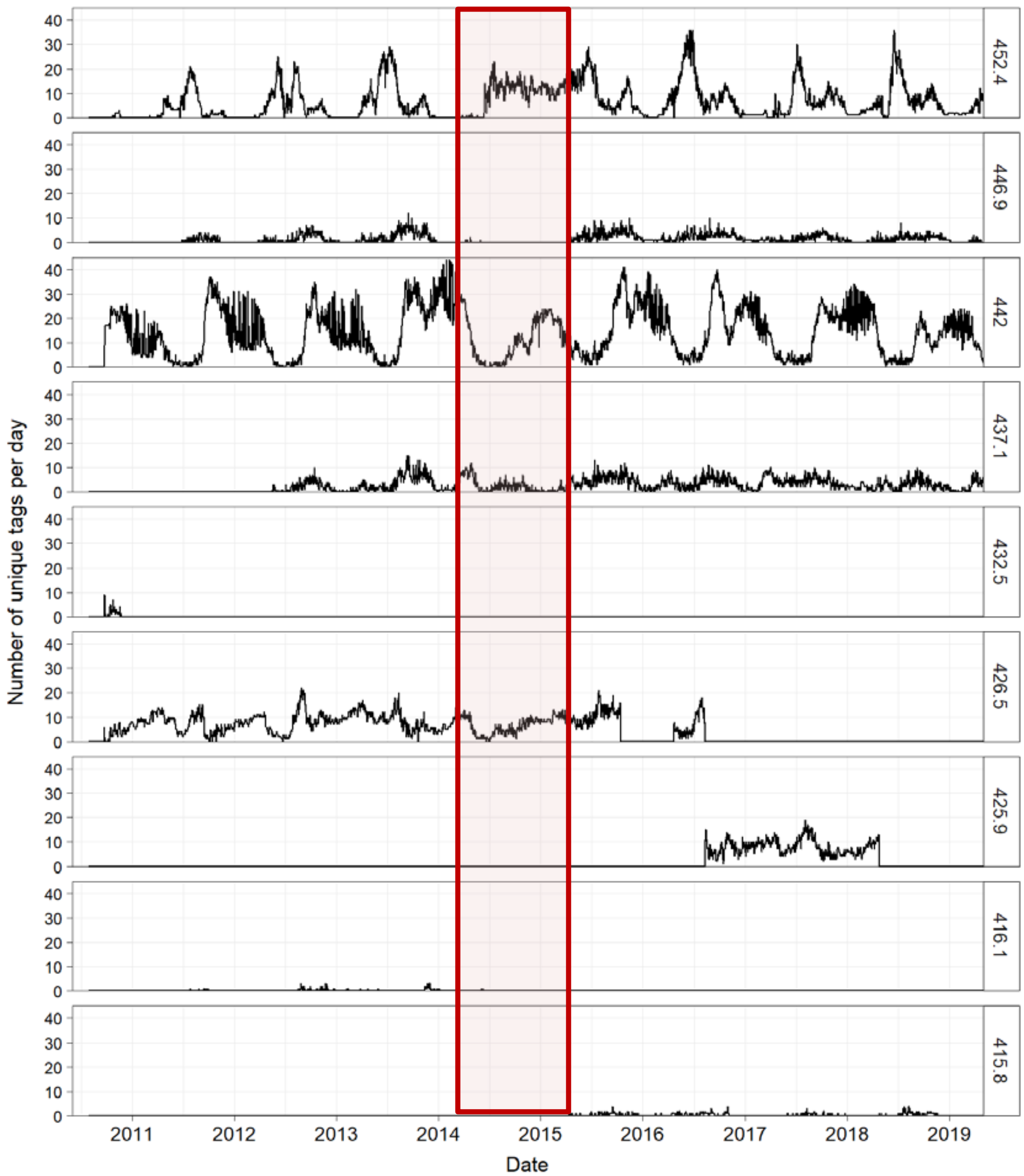


Figure 4 **Number of adult white sturgeon detected at acoustic monitoring stations (on right Y-axis) and corresponding River Mile in Wanapum Reservoir from July 29, 2010 to May 2, 2019. The red outlined area indicates an emergency drawdown period of Wanapum Reservoir associated with dam repairs from approximately February 27, 2014 to March 16, 2015.**

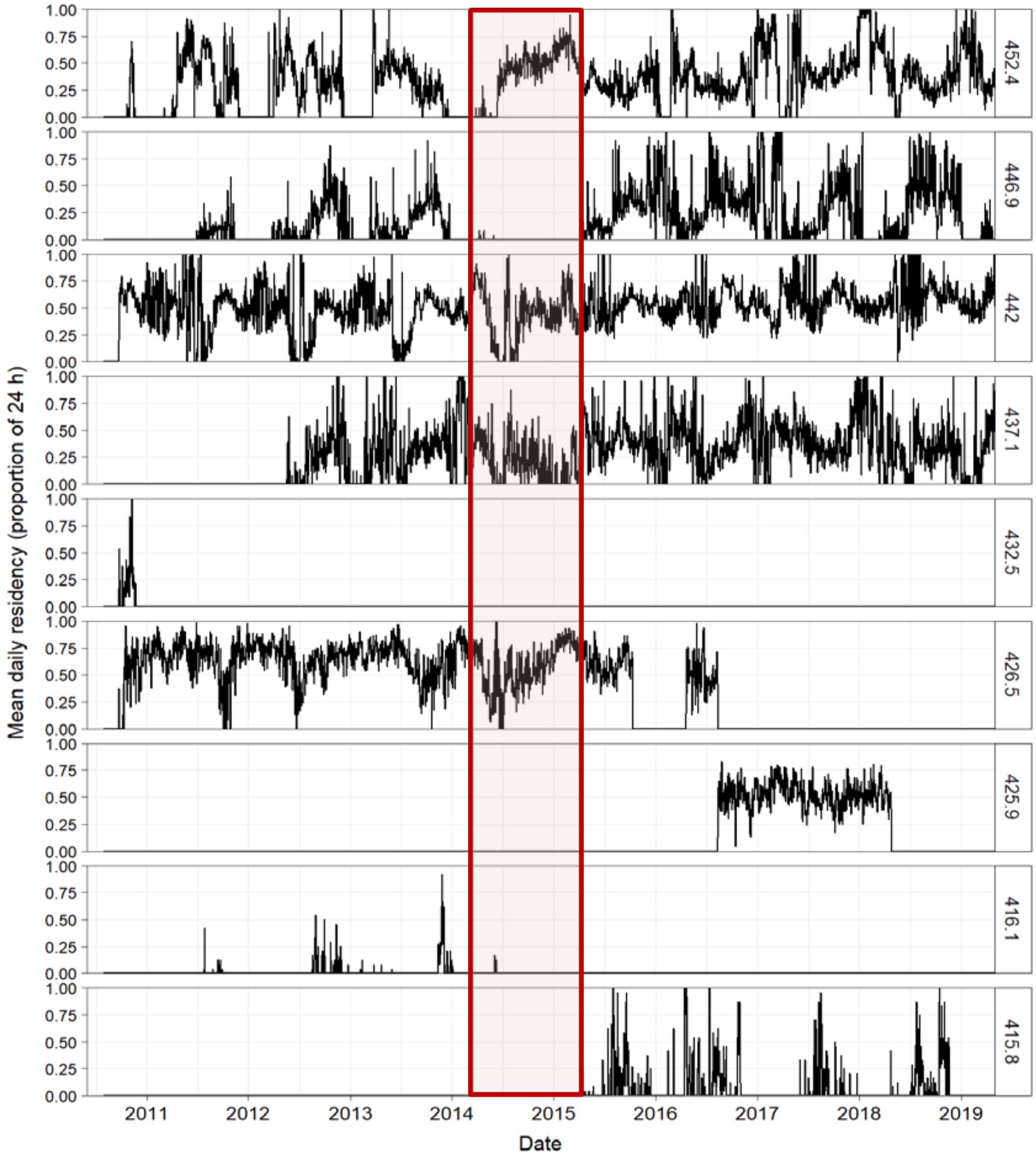


Figure 5 **Mean daily residency of adult white sturgeon at Wanapum Reservoir at acoustic monitoring stations (on right Y-axis) and corresponding River Mile from July 29, 2010 to May 2, 2019. The red outlined area indicates an emergency drawdown period of Wanapum Reservoir associated with dam repairs from approximately February 24, 2014 to March 16, 2015.**

Priest Rapids Reservoir

In total, up to five monitoring stations at any one time were deployed in Priest Rapids Reservoir to monitor the movement of acoustic-tagged fish. During the nine years of acoustic telemetry monitoring, all stations experienced some loss of structural integrity due to high water velocity and wave action during wind events and high flow periods. Tampering and theft of stations were also an issue in Priest Rapids Reservoir, which warranted the use of alternative station deployment systems (i.e., shore-anchored cables and mounting frames) to reduce the visible profile of high-risk stations. During capture programs conducted in 2010, the number of wild fish captured in Priest Rapids Reservoir was low. As such, only 11 high gain tags with ten-year battery lives were deployed into wild fish. An additional two tags were deployed into fish from the 2002BY

The highest adult tag detection frequency was recorded at RM415.5 in the Wanapum Dam tailrace, which was previously identified as a high use area by White Sturgeon based on the juvenile population indexing and telemetry studies (Golder 2018, 2019) and adult population indexing studies conducted in 2015 (Golder 2016) and 2018 (Golder 2019; Figure 6). Lower detection frequencies were recorded at downstream stations, indicating some movement by adult fish between the Wanapum Dam tailrace and possible holding and feeding habitats in the lower section of Priest Rapids Reservoir near RM404, RM403 and RM398.1. Fish at stations in the upper and lower reservoir sections had higher mean daily residency time (Figure 7), which suggests that these fish tend to move less and have a higher fidelity to specific habitat locations in these sections of the reservoir. Distinct seasonal movements associated with spawning, like those recorded in Wanapum Reservoir, were less evident in Priest Rapids Reservoir. Unlike Wanapum Reservoir, where the spawning and overwintering habitats are spatially separated by a long distance (i.e., 10 River Miles), spawning and overwintering habitats in Priest Rapids Reservoir appear to be limited to the same general area near the Wanapum Dam tailrace.

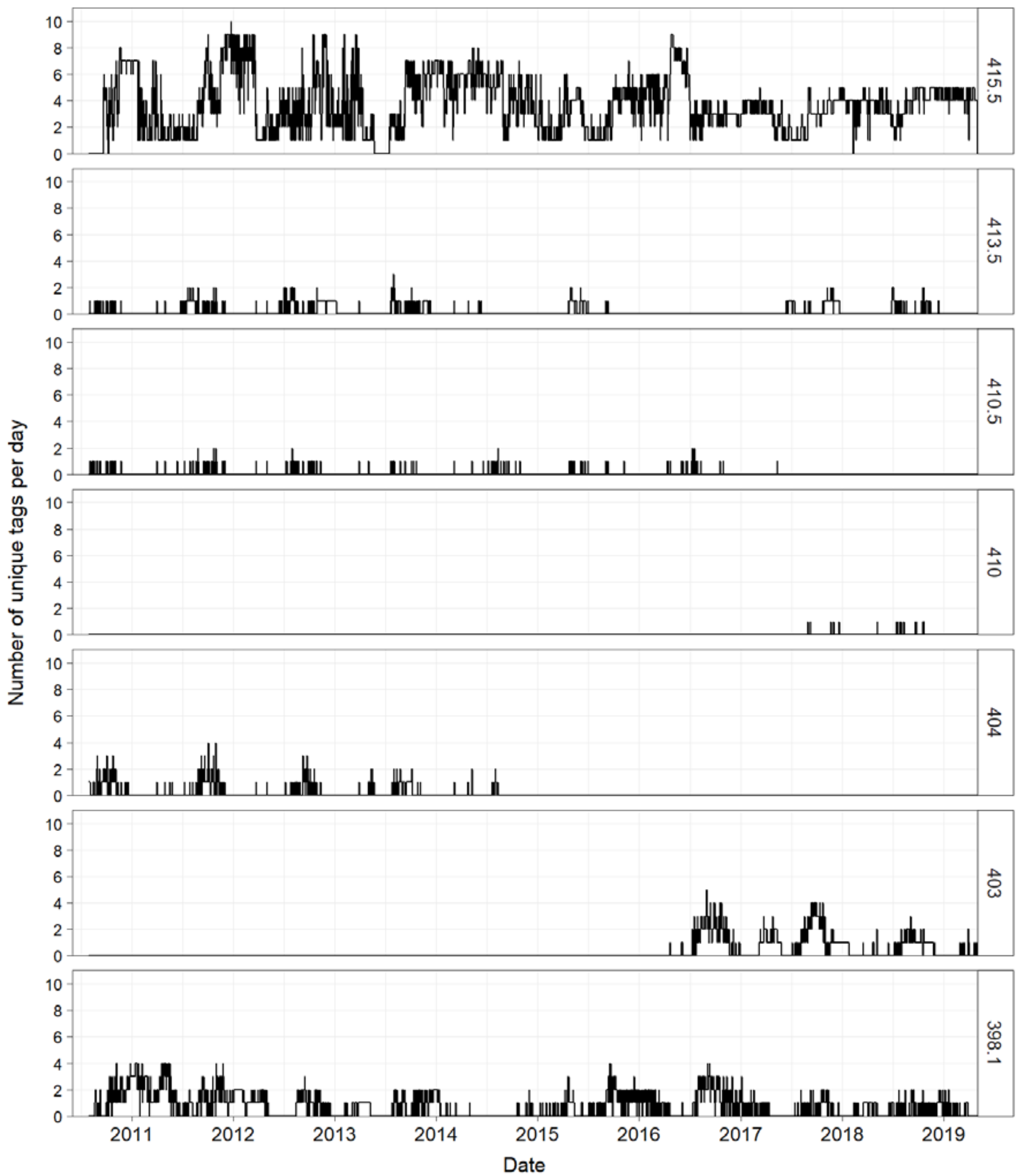


Figure 6 **Number 9 of adult white sturgeon detected at acoustic monitoring stations (on right Y-axis) and corresponding River Mile in Priest Rapids Reservoir from July 29, 2010 to May 2, 2019.**

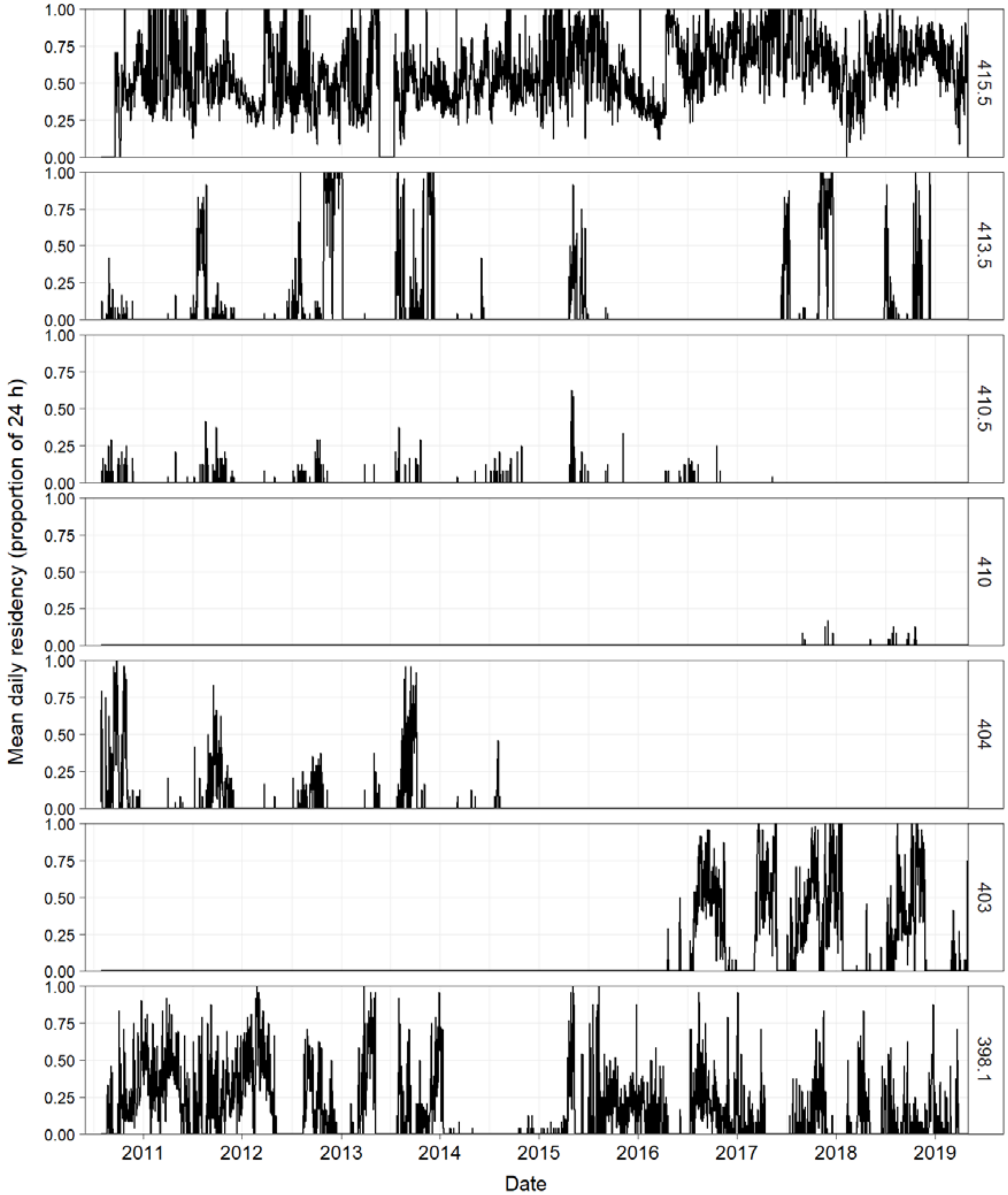


Figure 7 Mean daily residency of acoustic-tagged adult white sturgeon at Priest Rapids Reservoir acoustic monitoring stations (on right &-axis) and corresponding River Mile from July 29, 2010 to May 2, 2019.

3.5 Juvenile White Sturgeon Population Assessment

3.5.1 Sample Effort

In Wanapum and Priest Rapids reservoirs, areal-based GRTS unequal probability site selection assigned sites, in equal numbers, to each of the three defined sections in each reservoir (i.e., lower, middle, and upper sections). Due to the smaller areal extent of the upper section of each reservoir compared to the middle and lower sections, sample intensity within the upper reservoir section was approximately 1.5 to 2 times greater than the middle section and 6 to 7 times greater than the lower section Table 5).

The mean depth and the range of depths sampled was greater in Wanapum Reservoir (mean = 19.7 m; range = 1.3 to 39.0 m) than in Priest Rapids Reservoir (mean = 11.3 m; range = 4.3 to 23.0 m). Lower mean *sample* depths were recorded in the upper sections of both Wanapum and Priest Rapids reservoirs compared to their lower and middle sections.

All set lines were deployed overnight, but actual deployment duration varied between 17.3 and 25.7 hours due to variations in deployment and retrieval order. In Wanapum Reservoir, set lines were successfully deployed at all the selected GRTS sites identified in the lower and middle sections and in-the-field selection of oversample replacement sites was not required. In the upper section of Wanapum Reservoir, three oversamples were selected in-the-field to replace sites that were considered unsuitable for sampling due to fast flow and/or the presence of underwater obstructions. In Priest Rapids Reservoir, use of oversample replacement sites was not required.

Table 5 Details of GRTS sample site distribution among Wanapum and Priest Rapids reservoir sections, areal extent of reservoir sections, estimates of sampling intensity, and set line sample depths and durations recorded during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

	Reservoir							
	Wanapum (15 m Bathymetric Contour)				**Priest Rapids (6 m Bathymetric Contour)**			
	Lower	**Middle**	**Upper**	**All**	**Lower**	**Middle**	**Upper**	**All**
Number of sample GRTS sites selected	90	90	90	270	30	30	30	90
Actual number of GRTS sites sampled per section	90	90	90	270	30	30	30	90
Sampling area (ha)	1,664	727	308	2,699	1,369	346	213	1,928
Samples/100 ha	5.4	12.4	29.2	10.0	2.2	8.7	14.1	4.7
Sample depths (m)								
mean	20.7	20.2	18.1	19.7	13.4	11.2	9.5	11.3
min	10.7	1.3	8.0	1.3	7.0	4.3	5.0	4.3
max	39.0	39.0	35.0	39.0	23.0	21.0	21.0	23.0
Sample duration (h)								
mean	21.5	21.5	22.0	21.6	22.8	23.5	22.8	23.0
min	19.2	17.3	18.9	17.3	20.3	22.0	19.3	19.3
max	24.9	25.1	25.6	25.6	24.9	25.7	24.4	25.7

From early to mid-September, mean daily water temperature remained above 19.0°C for 18 of the 29 set line retrieval days, with water temperature lower than 19.0°C recorded only during the latter half of the sampling effort from September 16 onward. At water temperatures 19°C and higher, crews noted fish exhibited more symptoms of stress (e.g., redness) and recovery times were longer. Use of a shade canopy, frequent water exchanges, and monitoring of water temperature mitigated heat related stress on fish during processing. As a result, most fish captured required minimal recovery time and appeared healthy and energetic when released.

3.5.2 2019 Juvenile White Sturgeon Indexing Catch

In total, 639 White Sturgeon were captured and processed during the juvenile indexing program in Wanapum (n = 566) and Priest Rapids (n = 73) reservoirs (Figure ; Table 126). These captures represented 620 individual fish, with 18 fish captured twice in Wanapum, and one fish captured twice in Priest Rapids Reservoir. Incidental captures were primarily Northern Pikeminnow (*Ptychocheilus oregonensis*; n = 109 in Wanapum Reservoir; n = 31 in Priest Rapids Reservoir). Within Priest Rapids Reservoir, incidental catch of Largescale Sucker (*Catostomus macrocheilus*; n = 2) and Channel Catfish (*Ictalurus punctatus;* n = 7) were also recorded.

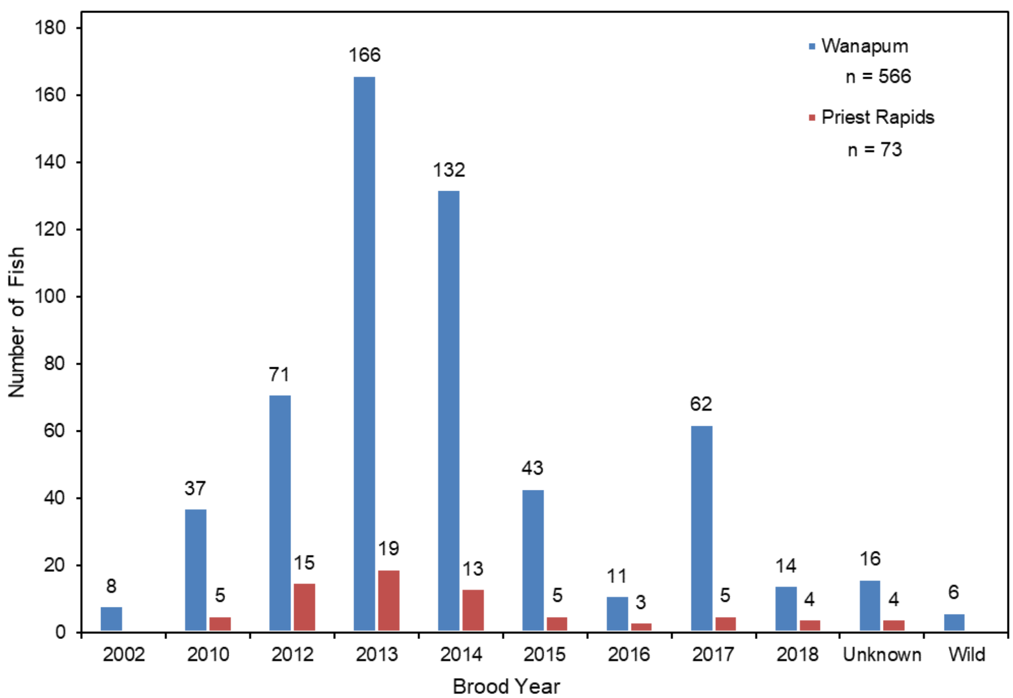


Figure 8 Hatchery and wild white sturgeon captured in the Priest Rapids Project area during the juvenile white sturgeon indexing program, August 28 to September 26, 2019. Unknown category represents fish suspected to be of hatchery origin but without a PIT-tag to allow identified of origin and brood year.

3.5.2.1 Wanapum Reservoir Catch

The 566 White Sturgeon captured in Wanapum Reservoir consisted primarily of hatchery origin fish released in Wanapum Reservoir (n = 420), and low numbers of entrained hatchery fish that had been released in either Rock Island Reservoir (2002BY; n = 8), Rocky Reach Reservoir (2010BY; n = 2, 2013BY; n = 1, 2014BY; n = 1, 2015BY; n = 1), and Wells Reservoir (2013BY; n = 1). Six fish were considered wild based on the absence of PIT-tag or scute removal marks and no obvious fin deformities (Figure 8, Table 6).

Sixteen fish had obvious hatchery scute removal marks and/or deformed fins, but no detectable PIT-tag (likely shed); these fish were considered of hatchery origin, but their brood source was classified as Unknown.

Table 6 Hatchery and wild sturgeon captured in the Priest Rapids area during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

Brood Year	Release Reservoir	Release Location	Brood Source	Date	Number Released	Capture Reservoir		Total
						Wanapum	Priest Rapids	
2002	Rock Island	Unknown	Unknown	Unknown	20,600	8	0	8
2010	Rocky Reach	Unknown	All	21-Apr-11	6,376	2	0	2
	Wanapum	Columbia Siding	UCW[1]	26-Apr-11	2,019	24	--	24
			MCW[2]	29-Apr-11	2,996	10	--	10
			LCC[3]	27-29-Apr-11	2,000	1	1	2
			All	--	7,015	35	1	36
	Priest Rapids	Wanapum tailrace	UCW	26-Apr-11	900	--	1	1
			MCW	28-Apr-11	601	--	2	2
			LCC	28-Apr-11	600	--	1	1
			All	--	2,101	--	4	4
2012	Wanapum	Columbia Siding	MCW	14-May-12	1,135	19	--	19
		Columbia Cliffs	MCW	14-May-12	1,129	52	--	52
			All	--	2,264	71	0	71
	Priest Rapids	Wanapum tailrace	MCW	14-15-May-13	1,717	--	15	15
2013	Wells	Unknown	MCW	10-Apr-14	--	1	--	1
	Rocky Reach	Unknown	MCW	08-May-14	--	1	--	1
	Wanapum	Rocky Coulee	MCW	06-May-14	3,330	134	3	137
			MCW	18-Sep-14	1,762	30	5	35
			All		5,092	166	8	174
	Priest Rapids	Wanapum tailrace	MCW	05-May-14	996	--	10	10
			MCW	17-Sep-14	504	--	1	1
			All		1,500	0	11	11
2014	Rocky Reach	Unknown	MCW	30-Apr-15	--	1	--	1
	Wanapum	Frenchman Coulee	MCW	1-May 2015	5,007	131	3	134
			All		5,007	132	3	135
	Priest Rapids	Wanapum Tailrace	MCW	1-May 2015	1,495	--	10	10
2015	Rocky Reach	Unknown	MCW	08-May-14	--	1	--	1
	Wanapum	Frenchman Coulee	MCW	28-Apr-16	2,005	42	--	42
			All		2,005	43	0	43
	Priest Rapids	Wanapum Dam Tailrace	MCW	28-Apr-16	1,253	--	5	5
2016	Wanapum	Frenchman Coulee	MCW	2-May-17	1,999	11	2	13
	Priest Rapids	Wanapum Dam Tailrace	MCW	2-May-17	1,249	--	1	1
2017	Wanapum	Frenchman Coulee	MCW	1-May-18	1,983	62	1	63
	Priest Rapids	Wanapum Dam Tailrace	MCW	1-May-18	1,241	--	4	4
2018	Wanapum	Frenchman Coulee	MCW	7-May-19	1,767	14	--	14
	Priest Rapids	Wanapum Dam Tailrace	MCW	7-May-19	890	--	4	4
Unknown[4]	Unknown	Unknown	Unknown	Unknown	n/a	16	4	20
Wild	n/a	n/a	n/a	n/a	n/a	6	--	6
All Sturgeon						566	73	639

[1]Upper Columbia Wild (UCW) - the progeny of wild broodstock captured in the upper Columbia River in Canada and reared by the Freshwater Fisheries Society at the Kootenay Sturgeon Hatchery in British Columbia.
[2]Mid Columbia Wild (MCW) - the progeny of wild broodstock captured either in PRPA or below McNary Dam and reared at the Yakama Nation Sturgeon Hatchery (YNSH).
[3]Lower Columbia Cultured (LCC) - the progeny of captive broodstock originally captured below Bonneville Dam in the lower Columbia River.
[4]These are likely hatchery origin, but brood year, source, or stocking location data are unknown.

Of the eight hatchery brood years released in the PRPA since 2011 (i.e., 2010BY, 2012BY, 2013BY, 2014BY, 2015BY, 2016BY, 2017BY, and 2018BY), the 2013BY (n = 166 or 29% of total catch) and 2014BY (n = 132 or 23%) were the dominant brood years caught in Wanapum Reservoir in 2019, followed by 2012BY (n = 71), 2017BY (n = 62), 2015BY (n = 43), 2010BY (n = 37), 2018BY (n = 14), and 2016BY (n = 11; Figure 8; Table 6). Hatchery fish release efforts prior to 2014BY contained distinct release groups differentiated based on either genetic lineage (i.e., 2010BY; Golder 2012), release location (2012BY; Golder 2014), or release timing (2013BY; Golder 2015), each of which were described and discussed in detail in the previous annual reports. Similar trends in the differences in catch proportion of each of the sub-groups identified for these brood years reported below were also recorded in previous juvenile population assessments (Golder 2017–2019).

In 2019, the following differences in catch proportion of brood year and the within-brood year release groups were identified:

- 2010BY: Although initial release numbers of the three within-brood year release groups (i.e., LCC = 2,000; MCW = 2,996; UCW =2,020) were similar, substantially fewer of the LCC release group were captured in 2019 (n = 1) compared to the UCW (n= 24) and MCW (n = 10) groups.
- 2012BY: In 2013, fish were released in equal numbers at Columbia Siding (RM450.6; n = 1,135) and Columbia Cliffs Eddy (RM442.0; n = 1,129) to assess the effect of avian predation based on depth at the release location and proximity to upstream bird colonies. Of the 2012BY captured in 2019 (n = 71), the majority (i.e., 73%; n = 52) were fish released at the deeper downstream site near Columbia Cliffs Eddy (RM442.0).
- 2013BY: Released in two groups at Rocky Coulee launch (RM421.4) in May (n = 3,331) and September (n = 1,762) 2014 during the Wanapum Reservoir emergency drawdown. The 2019 catch of the May-released fish (n = 134) exceeded the catch of September-released fish by more than four times (n = 30) and suggests that the May-released fish had higher survival.
- 2014BY: The total release of the 2014BY (n = 5,007) was comparable to 2013BY (n = 5,093); total 2014BY catch (n = 132) was 20% lower than of the 2013BY catch (n = 164). These data appear to support a difference in post-release survival between the two groups with assumed equal catchability and initial density, although the difference in catch between these two brood years was less in 2019 than in previous studies.
- 2015BY: Catch of 2015BY released in 2016 (n = 2,005) declined annually from 2016 (n = 69) to 2017 (n = 41) to 2018 (n = 29), but increased in 2019 (n = 42). However, the catch proportion of 2015BY was similar in all years and ranged between 6.4% in 2018 and 9.2% in 2016.
- 2016BY: Although the 2016BY release size (n = 1,999) was nearly identical to the 2015BY, the 2016BY are less abundant, with only low numbers captured in 2017 (n = 1) and 2018 (n = 1), with slightly more captured in 2019 (n = 11). The continually low contribution of this brood year to the total catch in all years suggests that either survival was low or, more likely, that emigration from the PRPA was high based on post-release telemetry data (Golder 2018) and capture of entrained 2016BY (n = 12 of 66 hatchery White Sturgeon recovered) during a fish salvage at Priest Rapids Dam (C. Mott, Grant PUD, personal communication, November 12, 2019).
- 2017BY: The 2017BY release (*n* =1,983) was comparable to the 2015BY and 2016BY release in terms of size. The 2017BY were captured low numbers in the 2018 release year (n = 17) but catch increased substantially in 2019 (n = 62) and suggests the 2017BY had a higher post-release survival rate than the 2015BY and 2016BY.
- 2018BY: The 2018BY release size (n = 1,767) is the smallest brood year release to date. The 2018BY were captured in low numbers during the 2019 release year (n = 14), but

catch was similar to numbers recorded for 2017BY during their release year, which suggest both the 2017BY and 2018BY may have had a similar post-release survival rate.

Sixteen untagged White Sturgeon (unknown origin) were captured in Wanapum Reservoir and were suspected to be hatchery fish based on scute marks or fin deformities (ranging from mild to severe). These fish likely either shed their PIT-tag and/or were not marked at the hatchery. Six confirmed wild White Sturgeon were captured in 2019. Apart of the absence of fin deformities, field crews noted that wild White Sturgeon can sometimes be distinguished from hatchery fish by their large, wide pectoral fins and elongated rostrum. The presence of these wild fish indicates that some natural recruitment likely occurs within the PRPA. After the 2002BY removal effort, which ended in 2018, the number of 2002BY was reduced and only low numbers of 2002BY (n = 8) were captured in Wanapum Reservoir in 2019.

3.5.2.2 Priest Rapids Reservoir Catch

The 73 White Sturgeon captured from Priest Rapids Reservoir in 2019 consisted mainly of hatchery fish released directly into Priest Rapids Reservoir (n = 54) and hatchery fish entrained from Wanapum Reservoir (n = 15; Figure 8; Table 6). Other White Sturgeon captured included four fish of unknown origin (n = 4). Due to low catch in 2019, only very general comparisons of relative abundance based on differences in the catch proportion between release groups were possible:

- 2010BY: The 2010BY catch in 2019 was low (n = 5) and contributed only 6.8% of the total catch, but they contributed 17.4% to the 2018 catch. The 2010BY catch proportion will continue to decrease as these fish grow and become less susceptible to capture by small-hook set lines.
- 2012BY; 2013BY; 2014BY: These three brood years were captured in approximately equal numbers in 2019, with slightly higher numbers of 2013BY captured (n = 19) compared to the 2012BY (n = 15) and 2014BY (n = 13). Entrained fish from Wanapum Reservoir contributed 42% (n = 8 of 19) of the 2013BY catch and 23% (n = 3 of 13) of the 2014BY catch. The 2012BY catch consisted only of fish released originally in Priest Rapids Reservoir. Similar catch proportions of these three brood years were reported in 2017 and 2018 and likely reflect their relative abundance in the reservoir (Golder 2018, 2019).
- 2015BY, 2016BY, 2017BY, and 2018BY: These brood years were captured in approximately equal and low numbers compared to the other brood years. The low contribution of the older brood years (i.e., 2015BY and 2016BY) suggests that these brood years may have a low abundance; whereas the low catch of the younger brood years (i.e., 2017BY and 2018BY) may be due to reduced catchability due to their smaller size and less aggressive feeding behavior.

A small number (n = 4) of White Sturgeon of unknown origin were captured in Priest Rapids Reservoir in 2019. Wild fish and 2002BY were not captured in Priest Rapids Reservoir in 2019.

3.5.3 Catch Rates and Distribution

Comparisons of relative abundance and catch distribution of juvenile White Sturgeon in the PRPA were based on catch rates calculated as catch-per-unit-effort (CPUE) in hook-hours (i.e., 1 hook-hour = 1 hook fished for 1 hour) and as a proportion of positive catch (Ep: proportion of sites that captured at least 1 fish) for each reservoir and reservoir section.

In total, 316,349 hook-hours of set line sample effort was expended during the 2019 juvenile White Sturgeon indexing program (Table 7). Within each reservoir, sample effort per reservoir section was nearly identical. Overall CPUE in the PRPA was 0.20 fish/100 hook-hours, with higher CPUE recorded in Wanapum Reservoir (0.24 fish/100 hook-hours) than Priest Rapids Reservoir (0.09 fish/100 hook-hours). In both reservoirs, the highest CPUEs were recorded in the middle reservoir section, followed by the upper section, with the lowest CPUE recorded in the lower section of each reservoir.

Overall, Ep was substantially higher in Wanapum Reservoir (all sections, Ep = 0.70) than in Priest Rapids Reservoir (all sections, Ep = 0.33; Figure 9) due to the high percentage (66.7%) of overnight set lines in Priest Rapids Reservoir that resulted in no catch compared to Wanapum Reservoir (30.1%; Figure 10). In Wanapum Reservoir, the proportion of set line effort that resulted in no catch was highest in the lower reservoir section (38.9%) and lower in the upper (27.0%) and middle reservoir sections (24.4%). A similar trend, but of greater magnitude, was recorded in Priest Rapid Reservoir, where the proportion of set line effort that resulted no catch was highest in the lower section (80.0%) and lower in the upper (63.3%) and middle reservoir sections (56.7%). Correspondingly, In Wanapum Reservoir Ep was slightly lower in the lower section (Ep = 0.61) and higher in the middle (Ep = 0.76) and upper sections (Ep = 0.73). In Priest Rapid Reservoir, the highest Ep (Ep = 0.43) was recorded in the middle section, which also had the highest CPUE (0.14 fish/100 hook-hours), with lower Ep in the upper section (Ep = 0.37) and lower section (Ep = 0.20) in Priest Rapids Reservoir.

Table 7 Total set line sample effort, catch, and CPUE in the Priest Rapids Project area during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

Reservoir	Reservoir Section	Sample Effort (hook-hours)	Catch (No. of fish)				CPUE (Fish/100 hook-hours)			
			Wild	H-123LAD	2002BY	Total	Wild	H-123LAD	2002BY	Wild & Hatchery
Wanapum	Lower	77,243	0	134	0	134	0.000	0.17	0.000	0.17
	Middle	77,371	2	217	3	222	0.003	0.28	0.004	0.29
	Upper	78,982	4	201	5	210	0.005	0.25	0.006	0.27
	all	233,597	6	552	8	566	0.003	0.24	0.003	0.24
Priest Rapids	Lower	27,292	0	11	0	11	0.000	0.04	0.000	0.04
	Middle	28,145	0	40	0	40	0.000	0.14	0.000	0.14
	Upper	27,315	0	22	0	22	0.000	0.08	0.000	0.08
	all	82,752	0	73	0	73	0.000	0.09	0.000	0.09
PRPA	Total	316,349	6	625	8	639	0.002	0.20	0.003	0.20

[1] H-123LAD is the field designation of a YNSH Hatchery juvenile White Sturgeon reared at the Yakama Nation Sturgeon Hatchery, produced from brood years in 2010, 2012, 2013, 2014, 2015, 2016, 2017, 2018 and released the following year.
[2] 2002BY is the field designation of a CRITFC Hatchery juvenile White Sturgeon reared by the Columbia River Inter-Tribal Fish Commission from a brood year in 2002 and released in 2003.

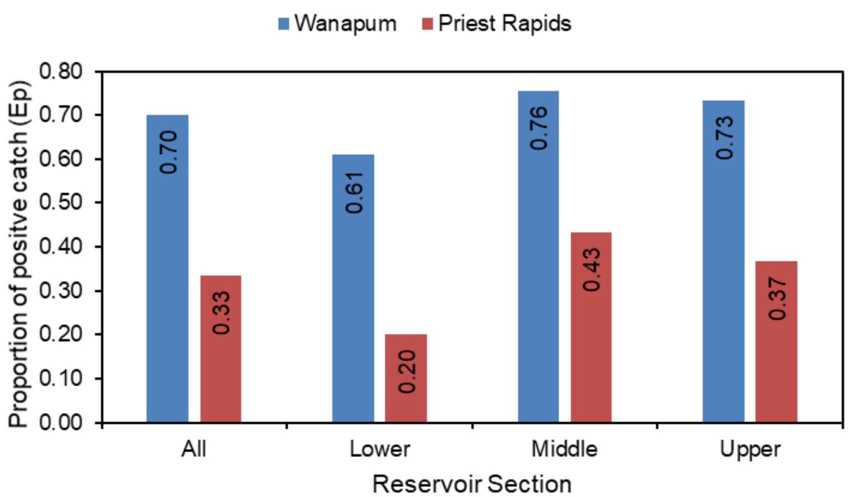


Figure 9 Proportion of positive catches recorded in the Priest Rapids Project area within the lower, middle, and upper section of each reservoir during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

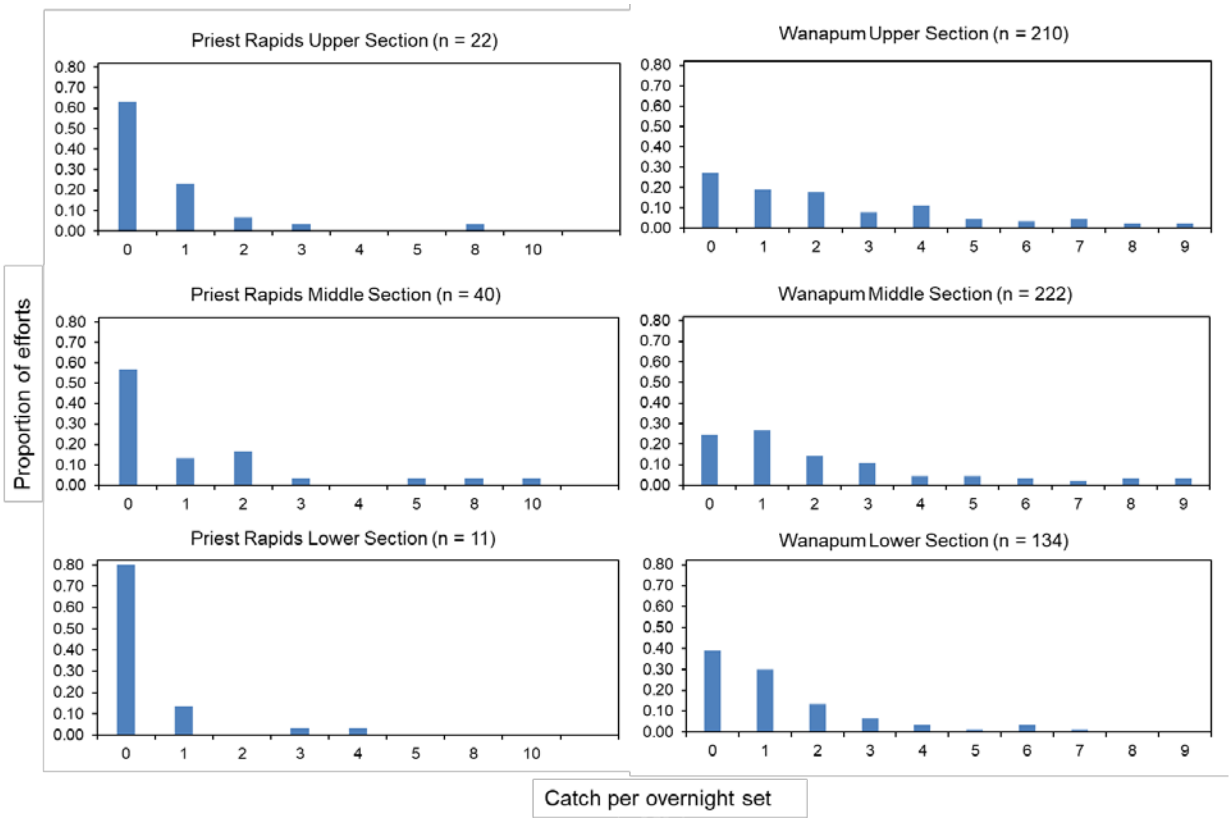


Figure 10 Frequency histograms of white sturgeon catch-per-overnight-set in the Priest Rapids Project area during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

The GRTS unstratified unequal probability sample design distributed effort over the areal extent of each reservoir. Histogram plots of catch, effort and CPUE by River Mile indicated general areas within each reservoir where higher captures of White Sturgeon were encountered (Figure 11). Catch and CPUE varied considerably by River Mile over the length of both reservoirs. Overall, the lower sections of each reservoir had much lower catch rates compared to upstream locations, with the highest catch locations within the middle and upper sections of each reservoir. Locations with high catch were assumed to correspond to areas that likely provide either suitable holding, rearing, or feeding habitat for White Sturgeon.

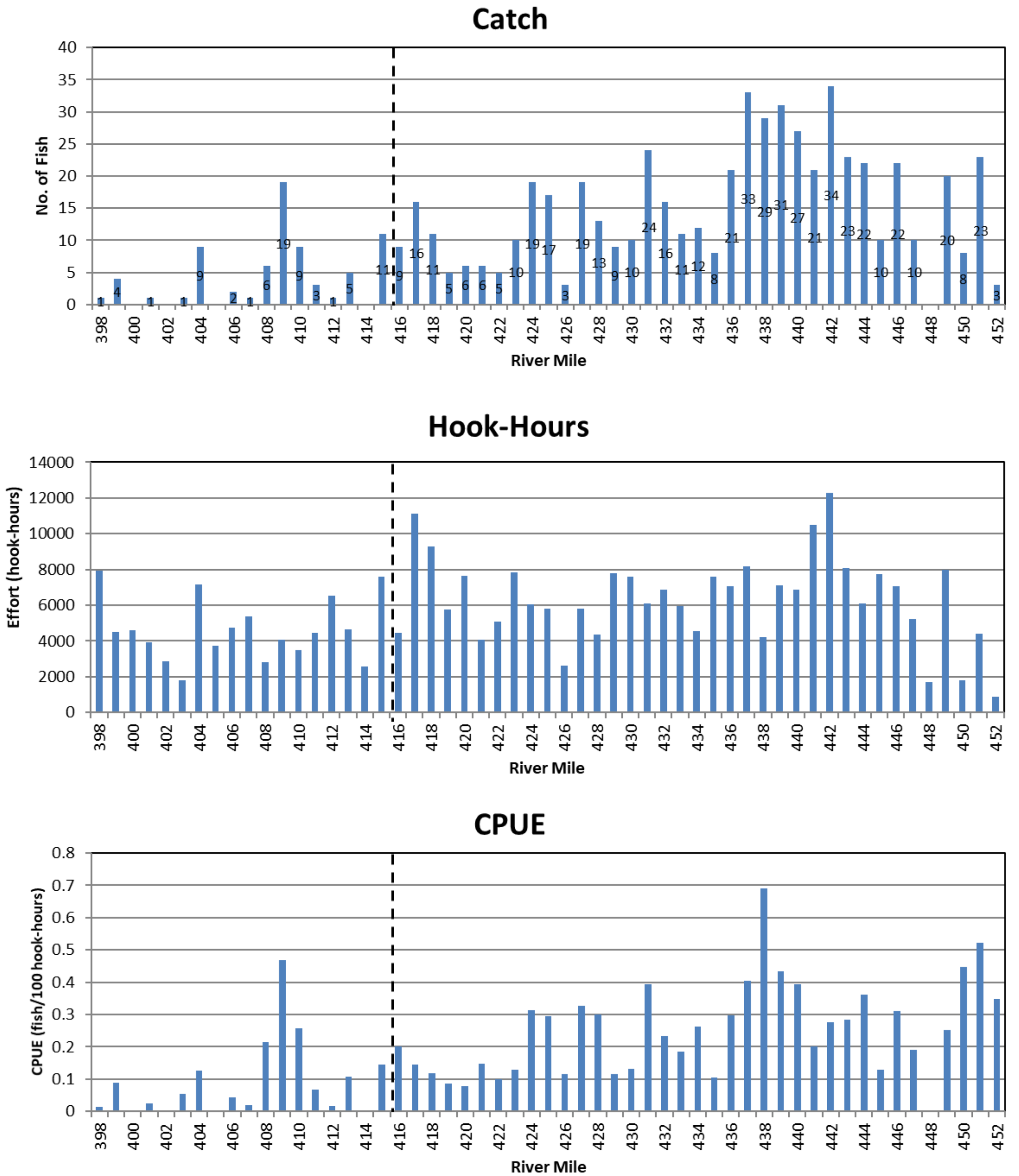


Figure 11 Juvenile white sturgeon catch, effort, and CPUE distribution by River Mile in the Priest Rapids Project area, during the juvenile white sturgeon indexing program from August 28 to September 26, 2019. Dash vertical line represents the location of Wanapum Dam.

In Wanapum Reservoir, a higher Ep was recorded for the 2010BY, 2012BY, and 2017BY in the upper reservoir section than in the middle and lower sections (Figure 12). For the 2014BY, 2015BY, and 2016BY, higher Eps were recorded in the middle reservoir section than in the upper and lower sections. High Eps were recorded for the 2013BY, with similar proportions of positive catches among all sections of Wanapum Reservoir. Low Eps, with no discernable difference among reservoir sections, were recorded for 2002BY and 2018BY in 2019.

In Priest Rapids Reservoir, the highest Eps were recorded in the middle section for the 2013BY, 2014BY, and 2012BY (Figure 12). Among brood year releases, the 2013BY appear to be the most broadly distributed among all three reservoir sections. Similar or very low Eps were recorded among all reservoir sections for 2010BY, 2015BY, 2016BY, 2017BY, and 2018BY.

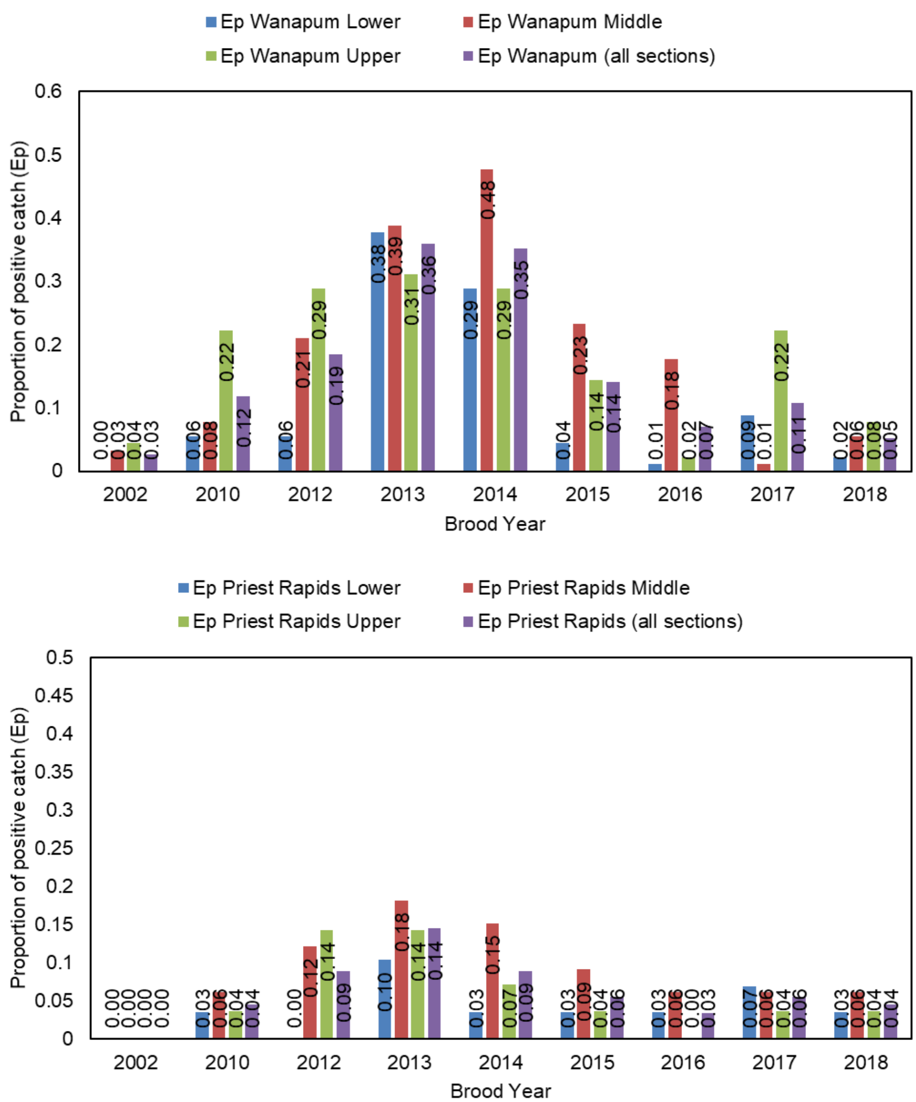


Figure 12 Proportion of positive catch (Ep) of wild and hatchery white sturgeon in Wanapum (upper panel) and Priest Rapids (lower panel) reservoirs recorded during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

3.5.4 Size, Growth, and Condition

In total, 620 individual White Sturgeon were captured and measured for fork length (FL) during the 2019 juvenile White Sturgeon indexing program in the PRPA. These fish ranged from 31.0 to

147.5 cm FL (mean = 65.3 cm FL; n = 548; Table 8) in Wanapum Reservoir and from 33.0 to 99.0 cm FL (mean = 59.6 cm FL; n = 72) in Priest Rapids Reservoir. The smaller length-frequency range in Priest Rapids Reservoir was attributed to the absence of the 2002BY from the catch and a large reduction of 2010BY caught compared to previous studies (Golder 2019). With the exception of the upper-most size range, the length-frequency histograms of brood years 2010BY through 2018BY captured in Wanapum and Priest Rapids reservoirs were similar and generally overlapped (Figure 13). Due to difference in growth rate among individuals in a given brood year, there was substantial overlap in length-frequency between brood years several years apart in age. For example, the fork length of the smallest 2010BY captured (55.5 cm FL), though six years older, was smaller in length than the largest 2017BY captured (57.0 cm FL). The notable decrease in catch frequency of fish over 90 cm FL likely represents the maximum effective capture size for the juvenile indexing set line gear; fish greater than 90 cm FL likely have reduced catchability.

Table 8 Fork length (cm) of white sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile white sturgeon indexing program, August 28 to September 26, 2019. The fork length recorded during first capture was used for individuals captured twice or more during the survey.

Program	Brood Year	Wanapum Fork Length (cm)					Priest Rapid Fork Length (cm)					Combined Fork Length (cm)				
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
CRITFC	2002	**7**	104.8	22.1	78.5	147.5	-	-	-	-	-	**7**	104.8	22.1	78.5	147.5
Chelan PUD	2010	**2**	102.8	13.1	93.5	112.0	-	-	-	-	-	**2**	102.8	13.1	93.5	112.0
	2013	**1**	94.0	-	94.0	94.0	-	-	-	-	-	**1**	94.0	-	94.0	94.0
	2014	**1**	63.0	-	63.0	63.0	-	-	-	-	-	**1**	63.0	-	63.0	63.0
	2015	**1**	46.0	-	46.0	46.0	-	-	-	-	-	**1**	46.0	-	46.0	46.0
Douglas PUD	2013	**1**	78.5	-	78.5	78.5	-	-	-	-	-	**1**	78.5	-	78.5	78.5
Grant PUD	2010	**34**	84.8	20.0	55.5	118.0	**5**	76.8	11.8	65.0	92.0	**39**	83.8	19.2	55.5	118.0
	2012	**68**	67.6	13.5	44.0	98.0	**15**	65.3	6.7	53.0	76.0	**83**	67.2	12.6	44.0	98.0
	2013	**159**	72.6	11.8	43.5	99.5	**18**	65.2	14.1	51.0	99.0	**177**	71.8	12.2	43.5	99.5
	2014	**127**	65.0	9.5	39.5	88.0	**13**	53.2	11.5	43.0	89.0	**140**	63.9	10.2	39.5	89.0
	2015	**42**	56.4	9.3	39.0	74.5	**5**	53.6	9.9	46.0	68.0	**47**	56.1	9.3	39.0	74.5
	2016	**10**	51.3	7.4	41.0	64.0	**3**	53.7	5.8	47.0	57.0	**13**	51.9	6.9	41.0	64.0
	2017	**60**	42.4	3.9	35.5	52.0	**5**	46.0	7.3	40.5	57.0	**65**	42.6	4.3	35.5	57.0
	2018	**13**	34.8	2.1	31.0	37.5	**4**	34.9	2.8	33.0	39.0	**17**	34.8	2.2	31.0	39.0
Unknown[1]	Unknown	**16**	63.8	21.0	40.0	115.0	**4**	66.3	13.8	51.0	83.0	**20**	64.3	19.5	40.0	115.0
Wild	Unknown	**6**	70.3	6.4	63.0	78.0	-	-	-	-	-	**6**	70.3	6.4	63.0	78.0
All Sturgeon	All	**548**	65.3	17.1	31.0	147.5	**72**	59.6	14.2	33.0	99.0	**620**	64.7	16.9	31.0	147.5

[1]These are likely hatchery origin, but brood year, source, or stocking location data are unknown.

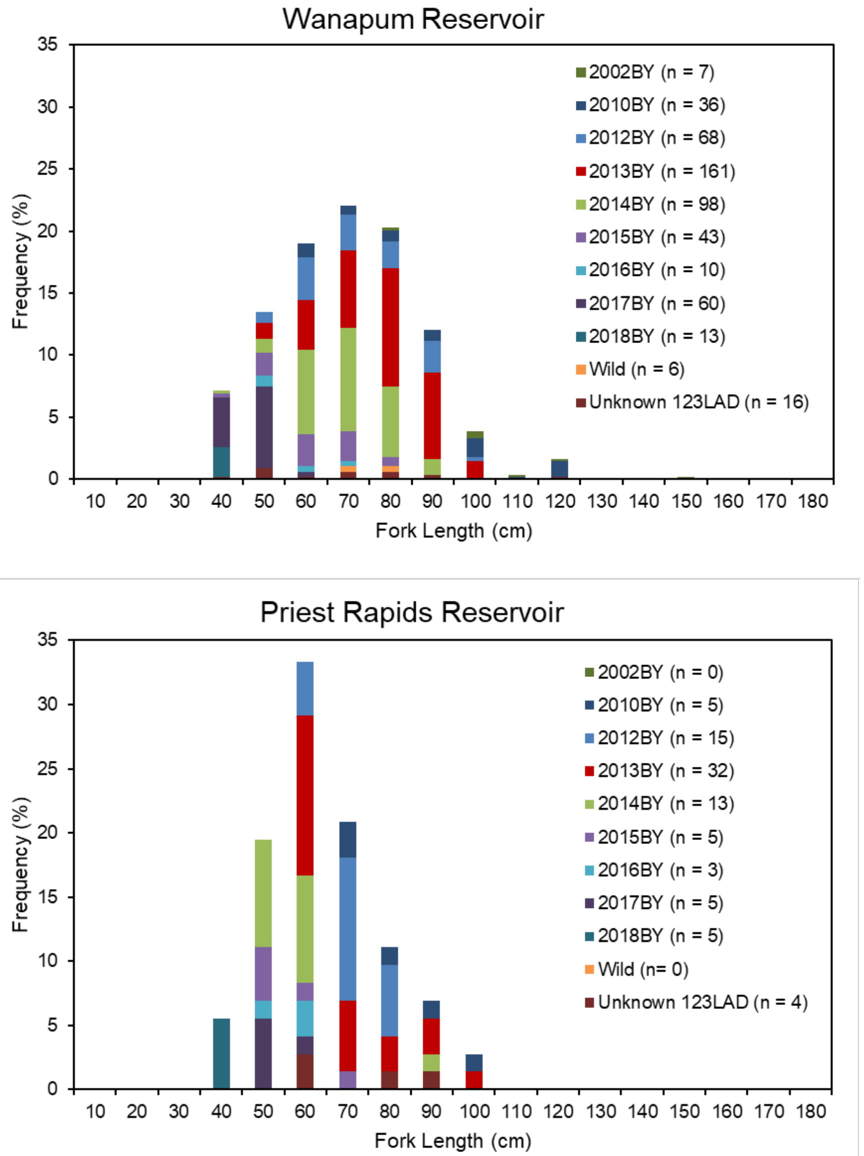


Figure 13 Length-frequency distribution by brood year for hatchery white sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

In Wanapum Reservoir, fish weight ranged from 185 to 13,240 g (mean = 1,994 g; n = 619). In Priest Rapids Reservoir, the range was smaller, with the smallest fish at 230 g and the largest at 8,700 g (mean = 1,620 g; n = 76; Table 9). The mean weight of fish captured in Wanapum Reservoir was higher than the mean weight of fish captured in Priest Rapids Reservoir, largely due to a reduced number of 2002BY and 2010BY fish captured in Priest Rapids Reservoir. Relationships between log^{10} FL and log^{10} weight were highly significant and regression parameter estimates were similar between reservoirs (Figure 14). Relative weight was slightly higher in Wanapum Reservoir (mean = 95%; n = 519) and ranged from 50% to 136%, compared to Priest Rapids Reservoir (mean = 91%; n = 68), with a range from 50% to 143% (Figure 15).

Table 9 **Weight (g) of white sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.**

Program	Brood Year	Wanapum					Priest Rapids					All				
		n	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**
CRITFC	2002	**6**	6,843	2,238	3,610	10,330	-	-	-	-	-	**6**	6,843	2,238	3,610	10,330
Chelan PUD	2010	**2**	10,205	2,100	8,720	11,690	-	-	-	-	-	**2**	10,205	2,100	8,720	11,690
	2013	**1**	6,010	-	6,010	6,010	-	-	-	-	-	**1**	6,010	-	6,010	6,010
	2014	**1**	1,755	-	1,755	1,755	-	-	-	-	-	**1**	1,755	-	1,755	1,755
	2015	**1**	575	-	575	575	-	-	-	-	-	**1**	575	-	575	575
Douglas PUD	2013	**1**	3,560	-	3,560	3,560	-	-	-	-	-	**1**	3,560	-	3,560	3,560
Grant PUD	2010	**34**	5,226	3,636	1,055	13,240	**5**	3,783	2,916	1,395	8,700	**39**	5,041	3,551	1,055	13,240
	2012	**68**	2,289	1,464	475	7,240	**15**	1,707	575	775	2,865	**83**	2,184	1,364	475	7,240
	2013	**159**	3,109	1,564	435	8,085	**18**	2,038	1,579	805	6,500	**177**	3,000	1,595	435	8,085
	2014	**127**	1,972	976	425	6,260	**13**	1,042	828	590	3,700	**140**	1,886	998	425	6,260
	2015	**42**	1,213	665	338	2,775	**5**	1,153	741	500	2,070	**47**	1,206	665	338	2,775
	2016	**10**	881	409	400	1,720	**3**	1,008	362	605	1,305	**13**	910	388	400	1,720
	2017	**60**	456	154	185	925	**5**	644	364	405	1,260	**65**	471	181	185	1,260
	2018	**13**	240	34	185	305	**4**	279	56	230	355	**17**	249	42	185	355
Unknown[1]	Unknown	**16**	2,509	2,978	335	1,2375	**4**	2,193	1,192	880	3,685	**20**	2,446	2,691	335	12,375
Wild	Wild	**6**	2,485	865	1,285	3,680		-	-	-	-	**6**	2,485	865	1,285	3,680
All Sturgeon	All	**547**	2,371	2,042	185	13,240	**72**	1,620	1,419	230	8,700	**619**	2,283	1,994	185	13,240

[1]These are likely hatchery origin, but brood year, source, or stocking location data are unknown.

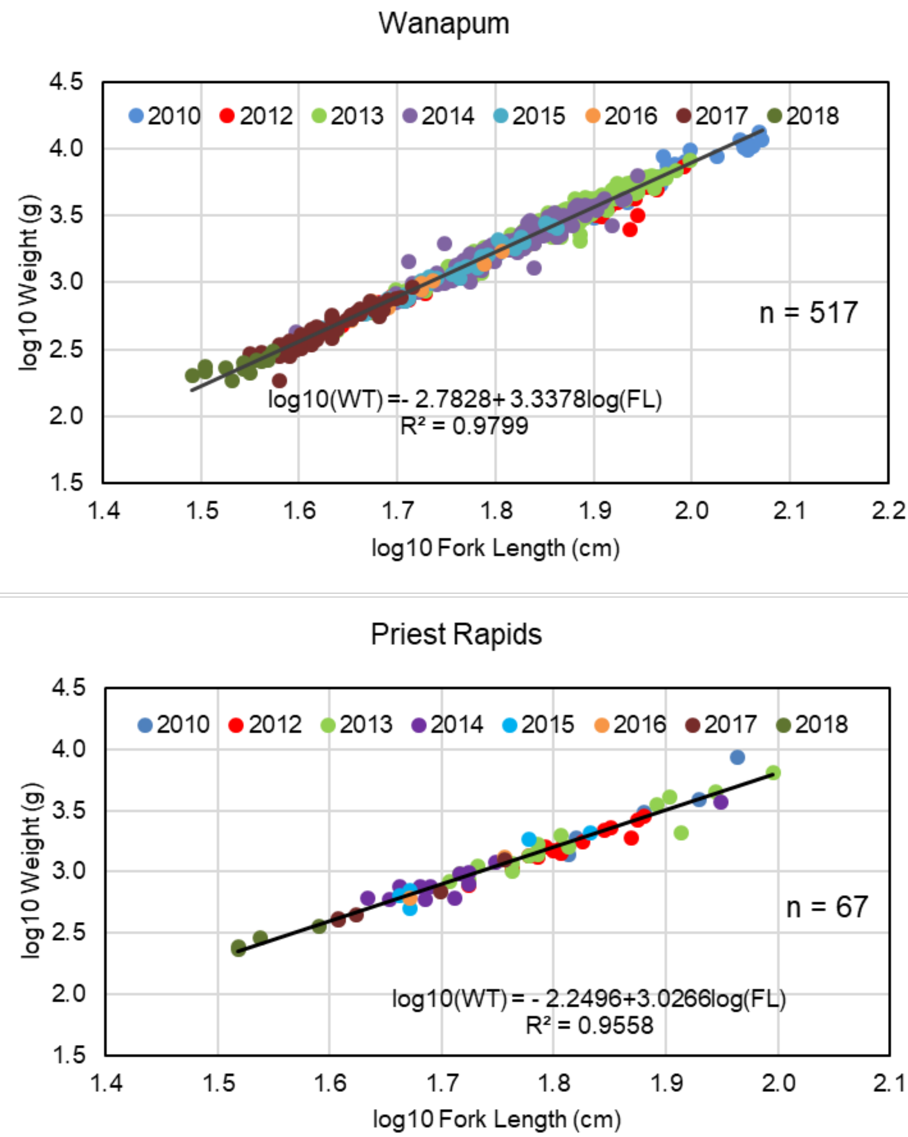
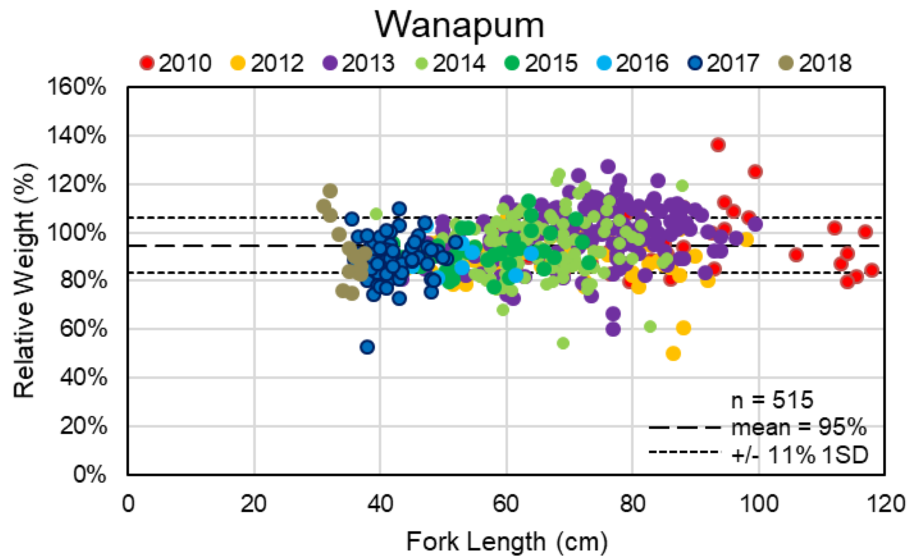


Figure 14 Linear regression of $\log_{10}$ fork length and $\log_{10}$ weight for hatchery juvenile white sturgeon of each brood year captured in Wanapum and Priest Rapids reservoirs during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.



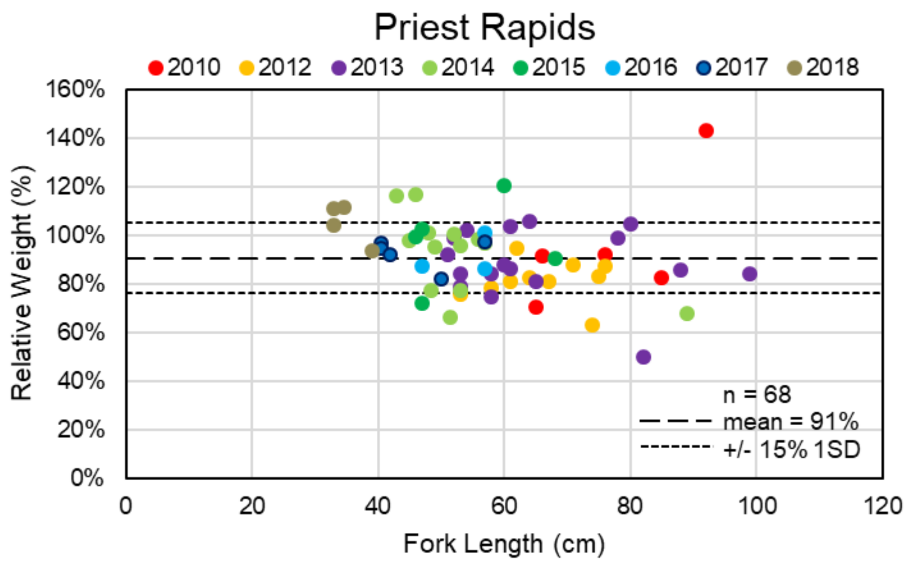


Figure 15 **Relative weight and fork length relationship for hatchery juvenile white sturgeon of each brood year captured in Wanapum and Priest Rapids reservoirs during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.**

Annual growth rate was calculated for each brood year based on the difference in fork length between release and capture, divided by the total number of days at large (Table 10). The highest growth rate was associated with the 2018BY (n = 17), at large for 0.36 years, with a mean annual growth rate of 19.7 cm/year and a range between 6.8 and 28.2 cm/year. After the first year at large, growth slows. After 1.38 years at large, the mean growth rate of the 2017BY (n = 65) was 10.1 cm/year and ranged from 4.0 to 19.1 cm/year. Prior to 2019, capture rates of 2016BY were low and previous growth estimates of the 2016BY were based on very few fish (i.e., 2017 n = 1; 2018 n = 3). With the capture of 13 fish in 2019, the mean growth rate of the 2016BY after 2.37 years at large was 9.8 $cm \cdot y^{-1}$ and ranged from 5.6 to 14.6 $cm \cdot y^{-1}$. This estimate was similar to the growth rate estimates for other brood years at this age (Golder 2018). For all brood years after release, growth rate decreases by approximately 50% after one full year at large and then remains relatively uniform for several years, gradually decreasing from approximately 10 cm/year after the second year at large to approximately 6 to 7 cm/year eight years after release. Growth rate data collected to date suggest that fish in Wanapum Reservoir grow at a faster rate than fish in Priest Rapids Reservoir.

Table 10 Time at large (years) and growth, expressed as change in fork length (FL; cm) and growth rate (FL; cm y^1), for Yakama Nation Sturgeon Hatchery fish captured during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

Reservoir	Program	BY	n	Time at Large (Years)				Growth (cm)				Growth Rate (cm· y^{-1})			
				Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Wanapum	Chelan PUD	2010	**2**	8.39	0.00	8.39	8.39	74.5	10.3	67.2	81.7	8.9	1.2	8.0	9.7
		2013	**1**	5.35	-	5.35	5.35	79.4	-	79.4	79.4	14.8	-	14.8	14.8
		2014	**1**	4.37	-	4.37	4.37	33.3	-	33.3	33.3	7.6	-	7.6	7.6
		2015	**1**	4.39	-	4.39	4.39	27.8	-	27.8	27.8	6.3	-	6.3	6.3
	Douglas PUD	2013	**1**	5.42	-	5.42	5.42	49.9	-	49.9	49.9	9.2	-	9.2	9.2
	Grant PUD	2010	**34**	8.39	0.01	8.37	8.42	57.6	21.2	20.5	91.0	6.9	2.5	2.4	10.9
		2012	**68**	6.34	0.01	6.32	6.37	38.3	13.3	14.8	65.1	6.0	2.1	2.3	10.3
		2013	**159**	5.29	0.14	4.97	5.39	45.3	12.8	18.0	75.9	8.6	2.4	3.4	14.1
		2014	**127**	4.38	0.02	4.35	4.41	33.7	9.7	10.7	54.0	7.7	2.2	2.4	12.3
		2015	**42**	3.38	0.02	3.36	3.41	26.3	9.6	6.4	43.3	7.8	2.8	1.9	12.9
		2016	**10**	2.37	0.02	2.35	2.39	23.0	7.0	13.3	34.7	9.7	3.0	5.6	14.6
		2017	**60**	1.37	0.01	1.35	1.40	13.6	4.9	5.5	26.5	9.8	3.5	4.0	19.1
		2018	**13**	0.36	0.01	0.33	0.38	6.7	2.2	2.5	10.6	18.6	5.8	6.8	28.2
Priest Rapids	Grant PUD	2010	**5**	8.38	0.03	8.34	8.42	47.6	13.0	29.6	60.9	5.7	1.5	3.5	7.2
		2012	**15**	6.32	0.02	6.29	6.33	36.7	7.5	22.7	50.0	5.8	1.2	3.6	7.9
		2013	**18**	5.23	0.18	4.95	5.39	37.3	15.8	17.2	74.7	7.1	2.9	3.5	13.8
		2014	**13**	4.37	0.02	4.35	4.41	21.1	12.6	11.3	60.8	4.8	2.9	2.6	13.8
		2015	**5**	3.38	0.02	3.36	3.39	23.5	9.2	16.0	37.1	7.0	2.7	4.8	10.9
		2016	**3**	2.38	0.01	2.36	2.38	24.3	5.9	17.5	28.0	10.2	2.4	7.4	11.7
		2017	**5**	1.38	0.02	1.35	1.40	17.4	5.9	12.9	24.0	12.5	4.1	9.3	17.1
		2018	**4**	0.35	0.03	0.31	0.37	8.2	2.8	4.2	10.3	23.1	6.6	13.4	28.1
All	Grant PUD	2010	**39**	8.39	0.02	8.34	8.42	56.3	20.5	20.5	91.0	6.7	2.4	2.4	10.9
		2012	**83**	6.34	0.02	6.29	6.37	38.0	12.4	14.8	65.1	6.0	2.0	2.3	10.3
		2013	**177**	5.28	0.15	4.95	5.39	44.4	13.3	17.2	75.9	8.4	2.5	3.4	14.1
		2014	**140**	4.38	0.02	4.35	4.41	32.5	10.6	10.7	60.8	7.4	2.4	2.4	13.8
		2015	**47**	3.38	0.02	3.36	3.41	26.0	9.5	6.4	43.3	7.7	2.8	1.9	12.9
		2016	**13**	2.37	0.02	2.35	2.39	23.3	6.5	13.3	34.7	9.8	2.7	5.6	14.6
		2017	**65**	1.38	0.01	1.35	1.40	13.8	5.0	5.5	26.5	10.1	3.6	4.0	19.1
		2018	**17**	0.36	0.02	0.31	0.38	7.0	2.3	2.5	10.6	19.7	6.1	6.8	28.2

3.5.5 Gear Performance

In total, 129 gangions (17.0% of the Wanapum gear inventory) were lost and/or damaged in Wanapum Reservoir, with slightly more 4/0 gangions lost or damaged (n = 72) than 2/0 gangions (n = 64; Table 11). Lost hooks, where the entire hook broke away from the gangion, represented less than 1% (7 of 800 hooks) of the inventory. Lost and damaged hooks in relation to the number of hooks deployed in Wanapum Reservoir over the study (n = 10,799 gangions fished) was 1.3%.

Gear was lost in Priest Rapids Reservoir at a lower rate than in Wanapum Reservoir, with 44 of the 400 hooks (11%) damaged. Approximately equal numbers of 2/0 and 4/0 hooks were damaged. Lost hooks represented approximately 1% (n = 4 of 400) of the gear allotment for Priest Rapids. Lost and damaged hooks in relation to the number of hooks deployed in Priest Rapids Reservoir over the study (n = 3,600 gangions fished) was 1.2%.

In Wanapum Reservoir, total catch by the 4/0 hook size was 36% higher than the 2/0 hook size. In Priest Rapids Reservoir, catch by the 4/0 hooks was 18% higher than 2/0 hooks. Based on the catch size range of each hook type, both hooks sizes caught smaller fish equally well, but the 4/0 hooks were marginally more effective in the capture of larger fish (Table 12).

Table 11 Hook rate and overall gangion damage in the Priest Rapids Project area during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

Reservoir	Hook Size	Gangions		Hook/Gangion Fate				
		No. Set	Gear Inventory	Bent	Lost	Total	Proportion of Set Gangions with Lost or Damaged Hooks	Proportion of Gangion Inventory with Lost or Damaged Hooks
		n	n	n	n	n	%	%
Wanapum	**2/0**	5,398	400	61	3	64	1.2	16.0
	4/0	5,401	400	68	4	72	1.3	18.0
Total		10,799	800	129	7	136	1.3	17.0
Priest Rapids	**2/0**	1,800	200	18	3	21	1.2	10.5
	4/0	1,800	200	22	1	23	1.3	11.5
Total		3,600	400	40	4	44	1.2	11.0
PRPA		14,399	1200	169	11	180	1.3	15.0

Table 12 White sturgeon catch by hook size in the Priest Rapids Project area during the juvenile white sturgeon indexing program, August 28 to September 26, 2019.

Reservoir	Hook Size	Catch	Fork Length (cm)			
		n	Mean	SD	Min	Max
Wanapum	2/0	220	64.6	16.6	32.0	118.0
	4/0	346	66.1	17.5	31.0	147.5
Priest Rapids	2/0	33	59.2	14.5	33.0	88.0
	4/0	40	60.9	15.3	33.0	99.0

3.5.6 Hatchery Juvenile White Sturgeon Abundance Estimates

Capture success during the 2019 juvenile White Sturgeon indexing program was sufficient to construct a set of Cormack-Jolly-Seber models to estimate survival (Table 13) and recapture probabilities of juvenile hatchery White Sturgeon released in Priest Rapids and Wanapum reservoirs (Table 14; Table 15). Of the nine models tested and used to calculate model-averaged values of recapture and survival estimates, the model with the lowest QAICc had survival as an additive function of brood year and age class (i.e., first year after release or any subsequent year) and recapture probability as a multiplicative function of sampling occasion, brood year, and release reservoir. The weighting for this model was 0.7, indicating some support, albeit low, for other models as well.

For all brood years, mean survival estimates were lower in the first year post-release than in subsequent years at large (Figure 16; Table 13). The highest mean survival estimates were recorded for the 2013BY (in Priest Rapids – 0.463 first year post-release, 0.819 all subsequent years), with slightly lower survival estimates recorded for the 2010BY (0.461, 0.817) and 2012BY (0.389, 0.769). For brood years released from 2015 onward, a notable decline in survival was evident, with survival estimates for the 2014BY (0.300, 0.691), 2015BY (0.259, 0.645), and 2016-2017 brood years (0.178, 0.818) releases substantially lower than the preceding brood years.

Recapture probabilities generally increased with fish age, although the extent depended on brood year and release reservoir (Figure 17; Table 14, Table 15). For example, in Priest Rapids Reservoir, the recapture probabilities of 2015BY increased from 0.015 in 2017 to 0.028 in 2018 and 0.036 in 2019. In comparison, in Wanapum Reservoir, recapture probabilities of 2015BY increased from 0.081 in 2015 to 0.187 in 2019. Overall, recapture probabilities in Wanapum Reservoir were 2 to 3 times higher compared to fish of the same age in Priest Rapids Reservoir.

The model-averaged survival estimates were used to calculate total annual population values with 95% confidence intervals to describe abundance of hatchery juvenile White Sturgeon released in the PRPA for each calendar year from 2011 to 2019 (Figure 18; Table 16). After the initial release of hatchery fish in 2011, the 2012 population abundance estimated for both reservoirs decreased, as hatchery fish were not released in 2012 (i.e., a 2011BY was not released). From 2012 to 2015, each successive annual release of hatchery fish was reflected in step increases in total annual population abundance estimates (Figure 18). Since 2015, the estimated population abundance of hatchery White Sturgeon in each reservoir has steadily decreased due to lower estimated survival of subsequent brood year releases compared to previous years. With the release of the 2018BY, the 2019 hatchery fish abundance estimate in Wanapum Reservoir was 5,262 (95% CI = 4,164 – 6,360) or 19.4% of total hatchery releases to date (n = 27,132 fish). In Priest Rapids Reservoir, the 2018 hatchery fish abundance estimate was 2,239 fish (95% CI = 1,737– 2,741) or 19.6% of total hatchery releases to date (n = 11,446 fish).

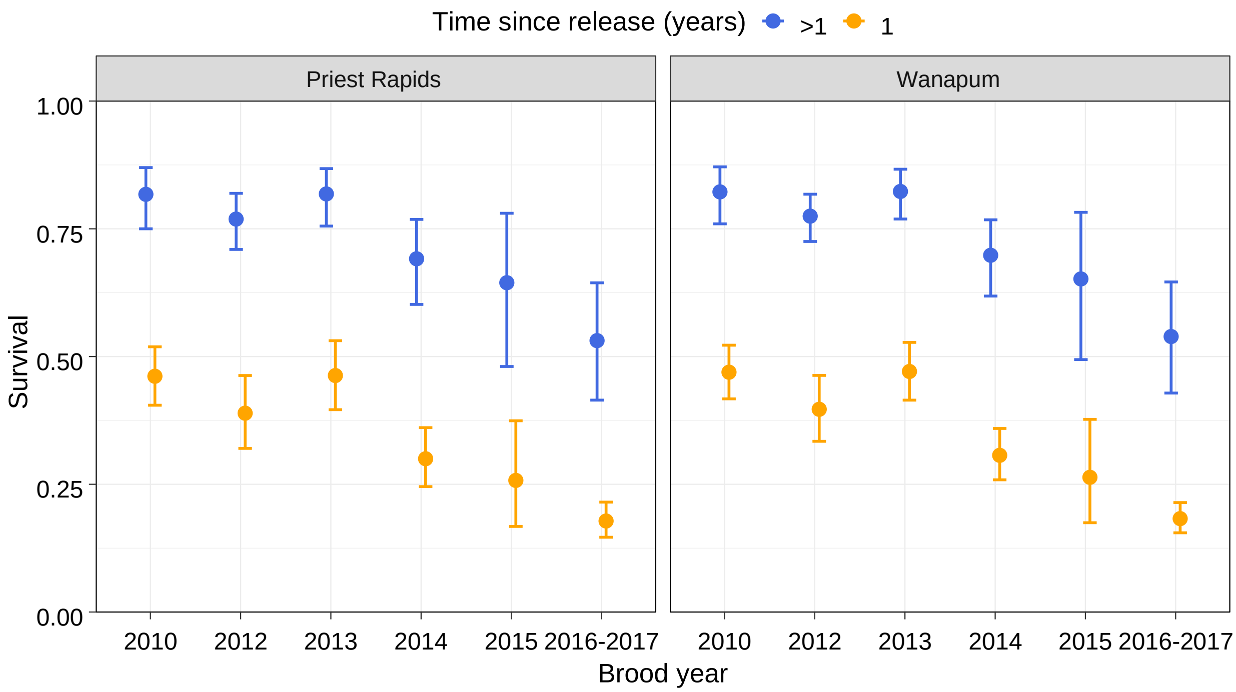


Figure 16 **Estimated survival of hatchery juvenile white sturgeon by brood year, release reservoir, and age class (i.e., first year post release or in any subsequent year combined).**

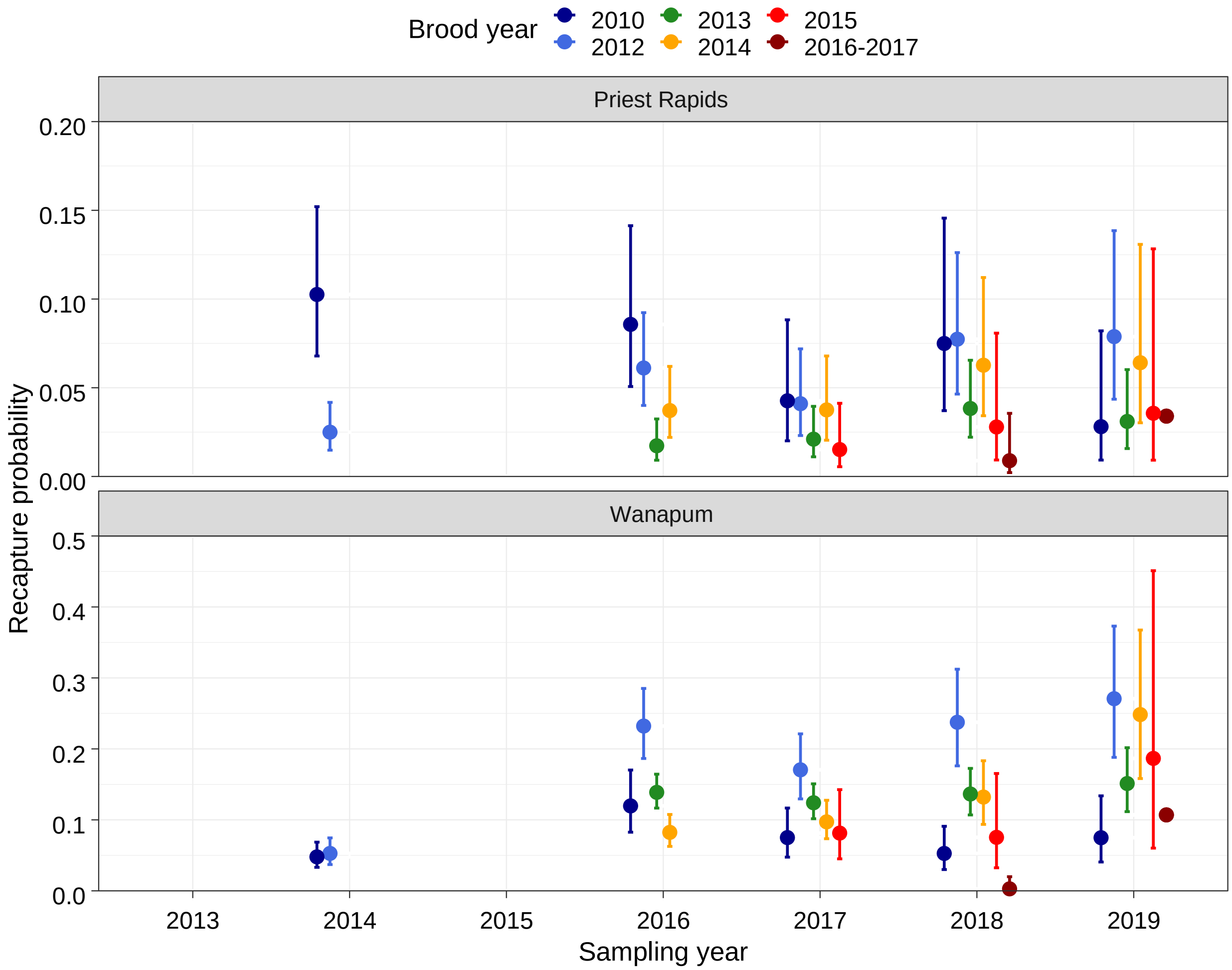


Figure 17 Estimated probability of recapture of hatchery juvenile white sturgeon by brood year, reservoir, and sampling year.

Table 13 **Cormack-Jolly-Seber model estimates of annual survival parameters for hatchery juvenile white sturgeon in the Priest Rapids and Wanapum reservoirs.**

Reservoir	Parameter	Estimate		
		Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Priest Rapids	Survival, 2010BY-First-Year, Post-Release	0.461	0.405	0.519
	Survival, 2010BY-All Subsequent Years	0.817	0.750	0.870
	Survival, 2012BY-First-Year, Post-Release	0.389	0.320	0.463
	Survival, 2012BY-All Subsequent Years	0.769	0.710	0.819
	Survival, 2013BY-First-Year, Post-Release	0.463	0.396	0.531
	Survival, 2013BY-All Subsequent Years	0.818	0.755	0.868
	Survival, 2014BY-First-Year, Post-Release	0.300	0.245	0.361
	Survival, 2014BY-All Subsequent Years	0.691	0.602	0.768
	Survival, 2015BY-First-Year, Post-Release	0.258	0.167	0.374
	Survival, 2015BY-All Subsequent Years	0.645	0.481	0.780
	Survival, 2016-2017 BY-First-Year, Post-Release	0.178	0.146	0.215
	Survival, 2016-2017BY-All Subsequent Years	0.531	0.415	0.644
Wanapum	Survival, 2010BY-First-Year, Post-Release	0.469	0.417	0.522
	Survival, 2010BY-All Subsequent Years	0.822	0.760	0.871
	Survival, 2012BY-First-Year, Post-Release	0.397	0.334	0.463
	Survival, 2012BY-All Subsequent Years	0.775	0.725	0.818
	Survival, 2013BY-First-Year, Post-Release	0.471	0.415	0.528
	Survival, 2013BY-All Subsequent Years	0.823	0.769	0.867
	Survival, 2014BY-First-Year, Post-Release	0.307	0.259	0.359
	Survival, 2014BY-All Subsequent Years	0.698	0.618	0.768
	Survival, 2015BY-First-Year, Post-Release	0.264	0.175	0.377
	Survival, 2015BY-All Subsequent Years	0.652	0.494	0.782
	Survival, 2016-2017 BY-First-Year, Post-Release	0.183	0.155	0.214
	Survival, 2016-2017BY-All Subsequent Years	0.539	0.429	0.646

Table 14 Cormack-Jolly-Seber model estimates of annual recapture parameters for hatchery juvenile white sturgeon in Priest Rapids Reservoir.

Reservoir	Parameter (Brood Year - Year Estimated)	Estimate		
		Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Priest Rapids	Recapture2010BY-2014	0.103	0.068	0.152
	Recapture2010BY-2016	0.086	0.051	0.141
	Recapture2010BY-2017	0.043	0.020	0.088
	Recapture2010BY-2018	0.075	0.037	0.146
	Recapture2010BY-2019	0.028	0.009	0.082
	Recapture2012BY-2014	0.025	0.015	0.042
	Recapture2012BY-2016	0.061	0.040	0.092
	Recapture2012BY-2017	0.041	0.023	0.072
	Recapture2012BY-2018	0.077	0.046	0.126
	Recapture2012BY-2019	0.079	0.044	0.139
	Recapture2013BY-2016	0.017	0.009	0.032
	Recapture2013BY-2017	0.021	0.011	0.040
	Recapture2013BY-2018	0.038	0.022	0.066
	Recapture2013BY-2019	0.031	0.016	0.060
	Recapture2014BY-2016	0.037	0.022	0.062
	Recapture2014BY-2017	0.038	0.020	0.068
	Recapture2014BY-2018	0.063	0.034	0.112
	Recapture2014BY-2019	0.064	0.030	0.131
	Recapture2015BY-2017	0.015	0.005	0.041
	Recapture2015BY-2018	0.028	0.009	0.081
	Recapture2015BY-2019	0.036	0.009	0.128
	Recapture2016-2017BY-2018	0.009	0.002	0.036
	Recapture2016-2017BY-2019	0.034	N/A – recapture probability was a fixed value	

Table 15 Cormack-Jolly-Seber model estimates of annual recapture parameters for hatchery juvenile white sturgeon in Wanapum Reservoir.

Reservoir	Parameter (Brood Year - Year Estimated)	Estimate		
		Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Wanapum	Recapture2010BY-2014	0.048	0.033	0.069
	Recapture2010BY-2016	0.120	0.083	0.170
	Recapture2010BY-2017	0.075	0.047	0.117
	Recapture2010BY-2018	0.053	0.030	0.091
	Recapture2010BY-2019	0.075	0.041	0.134
	Recapture2012BY-2014	0.053	0.037	0.075
	Recapture2012BY-2016	0.232	0.186	0.285
	Recapture2012BY-2017	0.171	0.130	0.221
	Recapture2012BY-2018	0.238	0.176	0.312
	Recapture2012BY-2019	0.271	0.188	0.373
	Recapture2013BY-2016	0.139	0.117	0.164
	Recapture2013BY-2017	0.124	0.102	0.151
	Recapture2013BY-2018	0.136	0.107	0.173
	Recapture2013BY-2019	0.151	0.112	0.202
	Recapture2014BY-2016	0.082	0.063	0.108
	Recapture2014BY-2017	0.097	0.073	0.128
	Recapture2014BY-2018	0.132	0.094	0.183
	Recapture2014BY-2019	0.248	0.158	0.367
	Recapture2015BY-2017	0.081	0.045	0.143
	Recapture2015BY-2018	0.075	0.032	0.165
	Recapture2015BY-2019	0.187	0.060	0.451
	Recapture2016-2017BY-2018	0.003	0.000	0.020
	Recapture2016-2017BY-2019	0.107	N/A – recapture probability was a fixed value	

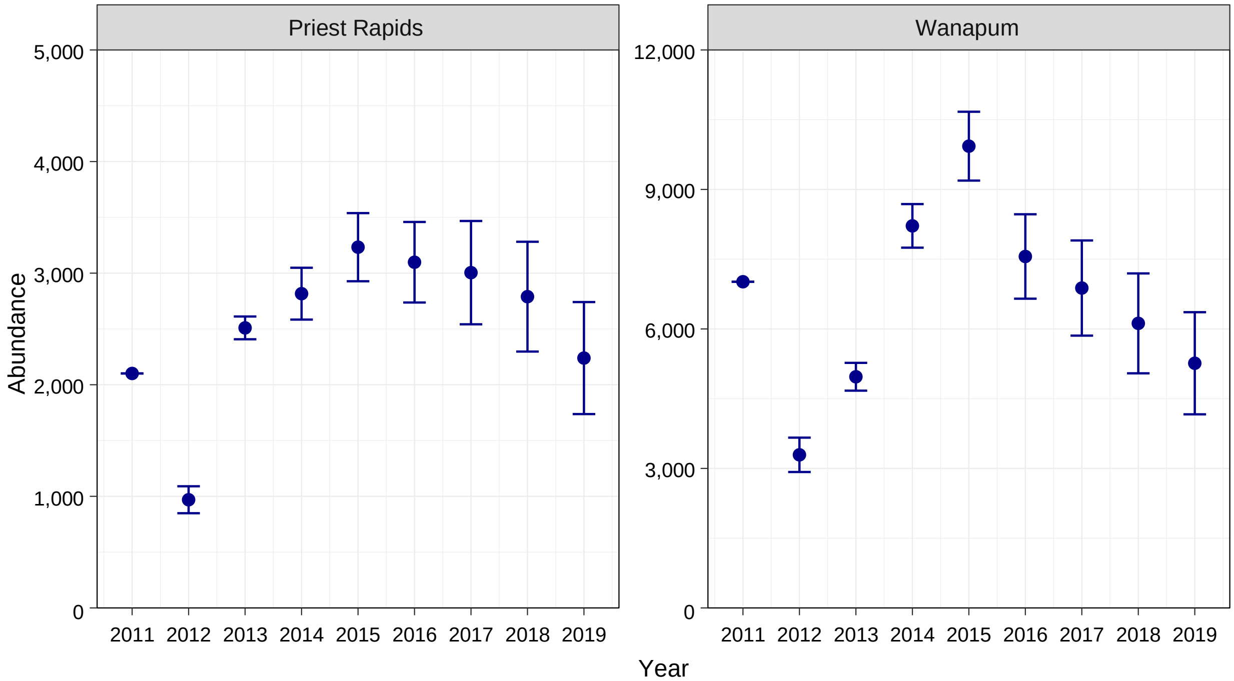


Figure 18 **Estimated abundance of hatchery juvenile white sturgeon (based on survival of 2010BY to 2018BY releases) by calendar year for Wanapum and Priest Rapids reservoirs, from 2011 to 2019.**

Table 16 Estimated total abundance of the hatchery juvenile white sturgeon (2010BY to 2018BY) releases in the Priest Rapids Project area by calendar year and in relation to annual and cumulative hatchery releases, 2011 to 2019.

	Calendar Year								
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Pool	**Abundance Estimate (95% CI)**								
Wanapum	**7,015**	**3,293**	**4,971**	**8,217**	**9,931**	**7,558**	**6,879**	**6,120**	**5,262**
	(7,015 - 7,015)	(2,923 - 3,662)	(4,673 - 5,270)	(7,748 - 8,685)	(9,191 - 10,671)	(6,651 - 8,466)	(5,856 - 7,903)	(5,046 - 7,194)	(4,164 - 6,360)
Annual Hatchery Release No.	7,015	0	2,264	5,092	5,007	2,005	1,999	1,983	1,767
Cumulative Release No.	7,015	7,015	9,279	14,371	19,378	21,383	23,382	25,365	27,132
Priest Rapids	**2,101**	**969**	**2,509**	**2,816**	**3,233**	**3,098**	**3,004**	**2,789**	**2,239**
	(2,101 - 2,101)	(849 - 1,090)	(2,407 - 2,611)	(2,584 - 3,048)	(2,927 - 3,538)	(2,737 - 3,459)	(2,542 - 3,467)	(2,297 - 3,281)	(1,737 - 2,741)
Annual Hatchery Release No.	2,101	0	1,717	1,500	1,495	1,253	1,249	1,241	890
Cumulative Release No.	2,101	2,101	3,818	5,319	6,814	8,067	9,316	10,566	11,446

4.0 Discussion

The following sections provide a brief discussion of the 2019 (FERC License Year 12) M&E program results for the PRPA in context with previous study results. In 2019, activities included the tagging and release of 2018BY juvenile White Sturgeon, broodstock capture and 2019BY production (both conducted as separate programs), and juvenile White Sturgeon population indexing.

4.1 Discharge and Temperature

Mean monthly discharge volume during freshet in 2019 (16,069 KAF[kilo-acrefeet]) was below average compared to the 30-year normal (17,165 KAF; 1981-2010 flow years) and was substantially lower than freshet flows in 2017 (23,362 KAF) and 2018 (32,790 KAF; Figure 19; NOAA 2019). For comparison, in 2018, the peak mean daily flow in the PRPA was 9,228 m³/s (May 14) and only 5,070 m³/s (May 19) in 2019. Although freshet flows were marginally higher in 2019 than in 2015, total annual discharge volume was higher in 2015 (76,482 KAF) than in 2019 (70,688 KAF). However, mean monthly total discharge volume and water temperature recorded during annual late summer (August, September, and October) juvenile White Sturgeon population indexing studies were similar from 2014 to 2019, with flows generally under 5000 KAF and water temperatures from 18°C to 20°C (Figure 20).

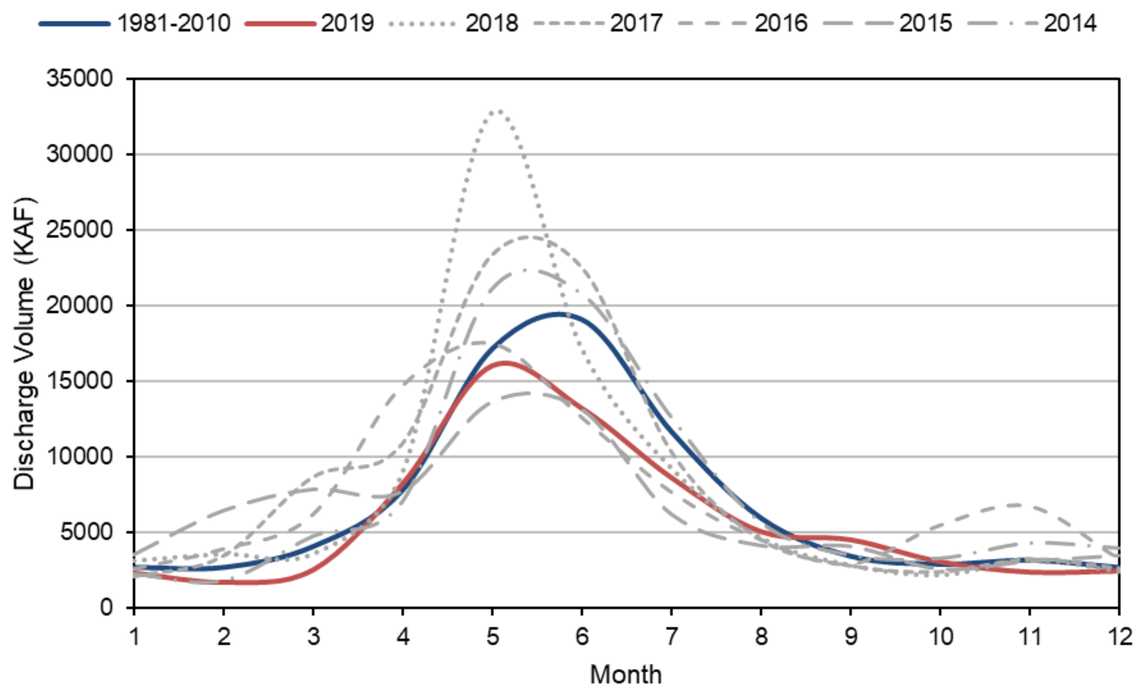


Figure 19 **The 2019 mean monthly discharge volume (red line) in comparison with the 30-year normal (blue line) and last five years from 2014 to 2018, as recorded at Rock Island Dam.**

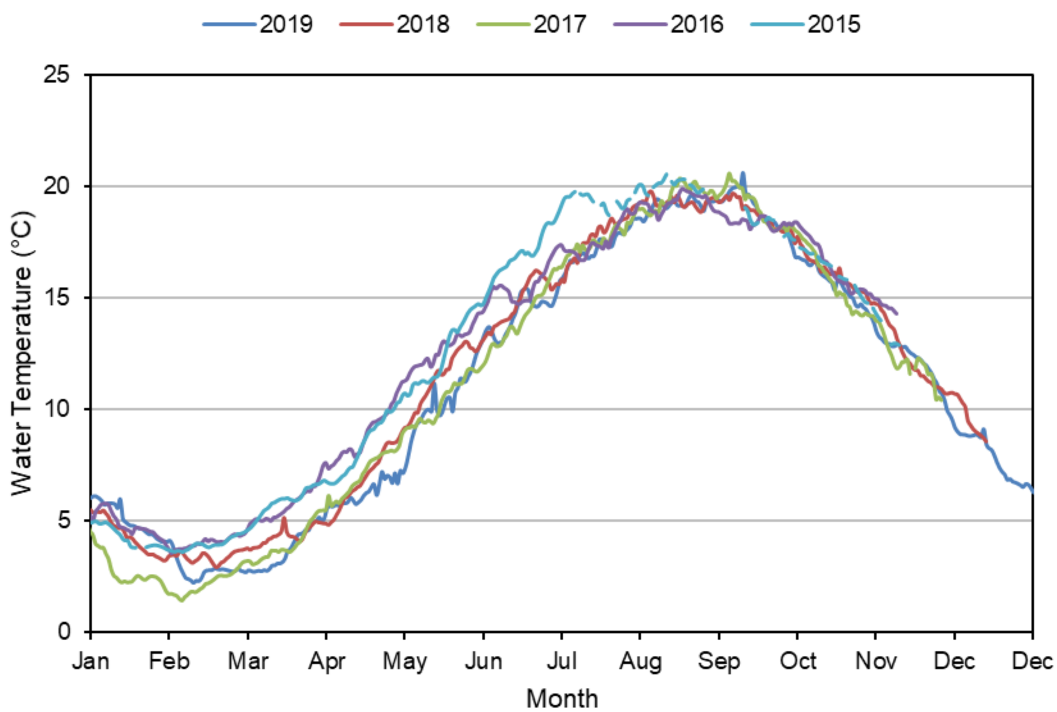


Figure 20 **Mean daily water temperature from 2014 to 2019 as recorded at Rock Island Dam.**

4.2 Juvenile White Sturgeon Processing and Release (2018BY)

Tagging and marking of the 2018BY was completed by April 10, 2019, which was comparable to previous brood tagging efforts that endeavored to have all fish tagged by mid-April. The mean fork length and weight of the 2018BY (26.7 cm FL and 128 g) at tagging were below the combined average of all brood year hatchery fish released to date (29.0 cm FL and 159 g; Table 17). However, after a post-tagging holding period of approximately 27 days prior to release on May 7, the fork length and weight of 2018BY at release were likely slightly higher than when the fish were tagged. The length and weight of fish at release may influence post-release survival, in that smaller fish typically experience higher rates of predation and higher post-release mortality than larger fish. In 2018, the highest post-release survival estimate was recorded for the 2013BY (0.445) and the lowest for the 2016BY (0.012) even though these two brood years were similar in size at release (2013BY mean = 27.5 cm FL; 2016BY mean = 27.2 cm FL). One identified source of juvenile White Sturgeon mortality in the release year is avian predation (see Section 4.6). Evidence to date indicates that avian predators can capture fish as large as 42.0 cm FL, and therefore, it is unlikely that the small difference in size at release among the different brood years affects avian predation success. These data suggest that post-release survival may be due to other factors (e.g., total river discharge at release, release location) rather than only release size.

During tagging of the 2018BY, fin deformities were observed and recorded in 31% of fish (n = 831 of 2,657). This fin deformity rate was lower than rates recorded in 2017BY (43%; n = 1,398 of 3,224) or the 2016BY (42%; n = 1,371 of 3,248 fish) and suggests that the cause of fin deformities, specifically mechanical damage during rearing, was mitigated to some extent by hatchery staff in 2018. The long-term biological implications of fin deformities on White Sturgeon survival, growth, and future reproduction are not known. However, during population indexing studies, fish with and without fin deformities from each hatchery brood year release have been captured in proportions that approximately equaled fin deformity rates reported for those brood years at release. These capture data suggest that fin deformities do not appear have a substantial effect on the survival of White Sturgeon during their early life history. During adult White Sturgeon population indexing and broodstock capture studies in the PRPA (Golder 2015), low numbers of adult fish with deformed or missing fins were captured. These fish appeared healthy and had mature or maturing gonads.

Table 17 Summary by brood year of hatchery white sturgeon juveniles released in the Priest Rapids Project area.

Brood Year	Reservoir	Release Location	River Mile	Brood Source	Release Date	Number Released	Fork Length (cm) Mean	Fork Length (cm) SD	Weight (g) Mean	Weight (g) SD
2010	Wanapum	Columbia Siding	450.6	UCW[1]	26-Apr-11	2,019 (20)	24.6	3	174	97
				MCW[2]	29-Apr-11	2,996 (30)	28.8	3.6		
				LCC[3]	27-29 April 2011	2,000 (20)	34.7	3.6		
				All	--	7,015 (70)	29.3	5.1		
	Priest Rapids	Wanapum Dam Tailrace	415.6	UCW	26-Apr-11	900 (9)	24.8	2.8	187	105
				MCW	28-Apr-11	601 (6)	29	3.6		
				LCC	28-Apr-11	600 (6)	35.9	2.9		
				All	--	2,101 (21)	29.8	5.3		
				Total 2010		**9,116 (91)**	**29.4**	**5.2**	**177**	**99**
2012	Wanapum	Columbia Siding	450.6	MCW	14-May-13	1,135 (13)	29.2	2.7	156	45
		Columbia Cliffs	442	MCW	14-May-13	1,129 (11)	29.8	2.6		
		All	--	MCW	--	2,264 (24)	29.5	2.6		
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	14-15 May 2013	1,717 (6)	28.5	2.4	149	41
				Total 2012		**3,981 (30)**	**29.1**	**2.6**	**154**	**44**
2013	Wanapum	Rocky Coulee	421.5	MCW	6-May-14	3,330 (32)	26.6	4.0	118	52
				MCW	18-Sep-14	1,762 (20)	29.1	4.4	152	74
				All	--	5,093 (52)	27.5	4.3	129	63
	Priest Rapids	Wanapum tailrace	415.6	MCW	5-May-14	996 (9)	27.2	4.2	131	56
				MCW	17-Sep-14	504 (5)	28.1	4.3	135	73
				All	--	1,500 (14)	27.5	4.2	133	63
				Total 2013		**6,592 (66)**	**27.5**	**4.3**	**130**	**63**
2014	Wanapum	Frenchman Coulee	424.5	MCW	30-Apr to 1-May 2015	5,007 (48)	31.3	2.9	199	55
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	30-Apr to 1-May 2015	1,495 (15)	31.5	3.5	194	57
				Total 2014		**6,502 (63)**	**31.3**	**3.0**	**198**	**56**
2015	Wanapum	Frenchman Coulee	424.5	MCW	28-Apr-16	2,005 (25)	30.4	2.7	173	47
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	28-Apr-16	1,253 (7)	30.1	2.6	167	44
				Total 2015		**3,258 (32)**	**30.3**	**2.6**	**171**	**46**
2016	Wanapum	Frenchman Coulee	424.5	MCW	2-May-17	1,999 (20)	27.0	3.2	125	47
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	2-May-17	1,249 (12)	27.5	2.9	129	43
				Total 2016		**3,248 (32)**	**27.2**	**3.1**	**126**	**45**
2017	Wanapum	Frenchman Coulee	424.5	MCW	1-May-18	1,983 (20)	28.9	4.3	150	56
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	1-May-18	1,241 (12)	27.9	4.1	136	59
				Total 2017		**3,224 (32)**	**28.5**	**4.3**	**144**	**58**
2018	Wanapum	Frenchman Coulee	424.5	MCW	7-May-19	1,767(0)	26.9	3.0	130	44
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	7-May-19	890 (0)	26.5	2.8	124	40
				Total 2018		**2,657 (0)**	**26.7**	**2.9**	**128**	**43**
				Total 2010-2018		**38,578 (346)**	**29.0**	**4.2**	**159**	**72**

[1]Upper Columbia Wild (UCW) - the progeny of wild broodstock captured in the upper Columbia River in Canada and reared by the Freshwater Fisheries Society at Kootenay Sturgeon Hatchery in British Columbia
[2]Mid Columbia Wild (MCW) - the progeny of wild broodstock captured either in PRPA or below McNary Dam and reared at the Yakama Nation Sturgeon Hatchery (YNSH)
[3]Lower Columbia Cultured (LCC) - the progeny of captive broodstock originally captured below Bonneville Dam in the lower Columbia River.

4.3 Broodstock Capture and Juvenile Production

In total, five females and six males captured below McNary Dam in 2019 were transported to YNSH. Of these fish, five females and five males were successfully spawned on June 14 to attempt a 5x5 spawning matrix. From this effort, four females were crossed with five males to produce 20 genetic crosses (4 unique crosses; 16 half-sibling crosses). The fifth female yielded only enough eggs to produce a full 1x3 spawning matrix that resulted in three genetic crosses and a partial fourth cross with a fourth male. In total, 23 genetic crosses (4 unique crosses and 19 half-sibling crosses) were produced for the 2020 Chelan PUD release, and 24 genetic crosses (4 unique crosses and 20 half-sibling crosses) were produced for the 2020 Grant PUD release.

4.4 Movements of Adult White Sturgeon

The majority of tagged adult wild White Sturgeon in Wanapum Reservoir exhibit some seasonal movements. In most years, adult fish moved in early summer from overwintering locations to spawning and feeding habitat downstream of Rock Island Dam, after which they returned to the overwintering areas by late fall. Based on the similarity in tag detection frequency recorded before and after the 2014 reservoir drawdown, the wild White Sturgeon population appears resilient to short-term changes in flow and habitat conditions and returned to normal behavior soon after the reservoir was refilled. Movement data from 2010 to 2019 suggest that a naturally reproducing population of White Sturgeon exists within Wanapum Reservoir, with individuals exhibiting consistent seasonal movement into known spawning habitat on an annual basis. Once mature, hatchery White Sturgeon may exhibit similar behaviors and may successfully spawn and contribute to a self-sustaining population in the reservoir over the long term. Whether mature hatchery White Sturgeon will exhibit the same movement periodicity and spawning habits as wild fish is currently unknown.

Due to its small size, the population of wild White Sturgeon in Priest Rapids Reservoir was historically smaller than in Wanapum Reservoir (Golder 2002). Telemetry data recorded from 2010 to 2019 identified regular seasonal movements for certain individual wild adult White Sturgeon in Priest Rapids Reservoir, moving between the Wanapum Dam tailrace and holding habitat downstream in the lower section of the reservoir. Other fish remain year-round in the upper section of the reservoir immediately downstream of Wanapum Dam and only move downstream for brief periods in either the summer or fall before returning upstream. Although spawning has been detected below Wanapum Dam (Golder 2011), whether a self-reproducing population is sustainable in this reservoir is not certain.

4.5 Juvenile Indexing Sampling Effort and Catch

The 2019 juvenile White Sturgeon population indexing study design and sample effort was identical to the 2016, 2017, and 2018 studies to maintain consistency and more readily allow the identification of variables that may influence the juvenile White Sturgeon population in the PRPA.

The total number of fish captured in 2019 (n = 639 fish) exceeded the catch in 2017 (n = 568 fish) and 2018 (n = 563 fish) but was less than the catch in 2016 (n = 887; Table 18). In all study years since 2016, substantially more fish were captured in Wanapum Reservoir (n = 2,256 fish) than in Priest Rapids Reservoir (n = 401 fish), with 96% of all fish captured (both reservoirs combined) identified as hatchery juvenile White Sturgeon (n = 2,554 of 2,657 fish captured). The decrease in catch after 2016 was likely due to a combination of factors that included the following: 1) reduced susceptibility of older brood year fish to capture with small-hook set lines as the size of the fish increased; 2) a reduction in the number of fish released annually after 2015 under the SOA; and 3) implementation of a selective harvest program conducted from 2015 to 2018 to remove 2002BY fish from Wanapum and Priest Rapids reservoirs. Fish harvested during the 2002BY removal program were selected based on a slot size [96.5 cm to 183.0 cm (38" to 72") total length]. This slot size encompassed the estimated size range of the 2002BY fish, but also encompassed the upper size range of the 2010BY release, as well as a portion of the wild sturgeon population, both of which were not the intended targets of the removal program. Consequently, a proportion of the 2010BY and the wild sturgeon population were harvested during the 2002BY removal program.

Table 18 White sturgeon catch by reservoir in the Priest Rapids Project area during the hatchery juvenile white sturgeon indexing conducted from 2016 to 2019.

Study Year	Wanapum Reservoir Catch	Priest Rapid Reservoir Catch	Total Catch
	n	n	n
2016	746	141	887
2017	490	78	568
2018	454	109	563
2019	566	73	639
All Years	**2256**	**401**	**2657**

4.5.1 Catch Distribution by Brood Year and Reservoir

Wanapum Reservoir

Consistent with previous indexing studies conducted since 2016, the 2013BY release contributed the largest portion of the 2019 catch in Wanapum Reservoir (29%; n = 166 of 566 fish), but was lower than the 2013BY catch proportion reported in 2016 (36%; n = 269 of 746 fish), 2017 (41%; n = 200 of 490 fish), and 2018 (38%; n = 171 of 454 fish). The catch proportion of the 2014BY, the second most abundant brood year recorded in 2019 (23%; n = 132 of 566 fish), was almost identical to the catch proportion recorded in 2018 (22%; n = 100 of 454 fish) and 2017 (21%; n = 102 of 490 fish). Previous studies inferred that, given that the number of 2013BY and 2014BY fish released were nearly equal in numbers, the consistent difference in catch proportion of these two brood years likely reflects their relative abundance in the PRPA population (Golder 2019). The change in the 2013BY and 2014BY catch proportion was attributed to a substantial increase in recapture probability for the 2014BY from 0.132 in 2018 to 0.248 in 2019. This increase was likely due to a change in feeding behavior that increased the susceptibility of the 2014BY to capture with small-hook set lines. As older brood years grow and increase in size, they will become less susceptible to capture by small-hook set lines and their catch proportion and recapture probability is expected to decrease.

Similar catch proportions of subgroups within the 2010BY (i.e., different genetic origin), 2012BY(i.e., different release locations), and 2013BY(i.e., different release times) have been recorded since 2016, even though total catch of these brood years in 2019 has decreased compared to the initial 2016 study. The consistency of the catch differential among subgroups within these three brood years over four sample years provides strong evidence that the reported catch proportions likely reflects the relative population abundance of each subgroup in the

Project area. These findings provide some insight into the effect that genetic differences and behavior may have on emigration (i.e., reduced LCC 2010BY) and the effect of different release strategies which may have on post-release survival.

The proportion of positive catch (Ep) recorded during the juvenile White Sturgeon indexing program in Wanapum Reservoir was high in 2016 (Ep = 0.79; Golder 2017), decreased in 2017 (Ep = 0.62; Golder 2018), and increased in both 2018 (Ep = 0.65; Golder 2019) and 2019 (Ep = 0.70). In 2019, the lowest Ep was recorded in the lower reservoir section (Ep = 0.61) compared to higher Eps in the middle (Ep = 0.76) and upper reservoir sections (Ep = 0.73); this trend has been consistent in all indexing studies conducted to date (Golder 2017-2019). Reduced catch in the lower section may be due to lower quality habitat for White Sturgeon in this section (e.g., inundated terrestrial habitat).

Catch rates of 2010BY through 2014BY in each reservoir section have been similar for each brood year in all four study years since 2016. Catch rate of 2010BY and 2012BY was highest in the upper reservoir sections. The 2013BY were captured at similar rates in all reservoir sections. The catch rate of the 2014BY was notably higher for the in the middle section compared to the other reservoir sections. Brood year releases after 2016 were released in lower numbers. Furthermore, catch rates of brood years released after 2016 were lower and more variable relative to brood years released prior to 2016.

The catch proportion of 2016BY in Wanapum Reservoir was less than 1% in both 2017 (n = 1 of 490 fish) and 2018 (n = 1 of 454 fish), and less than 2% in 2019 (n = 11 of 566 fish). This suggests that the present abundance of the 2016BY in Wanapum Reservoir is low, likely due to low post-release survival or high emigration out of the Project area. Telemetry data, although limited, suggest an increased rate of entrainment and emigration of the 2016BY in their release year compared to other brood years (Golder 2018). The presence of moderate numbers of entrained 2016BY (n = 12 of 66 hatchery White Sturgeon) recovered during a 2019 fish salvage at Priest Rapids Dam provided additional evidence that 2016BY emigration was higher compared to other brood year releases (C. Mott, Grant PUD, personal communication, November 12, 2019).

Priest Rapids Reservoir

In Priest Rapids Reservoir, the 2019 catch (n = 73) was comparable to the 2017 catch (n = 78 fish), both of which were substantially lower than catches recorded in 2016 (n = 141) and 2018 (n = 109 fish). The low catch in 2019 limited conclusions that could be drawn from relative abundance comparisons between brood years as marginal differences in catch of the different brood years were recorded. The catch proportion of 2013BY was higher in 2017 (25%; n = 20 of 78 fish), 2018 (29%; n = 32 of 109 fish), and 2019 (26%; n = 19 of 78 fish) ,with the other brood years individually contributing 21% or less. Similar differences, albeit slight, in the catch proportions of 2012BY and 2014BY were also recorded in 2017, 2018, and 2019, suggesting that the abundance of the 2012BY may be higher than the 2014BY in Priest Rapids Reservoir. In all previous indexing studies, Priest Rapids Reservoir catch has consisted of a moderate proportion of fish entrained from upstream reservoirs. In 2019, a similar trend was recorded, with entrained fish contributing to 20% of 2010BY catch (n = 1 of 5 fish), 42% of 2013BY catch (n = 8 of 19 fish), 23% of 2014BY catch (n = 3 of 13 fish), 66% of 2016BY catch (n = 2 of 3 fish) and 20% of 2017BY catch (n = 1 of 5 fish).

Since 2016, total catch in Priest Rapids Reservoir has contributed between 11 and 19% to the total annual catch in the Project area. The proportion of positive catch (Ep) recorded during the juvenile White Sturgeon indexing program in Priest Rapids Reservoir decreased from a high in 2016 (Ep = 0.53) to lower levels in 2017 (Ep = 0.39), 2018 (Ep = 0.41), and 2019 (Ep = 0.33). Historically, catch rate by reservoir section has been variable, with generally higher catch rates in the middle and upper sections and lower catch rates in the lower reservoir section. Catch rate in the lower reservoir section in 2019 was exceptionally low (Ep = 0.2), and even though considerable sampling effort was conducted (30 overnight sets), only 11 fish were captured. Approximately 30% of all hatchery juvenile White Sturgeon were released in Priest Rapids Reservoir (n = 11,446 of 38,578 fish). As such, expected annual catch of hatchery fish in Priest Rapids Reservoir should be approximately 30% of the total catch in Wanapum Reservoir, or 170 fish. As the 2019 catch was only 73 fish (i.e., 43% of the expected catch), this difference between the expected and actual catch could be attributed to low survival and an overall low abundance of hatchery juvenile White Sturgeon. However, telemetry data indicate that White Sturgeon are highly aggregated in Priest Rapids Reservoir, with the greatest densities of fish located in the upper section near the Wanapum Dam tailrace. Unlike Wanapum Reservoir, where spawning and overwintering areas are spatially separated by large distances, the upper section of Priest Rapids Reservoir appears to contain suitable spawning, rearing, and overwintering habitat for this species. Consequently, White Sturgeon exhibit less substantial migrations and remain within the upper section of Priest Rapids Reservoir for most of the year. Based on catch data from the upper reservoir section, White Sturgeon aggregate in discrete areas of limited areal extent. White Sturgeon sampling gear deployed in or near these high use areas have a higher probability of catching fish compared to set lines immediately adjacent to these high use areas. Within the Wanapum Dam tailrace, a substantial proportion of the tailrace area (e.g., near spillways) are excluded from GRTS set line sample site selection due to safety regulations and unsafe conditions. During late summer when spillways are closed, these areas may contain large numbers of White Sturgeon but will be excluded from sampling. Consequently, sample efforts based on a GRTS study design may not effectively sample a large proportion of the population and potentially underestimates White Sturgeon abundance in Priest Rapids Reservoir.

4.5.2 Growth

In 2019, length frequency, average annual growth rates, and relative length-weight relationships of White Sturgeon juveniles were generally similar for both reservoirs for all brood years, with higher growth rates recorded for fish less than one year at large (e.g., 2018BY mean = 19.7 cm/year; n = 17) and slower average annual growth rates recorded for older cohorts (e.g., 2010BY; mean = 6.7 cm/year; 2012BY mean = 6.0 cm/year). A similar growth trend was reported in 2017 and 2018 with the highest growth recorded for recent brood year releases and slower average annual growth rates associated with older brood years. The 2017, 2018, and 2019 indexing studies determined that the 2012BY are growing slower than other brood years. A von Bertalanffy plot for all brood years found a statistical difference ($F_{223, 5043} = 2.67$; $p<0.001$) in growth between brood years and a comparison of the growth curves indicate that the 2012BY are growing more slowly than other brood years (Figure 21). The slower growth of the 2012BY was largely attributed to higher energetic requirements in the upper section of Wanapum Reservoir where the bulk of this brood year was recorded during most study years. In the upper section of Wanapum Reservoir, water velocity is typically higher compared to the middle and lower reservoir sections. In both 2018 and 2019, mean fork length of 2012BY captured in the upper reservoir section was notably lower (2018, 56.5 cm FL; 2019, 60.8 cm FL) than in either the middle (2018, 67.8 cm FL; 2019, 76.7 cm FL) or lower reservoir sections (2018, 77.8 cm FL; 2019, 83.7 cm FL). This trend of smaller sizes in the upper section of Wanapum Reservoir compared to fish in the middle and lower sections was first noted during the 2014 juvenile indexing program and was supported by data collected during subsequent studies (e.g., Golder 2015). Possible explanations for this trend include the following: 1) higher velocity habitat in the upper section require more energy for fish to hold and feed, 2) the greater abundance of fish in the upper section results in increased competition for available food resources, or 3) genetic differences that affect food conversion and growth rate.

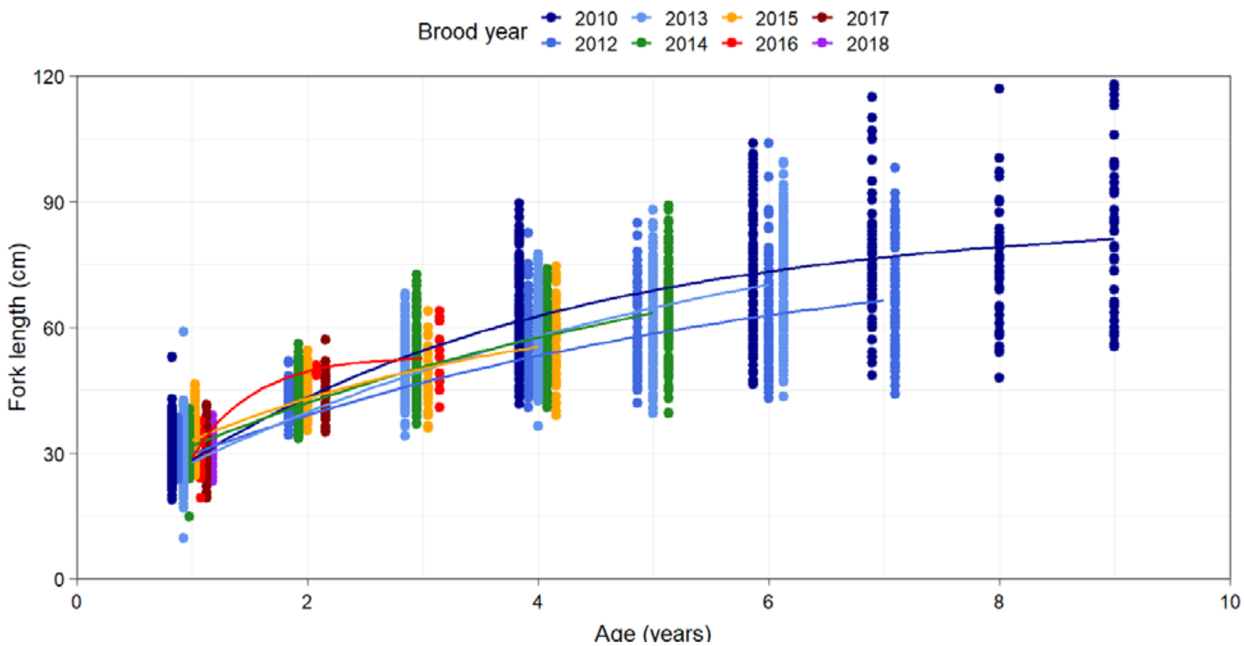


Figure 21 Von Bertalanffy 2019 growth curves of hatchery juvenile white sturgeon from brood years 2010 to 2018 released in the Priest Rapids Project area.

A substantial increase in growth of all brood years of hatchery juvenile White Sturgeon was evident in 2019 compared to previous indexing studies (Figure 22). Between 2018 and 2019, mean fork length of the 2010BY increased by 11.0 cm FL (Δ FL = 73.8 to 84.8 cm FL). In comparison, previous annual growth of the 2010BY between the 2016 and 2017 indexing studies increased by 1.4 cm FL (Δ FL = 72.0 to 73.4 cm FL) and by 0.4 cm FL (Δ FL = 73.4 to 73.8 cm FL) between the 2017 and 2018 indexing studies. A substantial increase in growth was also recorded for the 2013BY between the 2018 and 2019 indexing studies, with a change in mean fork length of 10.4 cm FL (Δ FL = 62.2 to 72.6 cm FL). Similar changes in mean weight of these brood years were also recorded. Other brood years also recorded considerable growth in 2019 that exceeded growth rates recorded in 2017 and 2018; however, these increases were not as substantial as they were for the 2010BY and 2013BY. The higher growth rates recorded in 2019 could be attributed to lower energetic requirements or better feeding opportunities due to lower than average flows in 2019.

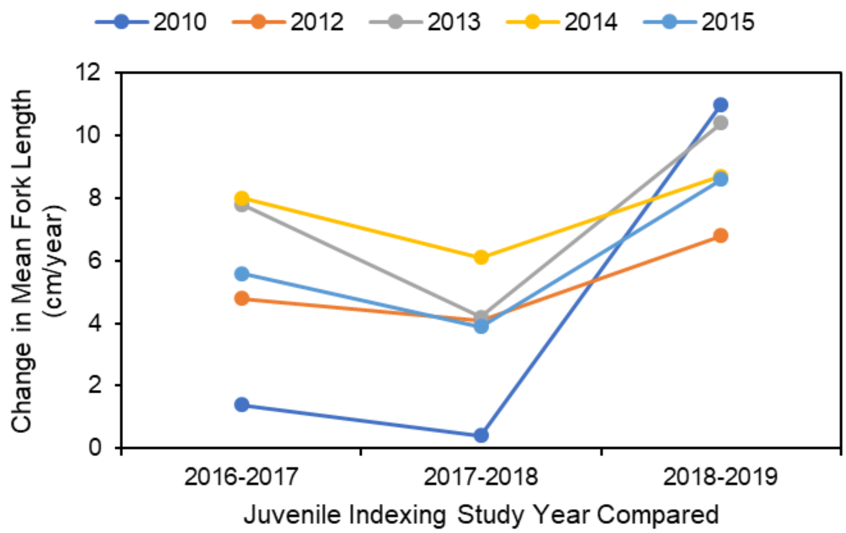


Figure 22 Growth of hatchery juvenile white sturgeon from brood years 2010 to 2015 based on the change in mean fork length measured during population indexing studies in 20196, 2017, 2018, and 2019.

4.5.3 Juvenile White Sturgeon Population Estimates

Brood-year specific survival estimates did not vary substantially between Priest Rapids Reservoir and Wanapum Reservoir, as evident from the high QAICc weighting of a model where survival did not differ by reservoir. With the inclusion of the 2019 catch data and the update of the model, updated population estimates were generated for 2011-2019. A comparison of estimated 2018 population abundance between the current model and previous analysis (Golder 2019) indicated that the updated model had overall higher abundance estimates than the values generated in 2018 (Golder 2019). In the Wanapum Reservoir, the previous estimate of 2018 population abundance was 5,765 fish (95% CI = 4,851 – 6,678), whereas the updated value was 6,120 fish (95% CI = 5,046 - 7,194). In Priest Rapids Reservoir, the previous and updated estimates of 2018 population abundance were similar, increasing slightly from 2,667 fish (95% CI = 2,332 – 3,002) in previous analysis to 2,789 fish (95% CI = 2,297 - 3,281) in the updated model.

Overall, model results indicated slowly decreasing abundances in both reservoirs, starting in 2016, when release numbers decreased. The lower annual release numbers, combined with the estimated decreased survival in more recent releases, results in abundance estimates that decline year to year. As juvenile fish from older brood years grow, they become less susceptible to capture by the juvenile sampling gear. Changes to the model in 2019 allowed recapture probabilities to be calculated for each brood year for each post-release year to track changes in recapture over time. Currently, no consistent reduction in recapture rates of the oldest brood year was estimated. However, it is expected that recapture probability estimates of older brood years will decline in the next few years. Once older brood years are less susceptible to the juvenile indexing gear, the model will no longer account for all hatchery-reared fish released in the PRPA since 2011. In order to accurately estimate survival, recapture probabilities, and abundance of older brood years, future modeling will likely need to include the hatchery catch encountered during the adult indexing program.

4.6 Avian Mortality

Telemetry data indicate that juvenile hatchery White Sturgeon have a tendency to disperse upstream after release in Wanapum Reservoir. Fish that move upstream into the Rock Island Dam tailwater area are exposed to a higher risk of avian predation by Cormorants typically near the Rock Island Dam forebay (PTAGIS mortality site = RISFWC). As of 2019, PIT-tag surveys of the Cormorant colony conducted by Chelan PUD have detected 784 PIT tags (2.9% of the 27,135 hatchery juvenile White Sturgeon released in the Wanapum Reservoir since 2011; Table 19). For fish that have been at large for more than one year, the lowest level of avian predation was recorded for the 2013BY (0.3%) and 2017BY (0.4%). The 2013BY were released at the temporary Rocky Coulee Launch (RM421.5) in the spring and fall of 2014 during the Wanapum Dam Reservoir drawdown. The 2017BY were released in the spring of 2018 at Frenchman Coulee Launch in a high flow year just prior to peak freshet. To date, PIT tags from the 2018BY, which were released in 2019, have not been detected at the colony, suggesting that this brood year may have experienced lower avian predation rates.

Table 19 PIT-tags from hatchery white sturgeon (2010BY to 2018BY) released into Wanapum Reservoir and subsequently detected at the Rock Island Dam bird colony (PTAGIS mortality site RISFWC). Data to October 10, 2019.

Brood Year	Release Location (RM)[b]	Wanapum Reservoir Hatchery Juvenile	PIT-tags Detected at RISFWC	Fork Length (mm)		Weight (g)		Percent of Wanapum Release PIT-tag detected at RISWSC
		White Sturgeon Release No.	n	Mean	S.D.	Mean	S.D.	%
2010	450.6	7,016	346	271	34	127	45	4.9
2012	450.6	1,135	183	292	26	150	42	16.1
	442.0	1,129	58	299	24	163	41	5.1
	All	2,264	241	294	26	153	42	10.6
2013a	421.5	5,093	15	286	34	141	48	0.3
2014	424.5	5,007	95	312	26	194	46	1.9
2015	424.5	2,005	58	296	25	160	40	2.9
2016	424.5	1,999	21	281	27	147	48	1.1
2017	424.5	1,983	8	288	33	113	33	0.4
2018	424.5	1,767	0	-	-	-	-	0.0
Grand Total		**27,134**	**784**	**285**	**33**	**146**	**49**	**2.9**

[a] The 2013BY were released in 2014 during reduced pool elevation level during the Wanapum Dam fracture repair efforts.
[b] RM450.6 Columbia Siding; RM442.0 Columbia Cliffs Eddy (boat-based release), RM421.5 Rocky Coulee Launch, RM424.5 Frenchman Coulee Launch.

4.7 Summary

In 2019, conservation aquaculture continues to provide viable hatchery juvenile White Sturgeon for release into the Project area. Broodstock collected below McNary Dam were spawned and resultant brood were reared, marked, and tagged at the Yakama Nation Sturgeon Hatchery for subsequent transport to release locations in the Project area by Grant PUD personnel.

The juvenile sampling methodology based on small-hook set line sampling continues to provide sufficient data to model survival and recapture probabilities and provide estimates of total juvenile hatchery White Sturgeon abundance for fish released since 2011. With completion of the 2019 indexing study, the number of recaptured juvenile White Sturgeon increased, which allowed survival and recapture probabilities to be calculated for individual brood years to refine the populations estimates in both Wanapum and Priest Rapids reservoirs. Other metrics, like CPUE and Ep estimates were calculated for each brood year to infer differences in survival and abundance among brood years to support the population model. Mean annual growth rates recorded in 2019 for each hatchery brood year were comparable to rates recorded during previous studies, with higher growth rates recorded in Wanapum Reservoir than in Priest Rapids Reservoir.

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Appendix A
2018 White Sturgeon Broodstock Collection Chelan PUD and Blue Leaf Environmental

MEMORANDUM

TO: Lance Keller, Chelan County PUD and Chris Mott, Grant County PUD

FROM: Corey Wright, *Blue Leaf Environmental*

DATE: July 10th, 2019

SUBJECT: Broodstock Collection Below McNary Dam in 2019

This year was the second year that there was a collaborative effort with Oregon Department of Fish and Wildlife (ODFW) and Grant and Chelan PUD's to both perform annual white sturgeon (*Acipenser transmontanus*) broodstock collection and assist ODFW with capture and acoustic tagging of ripe sturgeon for a spawning behavior telemetry study. As in past years professional fishing guides were utilized to capture broodstock for the Mid-Columbia sturgeon recovery effort with additional effort from ODFW fishing single set setlines out of their research vessel concurrently with the guides. Fishing took place in the white sturgeon spawning sanctuary below McNary dam on the Columbia River. Similar to past years this effort was jointly supported by Chelan County PUD and Grant County PUD with Bonneville Power Administration (BPA) funding ODFW's contribution.

This year fishing took place over fourteen days from May 15th to May 24th and from May 31st to June 3rd. When fishing began on the 15th water temperatures were 13.2°C and tracking the ten-year mean, however, temperatures began to cool and stayed down for the first ten days of the effort. Catch was also down compared with past years so after the 24th a decision was made to delay the remaining 4 days of the effort until river temperatures came back up. On May 31st temperatures river temperature was at 14.7°C and anticipated to continue climbing so to effort resumed. Mean flows during the effort this year were 312 kcfs, just under the ten year mean of 322 kcfs for the same period.

There were 147 individual white sturgeon captured and 7 fish were captured twice and one fish three times for a total of 156 sturgeon landings. The mean number of fish captured per day was 11 while the mean per day per boat was 3.6 down from the 2012-2018 mean per day per boat of 4.7. Of the individuals captured, 80 were greater than 150 cm, or mature spawning sized sturgeon, and 67 were less than 150 cm. As a part of ODFW's spawning study acoustic tags were implanted in 15 ripe males, 5 ripe females and 3 F3 females for a total of 23 tags released during the effort. For the broodstock collection effort 5 ripe females and 6 ripe males were transported to Marion Drain Hatchery. On the 14th of June a 5x5 spawning matrix was attempted which resulted in 23 paternal families for Chelan and 24 for Grant. Four females were each crossed with 5 males and the fifth female which was the farthest along in maturation, and had started reabsorbing her eggs, produced enough eggs to cross with 3 males and a partial cross with a fourth male. One male transported to the hatchery did not produce viable milt.

This year three sturgeon previously transported to the hatchery were recaptured. One male transported to the hatchery in 2014 was recaptured in 2015 and again in 2019. Two females that participated in past spawns, one in 2017 and one in 2018 were both recaptured this year. The female from the 2018 spawn was recaptured twice in 2019 and the female from the 2017 spawn had fully developed eggs (F5) and was tagged this year for ODFW.

Table 1. Recaptures of sturgeon previously transported to the hatchery. Information on sex and spawn participation included where available (hatchery = transported, R2R = released to river).

PIT	Sex	2012	2013	2014	2015	2016	2017	2018	2019
3D9.1BF10E073C	Male			hatchery, spawned				R2R	
3D9.1BF139B6E0	Male			hatchery, spawned	R2R				
3D9.1BF1C51CB5	Female					hatchery		R2R	
3D9.1C2DCB541F	Female		R2R		hatchery, not spawned	R2R			
3D9.1C2DCBB852	Female		hatchery		R2R				
3D9.1C2DF1B788	Male				hatchery, spawned			R2R	
3D9.1C2E0A5E28	Male	hatchery					R2R		
3D9.1C2E0AAA13	Male	hatchery		R2R	R2R			R2R	
3DD.00775330EB	Male			R2R	hatchery, spawned	R2R			
3DD.007753466E	Male			hatchery, not spawned	R2R				R2R
3DD.0077536116	Female				R2R	hatchery		R2R	
3DD.00778F2028	Male						hatchery	R2R	
3D9.1C2E0A5EBF	Female							hatchery	R2R
3D9.1C2DC936A2	Female						hatchery		R2R
Total re-encountered post transport				1	4	2	1	6	3

A complete summary of capture history and biometrics are found in Table 2.

ACKNOWLEDMENTS

Blue Leaf Environmental thanks the staff of Chelan PUD and Grant PUD for allowing us to assist them in this effort. We also thank Dan and Neil Sullivan as well as Jake Apperson of Rivers West Sport Fishing, Stuart Hurd from Hurd's Guide Service and Jaime Whitney for all their fishing services and expertise. ODFW for providing a third boat for the fishing effort and facilitating the collaborative effort. Donella Miller and the staff at Marion Drain Hatchery for assisting with transported fish and undertaking the spawning effort. The many fishing volunteers without which fish would not get landed. We finally thank ODFW and WDFW and there permitting staff for assistance executing permits.

Table 2 . Catch data from white sturgeon broodstock collection efforts below McNary Dam in 2019.

No.	Date	Sex Code	Length (mm)	Total Length (mm)	Girth (cm)	Fate	Event Type	Mark @ Cap	PIT Tag
1	5/15/2019	F3	1830	2110	76	R2R	Recapture	L2,17,18	3DD.007763ACDC
2	5/15/2019	M1-4	1630	1800	65	R2R	Mark	R17	3DD.007790E3A0
3	5/15/2019	F5	2470	2770	115	R2R	Mark	L22	3DD.00778F17ED
4	5/15/2019	F5	2530	2820	109	R2R	Mark	R7	3DD.007791642F
5	5/16/2019	UNK	2520	2810	117	R2R	Mark	L8	3DD.007790FE98
6	5/16/2019	M1-4	1730	1950	70	R2R	Mark		3DD.00778F2F81
7	5/16/2019	M1-4	2190	2490	84	R2R	Recapture	L2	3D9.1C2DECBA0C
8	5/17/2019	UNK	2380	2680	99	R2R	Recapture	L2,7	3DD.0077634FAF
9	5/17/2019	JUV	1550		57	R2R	Recapture	L2	3DD.0077906271
10	5/17/2019	M1-4	1650		63	R2R	Mark		3DD.0077843F95
11	5/18/2019	M5	2390	2710	93	R2R	Recapture	L2	3D9.1BF10E37C1
12	5/18/2019	M5	1920	2170	83	Hatchery	Mark	L2,7,9 R2	3D9.1C2D6726D6
13	5/18/2019	M5	1940	2220	81	Hatchery	Recapture	L2, R7	3D9.1C2DF16FF7
14	5/18/2019	F5	2390	2630	119	Hatchery	Mark		3DD.00778F45EF
15	5/19/2019	F4	2460	2710	101	R2R	Mark		3DD.007791262F
16	5/19/2019	M5	2210	2470	91	R2R	Mark		3DD.007790BE72
17	5/19/2019	M1-4	1540	1740	60	R2R	Recapture	L1,8	3D9.1BF10E870B
18	5/19/2019	M5	1640	1850	68	R2R	Mark	L2, L7, R9	3DD.0077907610
19	5/20/2019	M1-4	1570	1780	61	R2R	Recapture	L2,8	3D9.1BF1B692A4
20	5/20/2019	M5	2140	2410	88	Hatchery	Mark		3DD.0077910504
21	5/20/2019	M1-4	2340	2590	93	R2R	Recapture	L2	3D9.1C2DCC46AE
22	5/20/2019	UNK	1310	1480	51	R2R	Mark		3DD.0077912FDA
23	5/20/2019	M1-4	2240	2550	88	R2R	Mark	R4	3DD.007790553D
24	5/20/2019	M1-4	2320	2580	100	R2R	Recapture	L2,	3DD.00779089AB
25	5/20/2019	UNK	1400	1680	55	R2R	Mark		3DD.0077910850
26	5/20/2019	F3	2610	2970	114	R2R	Mark		3DD.00779148C8
27	5/21/2019	F3	1820	2150	86	R2R	Recapture	L2, R8,10	3D9.1BF1B9227B
28	5/21/2019	M1-4	2440	2700	109	R2R	Recapture	L2	3DD.0077529606
29	5/21/2019	M1-4	1750	1980	77	R2R	Recapture	L2,7,9,R22-23	3D9.1BF10DF1C8
30	5/21/2019	M1-4	2100	2330	82	R2R	Mark		3DD.0077914B91
31	5/21/2019	M5	2410	2650	92	R2R	Mark	R8,18	3DD.007790EC82
32	5/21/2019	M1-4	2340	2610	95	R2R	Recapture	L2	3D9.1C2DF1735D
33	5/22/2019	M1-4	2320	2520	92	R2R	Recapture	L2	3D9.1C2E0A5EBF
34	5/22/2019	M1-4	2250	2490	90	R2R	Recapture	L2	3DD.007753466E
35	5/22/2019	M1-4	1890	2140	74	R2R	Recapture	L2 R2,9	3D9.1C2DF540B0
36	5/22/2019	M1-4	1990	2240	77	R2R	Mark		3DD.007790D7DC
37	5/23/2019	F3	2230	2520	87	R2R	Mark		3DD.007791161B
38	5/23/2019	M5	2410	2710	87	Hatchery	Mark		3DD.007784311B
39	5/23/2019					R2R	Recapture		3DD.0077529606
40	5/23/2019	F3	2540	2820	107	R2R	Mark		3DD.00778F1F24
41	5/23/2019	UNK	1670	1880	62	R2R	Mark		3DD.0077835B61
42	5/23/2019					R2R	Recapture		3D9.1C2E0A5EBF
43	5/23/2019	M5	2129	2380	84	R2R	Recapture	L1,8-9	3D9.1BF10E707F
44	5/23/2019	M5	2200	2470	92	R2R	Mark	L2,7	3DD.007790CD9F
45	5/23/2019	F4	2520	2740	95	R2R	Mark		3DD.007790F4AF
46	5/24/2019	M1-4	2010	2250	76	R2R	Mark		3DD.007790894A
47	5/24/2019	M5	2090	2380	77	R2R	Recapture	L1,2,3	3D9.1C2E0AAFE4
48	5/24/2019	M1-4	1870	2090	70	R2R	Mark	R20,23	3DD.007790FDB1
49	5/24/2019	F3	2630	2900	119	R2R	Mark		3DD.007790B5B8
50	5/24/2019	F3	2410	2730	103	R2R	Mark		3DD.00778F68E0
51	5/24/2019	M5	2100	2540	87	R2R	Recapture	L2,R14	3D9.1C2DF15C39
52	5/31/2019	F5	2310	2590	106	Hatchery	Mark		3DD.0077906DD0
53	5/31/2019	F1-2	1620	1830	76	R2R	Recapture	L2,R10	3D9.1BF1B6B028
54	5/31/2019	F5	2370	2650	102	R2R	Mark	R10	3DD.0077909630
55	5/31/2019	M5	1800	2030	77	Hatchery	Recapture	L2,9,11,	3D9.1BF10E8645
56	5/31/2019	M5	1980	2260	78	R2R	Mark		3DD.00778F18AC
57	5/31/2019	F3	2470	2770	108	R2R	Mark		3DD.007790CC7E
58	5/31/2019	F5	2640	2920	109	R2R	Recapture	L2	3D9.1C2DC936A2
59	6/1/2019						Recapture		3D9.1C2DECBA0C
60	6/1/2019	F3	2400	2700	92	R2R	Recapture	L2	3D9.1C2DC9459B

No.	Date	Sex Code	Length (mm)	Total Length (mm)	Girth (cm)	Fate	Event Type	Mark @ Cap	PIT Tag
61	6/1/2019	UNK	970	1110	37	R2R	Recapture	L2	3D9.1BF23F7099
62	6/1/2019					R2R	Recapture		3DD.007763ACDC
63	6/1/2019	JUV	1270	1440	51	R2R	Mark		3DD.0077918298
64	6/1/2019	F5	2920	3210	115	Hatchery	Mark		3DD.0077908CAA
65	6/1/2019	F5	2390	2640	98	Hatchery	Mark		3DD.00779054CA
66	6/1/2019	F4	2770	3130	103	R2R	Recapture		3DD.0077538A83
67	6/1/2019	F1-2	1630	1830	70	R2R	Recapture	L2	3D9.1C2DF1A6F1
68	6/1/2019	M5	2410	2700	97	R2R	Mark		3DD.0077906DFD
69	6/1/2019	M1-4	2580	2880	116	R2R	Recapture	L2,R16,17,19	3DD.0077530EBA
70	6/2/2019	M5	2360	2390	93	R2R	Mark		3DD.00779095A4
71	6/2/2019	M5	1760	1950	70	R2R	Mark		3DD.0077911748
72	6/2/2019	M1-4	2390	2660	105	R2R	Mark	R16	3DD.007790E577
73	6/2/2019					R2R	Recapture		3D9.1C2E0A5EBF
74	6/2/2019	F4	2330	2660	102	R2R	Recapture	L2	3D9.1C2DC93819
75	6/2/2019	JUV	1360	1560	56	R2R	Recapture	L2	3DD.0077619D63
76	6/2/2019	M5	1840	2060	75	R2R	Mark	R9,10	3DD.007790BE64
77	6/2/2019	M5	2420	2720	97	R2R	Mark		3DD.0077909710
78	6/2/2019	F5	2490	2820	100	R2R	Recapture	L2	3DD.007790B461
79	6/2/2019	M5	2370	2560	84	R2R	Recapture	L2	3D9.1C2E0A62D3
80	6/2/2019	M5	2040	2250		R2R	Recapture	L2,R2-4	3D9.1C2DCB7B0E
81	6/2/2019	JUV	1370	1540	55	R2R	Mark	L9	3DD.00778F4F97
82	6/3/2019	UNK	2210	2500	86	R2R	Mark	L11,16,21	3DD.007790D1AD
83	6/3/2019	UNK	2590	2940	112	R2R	Recapture	L2, R20	3DD.0077915D8C
84	6/3/2019	F5	2480	2770	109	Hatchery	Mark		3DD.007783F77F
85	6/3/2019	JUV	1830	2070	67	R2R	Mark		3DD.007790B300
86	6/3/2019	JUV	1520	1720	59	R2R	Mark		3DD.00779107E7
87	6/3/2019	F3	2420	2720	98	R2R	Mark		3DD.0077844961
88	6/3/2019	M5	2240	2580	87	R2R	Mark		3DD.007790FCA7
89	6/3/2019	JUV	1700	1910	71	R2R	Recapture	L7	3D9.1BF10E8061
90	6/3/2019	M1-4	2190	2480	88	R2R	Recapture	L2,L9,R10-11	3D9.1BF10E25C9
91	6/3/2019	JUV	1330	1510	59	R2R	Mark		3DD.0077913E73
92	6/3/2019	JUV	1200	1380	50	R2R	Recapture	L2, R11	3D9.1BF1C96530
93	6/3/2019	M1-4	2590	2900	102	R2R	Mark		3DD.007791149D
1- JUV	5/15/2019	JUV	1080	1250	46	R2R	Recapture		3D9.1BF264C42B
10- JUV	5/19/2019	JUV	1140	1320	48	R2R	Mark		3DD.007790B0A3
11- JUV	5/19/2019	JUV	1040	1210	48	R2R	Mark		3DD.0077915DBD
12- JUV	5/19/2019	JUV	1190	1340	55	R2R	Recapture		3D9.1C2DECCFBC
13- JUV	5/20/2019	JUV	1090	1230	49	R2R	Recapture		3DD.00776360E4
14- JUV	5/20/2019	JUV	1270	1440	53	R2R	Recapture		3DD.007790617B
15- JUV	5/20/2019	JUV	1020	1140	44.5	R2R	Mark		3DD.007790622B
16- JUV	5/20/2019	JUV	890	1010	36	R2R	Recapture		3DD.0077537A4B
17- JUV	5/20/2019	JUV	1170	1310	52	R2R	Recapture		3D9.1C2DECCFBC
18- JUV	5/20/2019	JUV	1080	1190	46	R2R	Mark		3DD.00779167F6
19- JUV	5/20/2019	JUV	1070	1190	45	R2R	Recapture		3DD.0077615782
2- JUV	5/16/2019	JUV	1200	1410	48	R2R	Recapture		3D9.1BF233BA04
20- JUV	5/21/2019	JUV	1020	1150	43	R2R	Mark		3DD.00778F2274
21- JUV	5/22/2019	JUV	1010	1125	42	R2R	Mark		3DD.0077907621
22- JUV	5/22/2019	JUV	620	720	25	R2R	Recapture		3DD.0077A071CE
23- JUV	5/22/2019	JUV	560	660	23	R2R	Recapture		3DD.00779FF9F1
24- JUV	5/22/2019	JUV	780	860	28	R2R	Mark		3DD.00779096EF
25- JUV	5/22/2019	JUV	1090	1250	45	R2R	Mark		3DD.007790AF5E
26- JUV	5/22/2019	JUV	1090	1230	44.5	R2R	Mark		3DD.007790C167
27- JUV	5/22/2019	JUV	1090	1220	50	R2R	Recapture		3DD.0077533489
28- JUV	5/22/2019	JUV	900	1010	39.5	R2R	Recapture		3DD.0077537A4B
29- JUV	5/22/2019	JUV	1150	1310	49.5	R2R	Recapture		3D9.1BF1C52841
3- JUV	5/16/2019	JUV	1110	1270	46.5	R2R	Mark		3DD.0077915AA3
30- JUV	5/22/2019	JUV	670	790	29.5	R2R	Mark		3DD.00778F2F47
31- JUV	5/22/2019	JUV	510	580	19.5	R2R	Recapture		3DD.00779FFF86
32- JUV	5/23/2019	JUV	1240	1420	50	R2R	Mark		3DD.007790F145
33- JUV	5/23/2019	JUV	950	1080	39.5	R2R	Recapture		3D9.1C2DCBA322
34- JUV	5/23/2019	JUV	1070	1220	44	R2R	Mark		3DD.0077906E35
35- JUV	5/23/2019	JUV	1010	1170	43	R2R	Mark		3DD.0077916ACD

No.	Date	Sex Code	Length (mm)	Total Length (mm)	Girth (cm)	Fate	Event Type	Mark @ Cap	PIT Tag
36- JUV	5/23/2019	JUV	560	640	20	R2R	Mark		3DD.00779095AC
37- JUV	5/23/2019	JUV	800	940	32	R2R	Mark		3DD.0077908AB9
38- JUV	5/23/2019	JUV				R2R	Mark		3DD.0077915DBD
39- JUV	5/24/2019	JUV	1100	1225	46	R2R	Recapture		3DD.007790802B
4- JUV	5/17/2019	JUV	1070	1210	51	R2R	Recapture		3D9.1C2DC93BA4
40- JUV	5/24/2019	JUV	1040	1170	41.5	R2R	Recapture		3DD.0077605DD4
41- JUV	5/24/2019	JUV	1200	1390	51	R2R	Recapture		3D9.1BF1661483
42- JUV	5/31/2019	JUV				R2R	Mark		3DD.00779064B2
43- JUV	5/31/2019	JUV	960		37	R2R	Recapture		3D9.1C2D2F7ADA
44- JUV	6/2/2019	JUV	1100	1250	45	R2R	Recapture		3D9.1C2DC8EA3C
45- JUV	6/3/2019	JUV	1040	1190	40.5	R2R	Mark		3DD.0077905F28
46- JUV	6/3/2019	JUV	1060	1120	46	R2R	Recapture		3D9.1C2DF56185
47- JUV	5/15/2019	JUV	1020	1160	43	R2R	Recapture		3D9.1C2E0ABD33
48- JUV	5/16/2019	JUV	1070	1250	47	R2R	Recapture		3D9.1C2D2F659B
49- JUV	5/16/2019	JUV	550	640	22	R2R	Recapture		3DD.00779F151A
5- JUV	5/17/2019	JUV	620	720	25	R2R	Recapture		3DD.0077A0AD65
50- JUV	5/17/2019	JUV	1130	1260	28	R2R	Recapture		3D9.1BF2648515
51- JUV	5/17/2019	JUV	1030	1160	47	R2R	Recapture		3DD.00779095CC
52- JUV	5/20/2019	JUV	930		41	R2R	Recapture		3DD.0077C246EE
53- JUV	5/21/2019	JUV	1130		48	R2R	Recapture		3D9.1C2DF56512
54- JUV	5/21/2019	JUV	1150		45	R2R	Recapture		3D9.1C2DC96973
55- JUV	5/21/2019	JUV	1120		45	R2R	Mark		3D9.1C2D67294F
56- JUV	5/21/2019	JUV	1090		44.5	R2R	Mark		3D9.1C2D79A6B5
57- JUV	5/21/2019	JUV	1090		46.5	R2R	Recapture		3D9.1C2DC933CE
58- JUV	5/22/2019	JUV	1220		46	R2R	Recapture		3D9.1BF233BA04
59- JUV	5/23/2019	JUV	1240		51	R2R	Recapture		3D9.1C2D671764
6- JUV	5/17/2019	JUV	1070	1195	41	R2R	Mark		3DD.007790E26E
60- JUV	5/23/2019	JUV	1360		49	R2R	Recapture		3D9.1C2D674780
61- JUV	5/24/2019	JUV	1030		44	R2R	Mark		3D9.1C2D799CF8
62- JUV	5/24/2019	JUV	1340		57	R2R	Mark		3D9.1C2D67258E
63- JUV	6/3/2019	JUV	1230		47	R2R	Recapture		3D9.1BF10E33B8
7- JUV	5/19/2019	JUV	800	905	35	R2R	Recapture		3D9.1C2D2F6330
8- JUV	5/19/2019	JUV	1250	1430	50.5	R2R	Recapture		3D9.1C2DA5BF06
9- JUV	5/19/2019	JUV	840	960	31.5	R2R	Recapture		3DD.0077918535

Appendix B
Washington Department of Ecology's March 19, 2020 Approval Email

From: Zimmerman, Breean (ECY)
To: Tom Dresser; Chris Mott; Mike Clement
Cc: Deb Firestone
Subject: RE: FOR APPROVAL: Grant PUD"s 2019 White Sturgeon Management Plan Annual Report
Date: Thursday, March 19, 2020 1:06:19 PM
Attachments: image001.png

Good afternoon, all.

With the public health emergency we are currently faced with and with my limited abilities as I am teleworking these days, I am providing this email in lieu of a tangible "no comment" letter in response to the 2019 White Sturgeon Management Plan Annual Report. Your patience is much appreciated during this time. Please let me know if you have questions or concerns.

The Department of Ecology (Ecology) has reviewed the *2019 White Sturgeon Management Plan Annual Report* sent via email to Ecology on February 6, 2020.

Ecology has **no comments** for the *2019 White Sturgeon Management Plan Annual Report*. This report is a requirement of Section 6.2(5)(d) for the *White Sturgeon Management Plan* of the 401 certification.

Please contact me at (509) 575-2808 or breean.zimmerman@ecy.wa.gov if you require further assistance.

Thank you,
Breean Zimmerman, Hydropower Projects Manager
Department of Ecology, Central Region Office, Water Quality Program
Direct line: (509) 575-2808, Cell: (509) 406-5130
breean.zimmerman@ecy.wa.gov

From: Zimmerman, Breean (ECY)
Sent: Tuesday, March 17, 2020 12:02 PM
To: 'Deb Firestone' <Dfirest@gcpud.org>
Cc: Tom Dresser <TDresse@gcpud.org>; Mike Clement <Mclemen@gcpud.org>; Chris Mott <Cmott@gcpud.org>
Subject: RE: FOR APPROVAL: Grant PUD's 2019 White Sturgeon Management Plan Annual Report

Thank you, Deb. I'll make sure to respond by the end of the day.

Breean Zimmerman
Water Quality Program

From: Deb Firestone <Dfirest@gcpud.org>
Sent: Tuesday, March 17, 2020 11:56 AM
To: Zimmerman, Breean (ECY) <bzim461@ECY.WA.GOV>
Cc: Tom Dresser <TDresse@gcpud.org>; Mike Clement <Mclemen@gcpud.org>; Chris Mott <Cmott@gcpud.org>
Subject: FOR APPROVAL: Grant PUD's 2019 White Sturgeon Management Plan Annual Report

Hi Breean,

Attached please find Grant PUD's final draft 2019 White Sturgeon Management Plan annual report for Washington Department of Ecology's review and approval. The finalized approved report is to be submitted to FERC on March 31, 2020. It was sent to the Priest Rapids Fish Forum on February 6, 2020. YN had comments which were incorporated into an executive summary of the report.

If you have questions regarding this final draft report, please contact Mike Clement at 509-754-5088 Ext. 2633 or by email at Mclemen@gcpud.org or Chris Mott at 509-754-5088 Ext. 2624 or Cmott@gcpud.org.

Thanks!

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