Grant County
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March 26, 2021

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) – 2020 White Sturgeon Management Plan Annual Report

Dear Secretary Bose,

Please find enclosed Public Utility District No. 2 of Grant County, Washington (Grant PUD) 2020 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 completed under the 2020 M&E program (FERC License Year 13) were as follows:

1). Develop and implement a tagging, marking, and release plan for the 2019 Brood Year (BY) juvenile White Sturgeon based on the annual release 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.

2). Monitor White Sturgeon spawning below Rock Island Dam from late June to early July, the peak period of sturgeon spawning, to determine spawning intensity and the feasibility of *in situ* incubation of wild spawned eggs to produce larval White Sturgeon to supplement juvenile stocking efforts.

3). Conduct a juvenile White Sturgeon mark and recapture program in September 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

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[1] 123 FERC ¶ 61,049 (2008)

juvenile White Sturgeon in the PRPA to estimate their survival and abundance (Golder 2015–2020). Sampling methods were standardized in 2016 and the same methodology was used in all subsequent years.

In a typical year, the annual M&E program included the collection of broodstock from John Day Reservoir downstream of McNary Dam in May and early June prior to the onset of peak White Sturgeon spawning in late June. Due to the COVID-19 pandemic in 2020, boat-based guided angling could not be conducted effectively while maintaining social-distancing and other COVID-19 risk mitigation measures. Operations at the Yakama Nation Sturgeon Hatchery (YNSH) were also suspended due to the high COVID-19 incidence rates within Yakima County, Washington. As such, broodstock collection was not conducted in 2020. Tagging and release of the 2019BY, usually conducted in April, was also delayed and the tagging effort in 2020 was reduced due to COVID-19.

On February 9, 2021, Grant PUD prepared and disseminated the draft 2020 WSMP Annual Report for a thirty day comment period to members of the PRFF, which includes Washington Department of Ecology (WDOE), U.S. Fish & Wildlife Service (USFWS), Washington Department of Fish & Wildlife (WDFW), Colville Confederated Tribes (CCT), 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 from the CCT and WDFW (Appendix B) and Grant PUD's responses are in Appendix C. On March 17, 2021, WDOE approved the 2020 WSMP Annual Report (found in Appendix A 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

2020
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 2021

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

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Mike Clement	Grant PUD
Paul Grutter	Golder Associates Ltd.
Sima Usvyatsov	Golder Associates Ltd.
Dustin Ford	Golder Associates Ltd.
David Roscoe	Golder Associates Ltd.
Corey Wright	Blue Leaf Environmental Inc.

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
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. The study objectives and tasks completed under the 2020 M&E program (FERC License Year 13) included the following study components; 1) tagging, marking, and release of the 2019 Brood Year (2019BY) hatchery juvenile White Sturgeon, 2) assess natural White Sturgeon spawning below Rock Island Dam, and 3) juvenile White Sturgeon population indexing to estimate survival rate and the population abundance of hatchery juvenile sturgeon released in the PRPA. In 2020, the study components were modified as needed to incorporate mitigation measures and precautions taken in response to the COVID-19 pandemic.

Prior to tagging, all fish in the 2019BY were to be tested individually for autopolyploid prior to tagging; however, testing could not be conducted due to the COVID-19 pandemic. Consequently, the 2019BY release was limited to 672 fish from a single maternal family of five produced that tested negative for spontaneous autopolyploidy during initial screening. These fish were tagged on July 7 and released on July 23 with 411 fish released in Wanapum Reservoir and 261 fish released in Priest Rapids Reservoir. Mean fork length of the 2019BY was 355 mm (SD ± 52 mm) and mean weight was 288 g (SD ± 106 g). In total, one or more fin deformities were recorded for 97% (654 of 672 fish) of the 2019BY.

White Sturgeon spawning activity was monitored in Wanapum Reservoir below Rock Island Dam from June 21 to July 2 with egg collection mats deployed at 11 shore sample sites and one mid-channel sample site. In total, 4,359 mat-hours of sample effort were conducted, which captured 1,613 White Sturgeon eggs released from three separate spawning events. Based on the time of capture and egg developmental stage, spawning events were estimated to have occurred on June 26, 27, and 28. The onset of spawning in 2020 was consistent with previous spawning studies conducted in the PRPA. Captured eggs were placed in an *in situ* floating incubator moored downstream of the spawning area. Previous spawning assessments below Rock Island Dam confirmed that spawning activity continues into July in most years (Golder 2014, 2016). Although monitoring ended on July 2, the discharge and temperature regime below Rock Island Dam remained conducive for spawning and spawning activity also likely continued into July in 2020.

The 2020 juvenile White Sturgeon population indexing program was based on small hook set line sampling, and the overall study design and sample effort were similar to previous studies conducted since 2016. In total, 333,016 hook-hours of set line sample effort was expended. Overall CPUE in the Project area was 0.19 fish/100 hook-hours, with slightly higher CPUE recorded in Wanapum Reservoir (0.20 fish/100 hook-hours) than Priest Rapids Reservoir (0.17 fish/100 hook-hours). The highest proportion of positive catch (Ep) and CPUE were recorded in the upper section of both reservoirs. In Wanapum Reservoir, the lowest Ep and CPUE was in the lower section and was attributed to high wind and wave conditions during

sampling. Catch in the lower and middle sections of Priest Rapids Reservoir was also low. Overall, Ep was higher in Wanapum Reservoir (all sections, Ep = 0.60) than in Priest Rapids Reservoir (all sections, Ep = 0.44).

In Wanapum Reservoir, 484 fish were captured, with the 2014BY (n = 116 of 484 fish) and 2013BY (n = 90) the dominant hatchery brood years caught, followed by the 2012BY (n = 65), 2017BY (n = 72), 2015BY (n = 62), 2018BY (n = 25), 2010BY (n = 17), 2016BY (n = 10), 2019BY (n = 7) and hatchery fish of unknown origin (n = 17). The remainder of the Wanapum Reservoir catch consisted of low numbers of wild juvenile White Sturgeon (n = 4) and the 2002BY (n = 2). In Priest Rapids Reservoir, 143 fish were captured, with slightly higher numbers of 2013BY (n = 34), 2012BY (n = 29), and 2014BY (n = 27) captured and low numbers of 2010BY (n = 14), 2015BY (n = 12), 2018BY (n = 6), 2017BY (n = 4), 2016BY (n = 2), 2019BY (n = 2) and hatchery fish of unknown origin (n = 14). Wild fish and 2002BY fish were not captured in Priest Rapids Reservoir in 2020.

Of fish captured, fork length (FL) ranged from 34.0 to 118.0 cm FL (mean = 65.9 cm FL; n = 469; Table 10) in Wanapum Reservoir and from 30.0 to 119.0 cm FL (mean = 63.8 cm FL; n = 140) in Priest Rapids Reservoir. In Wanapum Reservoir, fish weight ranged from 195 to 12,200 g (mean = 2,454 g; n = 467). In Priest Rapids Reservoir, the lowest-weight fish captured was 280 g and the largest was 13,250 g (mean = 2,164 g; n = 139). Age and length data from recaptured hatchery-released fish were used to construct von Bertalanffy growth curves to assess growth between brood years and reservoirs. Length-at-age growth curves in Wanapum Reservoir were consistent with previous findings (Golder 2020) with the highest growth rate recorded for the 2010BY and slightly lower growth rates recorded for the 2013BY, 2014BY, and 2015BYs. A comparison of the growth curves indicated that the 2012BY are growing more slowly than the other older brood years. In Priest Rapids Reservoir, growth of older fish was lower compared to the same age classes in Wanapum Reservoir, as growth of age-6 and older fish plateaued as growth rates of these older fish decreased, with the slowest growth recorded in the 2014BY. Based on a preliminary review of growth by reservoir section, the lowest growth rates for all brood years were recorded in the upper sections of each reservoir. Highest growth rates for all brood years were in the lower sections of both reservoirs. The difference in growth rates between the upper and lower sections of each reservoir was assumed to be due to higher energetic costs in the riverine section (i.e., upper section) of each reservoir. Fish distribution, density dependence were also likely factors. To date, all brood years in Priest Rapids Reservoir have been released in the upper section of the reservoir. An alternative release strategy for Priest Rapids Reservoir was proposed based on the release of future brood years into the lower section of Priest Rapids Reservoir.

Catch data were modelled to estimated first year and post-first year brood year survival probabilities for the combined PRPA population and the brood year recapture probabilities within each reservoir. The survival probabilities were used to estimate White Sturgeon population in Wanapum and Priest Rapids reservoirs. The highest first-year survival estimate was recorded for the 2017BY (0.449) and the lowest for the 2016BY (0.070). Not including the 2016BY, post-first year survival was high (>.90) for all brood years. Recapture probability declined with age and were substantially lower in Priest Rapids Reservoir than in Wanapum Reservoir. With the release of the 2019BY, the 2020 hatchery fish abundance estimate in Wanapum Reservoir was 6,190 fish (95% CI = 4,878–7,502) or 22.5% of total hatchery releases to date (n = 27,544 fish). In Priest Rapids Reservoir, the 2020 hatchery fish abundance estimate was 2,759 fish (95% CI = 2,203–3,315) or 23.6% of total hatchery releases to date (n = 11,707). Catch bias due to selectivity of the small-hook set line gear was identified as a factor that may affect abundance, survival, and growth estimates. Large-hook set line capture data collected as part of adult indexing studies will be included in future modeling and analysis to address catch bias uncertainties.

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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 (the 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 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, with the goal of creating a self-sustaining and genetically diverse population to levels commensurate with the available aquatic habitat in the PRPA. Under the WSMP, the main objectives of the studies conducted under the M&E program were to assess 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 by members of the Priest Rapids Fish Forum (PRFF) who, through consensus, provide recommendations to modify and align the M&E program with long-term recovery objectives for the PRPA and other White Sturgeon recovery initiatives in the Columbia River Basin.

Due to the COVID-19 pandemic, the 2020 M&E program was modified to accommodate the health and safety protocols established to reduce the risk of COVID-19 transmission and still allow elements of the program to proceed. For some study components, an effective COVID-19 mitigation plan was developed and these studies proceeded with only minor disruption. For other components, effective mitigation measures were not feasible and these study components were either substantially reduced in scope or not conducted in 2020. This report summarizes the 2020 M&E program developed as part of this ongoing evaluation effort.

The study objectives and tasks completed under the 2020 M&E program (FERC License Year 13) were as follows:

1). Develop and implement a tagging, marking, and release plan for the 2019 Brood Year (BY) juvenile White Sturgeon based on the annual release 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.

2). Monitor White Sturgeon spawning below Rock Island Dam from late June to early July, the peak period of sturgeon spawning, to determine spawning intensity and the feasibility of *in situ* incubation of wild spawned eggs to produce larval White Sturgeon to supplement juvenile stocking efforts.

3). Conduct a juvenile White Sturgeon mark and recapture program in September 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 2015–2020). Sampling methods were standardized in 2016 and the same methodology was used in all subsequent years.

In a typical year, the annual M&E program included the collection of broodstock from John Day Reservoir downstream of McNary Dam in May and early June prior to the onset of peak White Sturgeon spawning in late June. Due to the COVID-19 pandemic in 2020, boat-based guided angling could not be conducted effectively while maintaining social-distancing and other COVID-19 risk mitigation measures. Operations at the Yakama Nation Sturgeon Hatchery (YNSH) were also suspended due to the high COVID-19 incidence rates within Yakima County and the Yakama Nation. As such, broodstock collection was not conducted in 2020. Tagging and release of the 2019BY, usually conducted in April, was also delayed and the tagging effort in 2020 was reduced due to COVID-19.

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 the 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 long (18 miles) 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 purpose 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 sections 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.

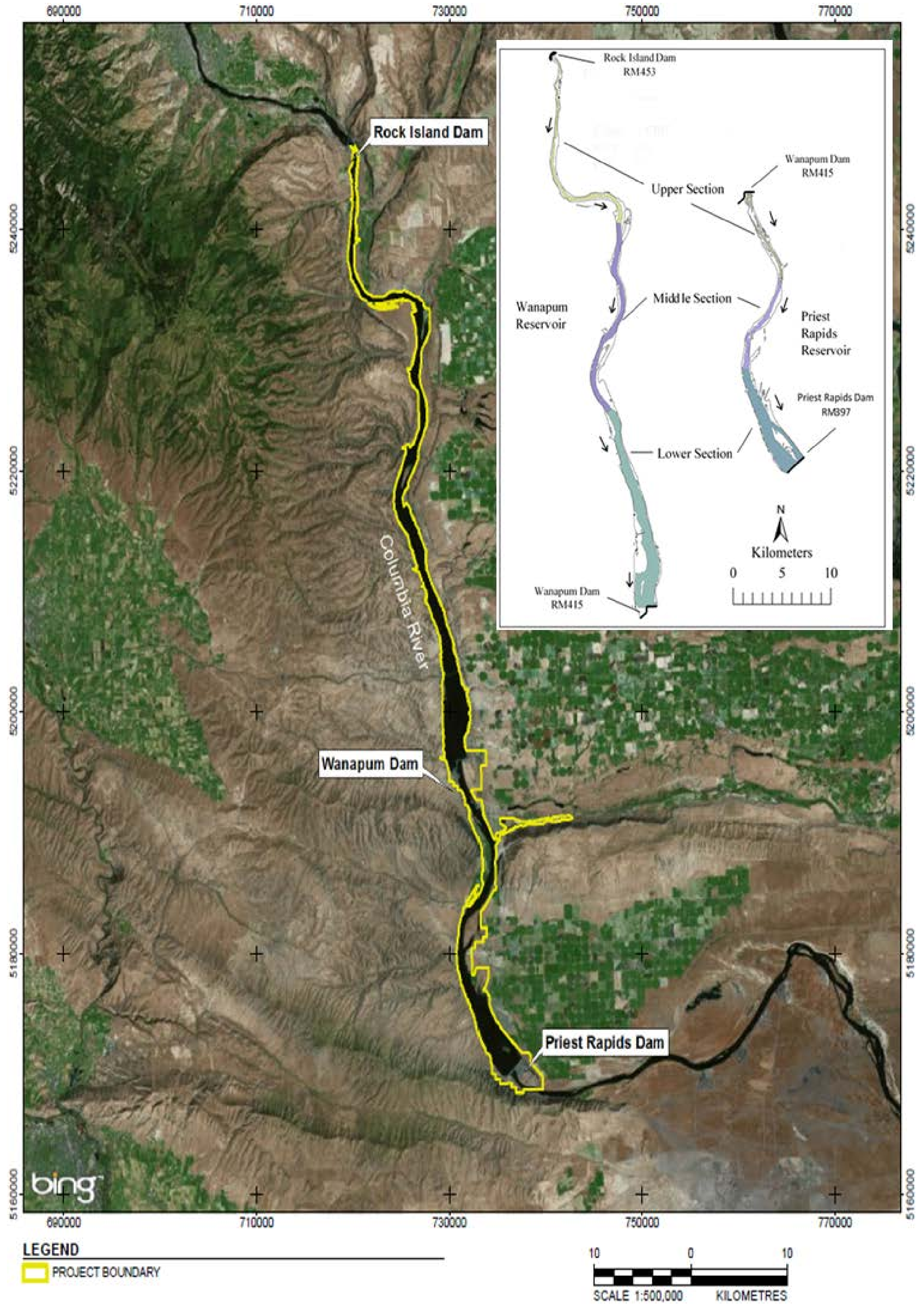

Figure 1 **The Priest Rapids Project area. Inset shows the location of the upper, middle, and lower sections in the Priest Rapids and Wanapum reservoirs.**

1.1 Consultation

Pursuant to the reporting requirements, Grant PUD provided a complete draft of the WSMP 2020 Annual Report to the PRFF on February 9, 2021 for review. Written comments were received from Colville Confederated Tribe (CCT) on February 16, 2021, and the Washington Department of Fish and Wildlife (WDFW) on March 11, 2021. A summary of written comments from the Priest Rapids Fish Forum (PRFF), as received by Grant PUD on the draft 2020 WSMP Annual Report, have been compiled along with responses from Grant PUD (Appendix C).

2.0 Methods

Study methods used in 2020 were similar to previous studies (Golder 2016, 2020), with a similar approach and level of effort applied for the study components common to each year, which includes hatchery juvenile White Sturgeon tagging and release, an assessment of natural spawning below Rock Island Dam in Wanapum Reservoir, and juvenile White Sturgeon population indexing.

The following sections provide general descriptions of methods used and details where the 2020 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, 2020 were obtained from the Columbia River Data Access in Real Time webpage (DART 2020).

2.2 2019BY Rearing and Marking, and Release

Originally scheduled for early April, COVID-19 risk mitigation measures delay tagging efforts until July. Total release numbers in 2020 were also reduced and the 2019BY release strategy modified due to pandemic-related schedule disruptions.

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 2019BY juvenile White Sturgeon to be released were the progeny of a partial 5Fx5M spawning matrix conducted on June 14, 2019 at YNSH. 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, 24 genetic crosses (4 unique crosses and 20 half-sibling crosses) were produced for the 2020 Grant PUD release. The progeny of each maternal family was kept in separate rearing pens.

A subsample of the progeny in each maternal family was tested for the presence of spontaneous autopolyploidy. White Sturgeon with autopolyploidy have a chromosome count of 12N compared to 8N in natural White Sturgeon populations. Autopolyploidy testing results indicated that one of the maternal families was negative and that the remaining families had a low but detectable presence for autopolyploidy, with between 2% to 4% of fish testing positive in the three remaining family groups (personal communication, Chris Mott, Grant PUD, October 8, 2019). If fish from families that tested positive were to be released, fish would have to be tested individually for autopolyploidy prior to tagging and release in 2020. A Coulter counter was purchased by Grant PUD to conduct the testing. Blood samples obtained from each fish would be prepared and examined with the Coulter counter as part of the tagging process to determine the genomic attribute of the fish. Fish determined as 8N would be selected for tagging and release.

By April 2020, when tagging of brood year progeny typically occurs, receipt of the Coulter counter was delayed due to manufacturing delays due to the COVID-19 pandemic. In addition, access to the YNSH hatchery was limited to hatchery personnel and instruction by UC Davis staff in the use of the Coulter counter could not be arranged due to travel restrictions. As testing and tagging the 2019BY was not going to proceed as originally planned, an alternative release strategy was developed that would allow some proportion of the 2019BY to be released in 2020. Approximately 700 fish of the 2019BY maternal family that tested negative for autopolyploidy in the initial 2019 screening would be tagged and released in July 2020. The three remaining 2019BY families, which consisted of approximately 2000 fish with low but detectable levels of autopolyploidy, would be held for an additional year at YNSH and then tested, tagged, and released in 2021.

All 2019BY White Sturgeon tagged in 2020 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).

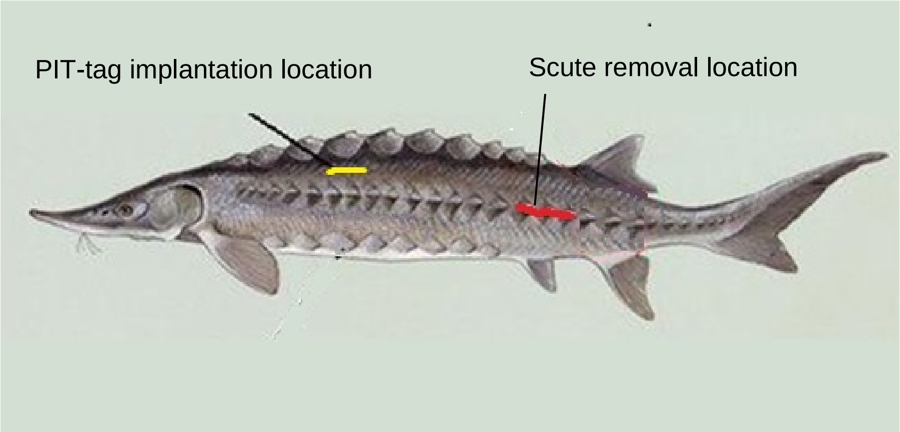

Figure 2 **Juvenile White Sturgeon tag implantation and mark locations.**

Tagging logistics and data collection were coordinated by Blue Leaf Environmental (BLE), with assistance from Grant PUD and 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 to be recorded were selected to document the genetic origin, holding and rearing water temperature, health and disposition, fin abnormalities, and the identifying tags and marks applied to each fish (Table 1).

Table 1 Data recorded in Biomark P4 for the 2019BY White Sturgeon tagged and released in the Priest Rapids Project Area in 2020.

Data Field	Description
Session	Project Code – Year – Session ID
Project Code	GCS
Session Comments	Record Release Pool (Wanapum or Priest Rapids) and Parental Family (1-5)
Rec #	Sequential record number
SRR code	Three-character code that identifies the species (White Sturgeon), run, and rear type of fish (B0W)
Event Site	Yakama Nation Sturgeon Hatchery (YNSH)
Event Type	Mark
Organization	Grant PUD (GPUD)
Life Stage	Juvenile
Tagging Date and Time	Date and time when each fish was tagged
PIT-Tag Code	HEX format
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	2019
Text Comments	Recorded fin deformities and if the fish were in poor health
Mark and Holding Temperature	In Celsius

2019BY Releases

In 2020, juvenile White Sturgeon were held in the hatchery for approximately two weeks post-tagging to allow recovery from the tagging process. The release of 2019BY fish into the PRPA was coordinated by Grant PUD biologists and technicians, who worked with staff and equipment provided by YNSH and Grant PUD. Consistent with 2015 to 2019 releases, in 2020, 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 boat 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.

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. Fish were released from the transport vehicle to the river either by dip net or via a flexible flume. 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. Any mortalities associated with the transport or release of fish were identified and the PIT tag number recorded for later removal from the release group record set. After release, the inside of the transport tank was inspected for any shed PIT tags, and if found, the PIT tag number was recorded for later removal from the record set.

2.3 Broodstock Capture

Broodstock capture effort since 2015 have been conducted in John Day Reservoir, immediately downstream of McNary Dam, and entailed a collective effort of public utilities, government agencies, and consultants in support of the White Sturgeon conservation aquaculture program at YNSH. This capture effort typically consisted of guide-assisted, boat-based, angling with BLE biologists, Chelan and Grant PUD personnel, and volunteers.

Due to the COVID-19 pandemic in 2020, the risk of contracting COVID-19 while working in close quarters on a guide river boat was considered too high to allow broodstock capture to be conducted in 2020. As such, broodstock were not captured in 2020 and a 2020 brood year of hatchery juvenile White Sturgeon was not produced.

2.4 White Sturgeon Spawn Monitoring and Egg Incubation

Previous studies have identified the left downstream bank below Rock Island Dam as a high-use White Sturgeon spawning and egg incubation area (Golder 2003, 2011, 2014, and 2016). From June 21 to July 2, 2020, egg collection mats were deployed below Rock Island Dam to capture wild-spawned White Sturgeon eggs and determine the timing and number of spawning events.

2.4.1 Spawning Assessment Methodology

The start date of spawn monitoring was selected to coincide with the historical occurrence of peak spawning activity of White Sturgeon. Peak spawning typically occurs in late June and early July based on previous spawning assessments conducted in the middle and upper sections of the Columbia River (Golder 2016). As in the previous spawning assessment studies conducted in the Project area, metal framed egg collection mats were deployed by boat at locations where White Sturgeon eggs were collected. The design and deployment method of egg collection mats used in 2020 was similar to methods used during the 2010, 2013, and 2015 spawning assessments (Golder 2011a, 2014, and 2016).

The egg collection mats were constructed of filter material (latex coated animal hair) cut into 76 cm by 76 cm sections and secured within an angle iron frame with strips of flat bar. The strips were secured within the frame by bolts to allow removal of the filter material for cleaning.

Two sections of filter material were placed back to back within each frame. This ensured that one side of the filter material always faced up, regardless of how the frame rested on the river bottom. A stainless-steel cable bridle with crimped thimble cable loops was attached to each mat frame with steel shackles; the bridle served as the primary attachment point for both the shore line and float retrieval line. The egg collection mats were deployed in pairs at each sample sites, connected by a 2.0 m long length of braided 0.95 cm (3/8-inch) diameter nylon rope referred to as a stringer.

When deployed near shore, the egg collection mats were connected to shore by a length of braided nylon rope connected to the bridle of the upstream-most mat (mat 1). As a secondary method of retrieval, should the shoreline or stringer fail, a float retrieval line was attached to the downstream-most mat (mat 2). In 2020, the length of the shoreline at each station was standardized to 20 m to allow more sampling sites to be positioned within the confines of the known spawning location. Float retrieval lines were also standardized to a length of 30 m for all sample sites. The length differential between the shoreline and float retrieval line allowed the field crew more time to retrieve the mats and avoid downstream sampling gear while drifting with the current during the retrieval. At shore sample sites, the mats were retrieved by first untying the shoreline and retrieving the mat, followed by the float line; the mid-set was retrieved by the float line. Gear was primarily retrieved with a side davit equipped with an electric winch. In situations where the sampling gear was stuck, a bow-mounted electric winch and the boat engine was used to assist in the retrieval of the egg collection mats.

A mid-channel anchoring system was also used to sample areas of potential spawning habitat located further away from shore. This deployment system (a mid-set) consisted of two metal 45-kg weights deployed on the river bottom and connected to a ground line to which the mat was attached. A float retrieval line was used to retrieve and redeploy the mat. A 1 m long metal cable placed in-line with the ground line and retrieval line to span anticipated abrasion points near the metal anchor and the mat frame that could cut the retrieval rope. The length of the ground line and retrieval line were approximately 3x the deployment depth for sufficient scope to anchor the gear and allow retrieval. The mid-channel site was retrieved using the side davit. When the mat reached the surface, it was disconnected from the ground line while holding the boat stationary, a new mat was attached, and the sampling gear was redeployed.

Egg collection mats were deployed and retrieved daily by a three-person crew (boat operator and two crew members). Measurements taken after each deployment of the egg collection mats included deployment (set) and retrieval (pull) times, date, and mean depth (as measured using the boat’s depth sounder). If conditions were too rough to assess each sample site in a given work day, the missed sample sites were assess the following day or when flow conditions allowed. Upon retrieval, each mat was visually inspected for sturgeon eggs by two crew members. If less than 150 eggs were observed, the eggs were manually removed from the mat material (i.e., with tweezers) and enumerated. If the mat captured hundreds of eggs, a sub-sample of eggs were removed from the mat, counted, and the number of eggs that remained on the mat were estimated. Eggs removed from the mat material were examined with a hand lens or stereomicroscope to identify development stage based on egg stages identified in Beer (1981). All manually removed eggs were kept in a water-filled cooler until transferred to the *in situ* egg incubator (see Section 2.4.4). In situations where an egg mat captured hundreds of eggs, the mat material was removed from the mat frame and the material was transferred immediately to the egg incubator. All sample data and catch results for each site were recorded in a field notebook and the field database developed for the study.

2.4.2 Sample Locations

In 2020, paired mats were deployed at 11 shore locations and a single mat was deployed at one mid-channel location along the left downstream riprap bank between the Rock Island Dam boat hazard sign and upstream of Haystack Eddy (Figure 3). The locations sampled and numbers of mats deployed along the left bank were constrained by the length of bank available and the amount of space each sample site required to be deployed and retrieved safely in fast flowing water. Once established, the sample site was marked with labelled flagging tape and a tag line was extended between a tie point above the high water to the water's edge to secure the shoreline. The site locations, site names, and UTM locations are provided in Table 2.

Table 2 Locations of egg collection mats deployed below Rock Island Dam, 2020.

Site Name	UTM Zone	UTM Easting	UTM Northing
RI-1	10T	720069	5247207
RI-2	10T	720121	5247166
RI-3	10T	720169	5247111
RI-4	10T	720208	5247050
RI-5	10T	720248	5247002
RI-6	10T	720279	5246954
RI-7	10T	720308	5246891
RI-8	10T	720339	5246830
RI-9	10T	720376	5246756
RI-10	10T	720407	5246688
RI-11	10T	720410	5246591
RI-M1	10T	720190	5246841

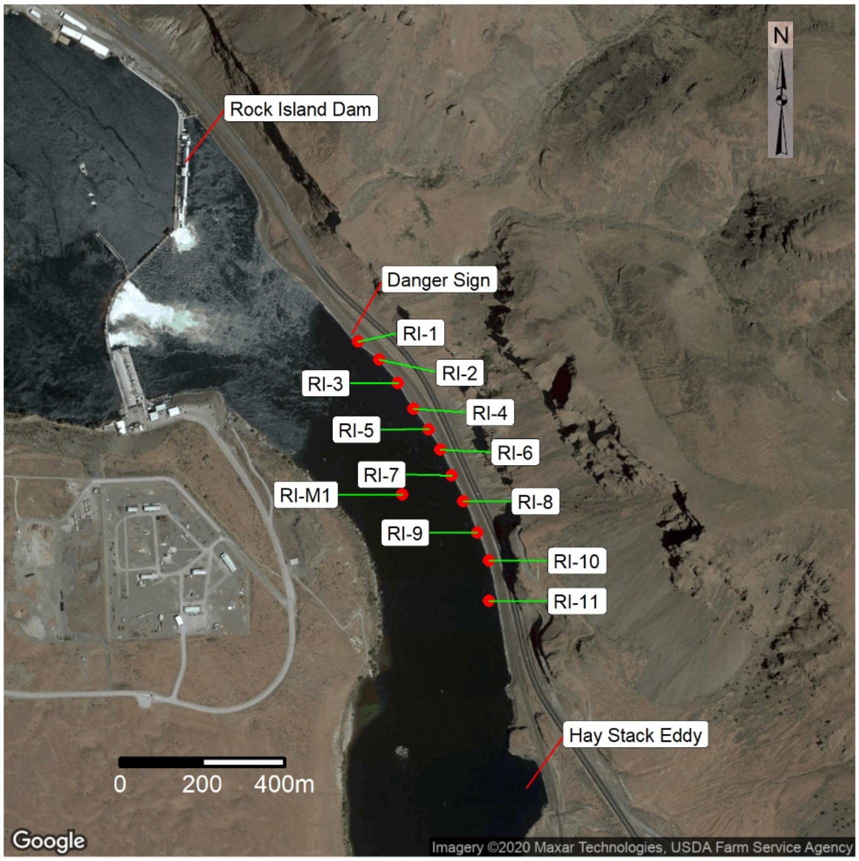

Figure 3 **Location of egg collection mats in the Wanapum Reservoir downstream of Rock Island Dam during the White Sturgeon spawning assessment surveys conducted in 2020.**

2.4.3 Spawning Event Identification

The number and timing of discrete sturgeon spawning events in Wanapum Reservoir were inferred based on the temporal distribution of egg captures, examination of developmental stages, and back calculation from the time of egg collection to spawning date based on developmental rates at the measured water temperature (Wang et al. 1985; Parsley et al. 2004).

2.4.4 Egg Incubation

An *in situ* incubator was deployed in an eddy approximately 3.5 km downstream of Rock Island Dam as a repository for captured White Sturgeon eggs and to incubate these eggs to hatch as a potential source of larval White Sturgeon in support of supplementation efforts. In 2020, a simplified version of the incubators deployed in 2013 and 2015 was used (Golder 2014, 2016).

The incubator consisted of a square 76 cm wide floating chamber, 120 cm deep, with screened ventilation ports to allow exchange between the inside of the incubator and the outside water (Figure 4). The incubator was designed to suspend panels of the egg-ladened mat material within the body of the incubator. In 2020, based on previous observations of swimming activity of free-embryos and larvae within the incubator (Golder 2014, 2016), the interior of the incubator was modified to provide cover for free-embryos and to concentrate actively swimming larvae within an easily accessible chamber of the incubator. If a mat captured many eggs, the mat material was removed from the mat frame, weight was added to the bottom edge of the material, and the mat was suspended from attachment points along the top edge of the incubator. This approach minimized handling time of the eggs, compared to manually removing them from the mat, and was expected to result in higher hatch success. A layer of “bioballs”- high surface area textured plastic spheres– was added to the bottom of the incubator. If an egg collection mat captured only a few eggs, these loose eggs were dispersed over the layer of bioballs. The purpose of the bioballs was to simulate spawning substrate and provide interstitial spaces for incubating eggs and cover for free-embryos after the eggs hatched. The incubator was designed with a rearing chamber to take advantage of actively swimming larvae by guiding them into a separate holding chamber to concentrate the larva and allow easier removal and enumeration by field staff (Figure 5).

As the developmental condition of the eggs incubated on mat material and bioball substrate could not be easily assessed once the eggs were placed within the incubator, a portion of the eggs were instead incubated within incubation cassettes to allow assessment of survival and development stage during the incubation period. Each incubation cassette held up to 50 eggs in individual cells. Once loaded with eggs, the cassettes were suspended inside the incubator.

A continuous temperature logger was deployed to monitor changes in mean hourly temperature within the incubator and for comparison with ambient river water temperature.

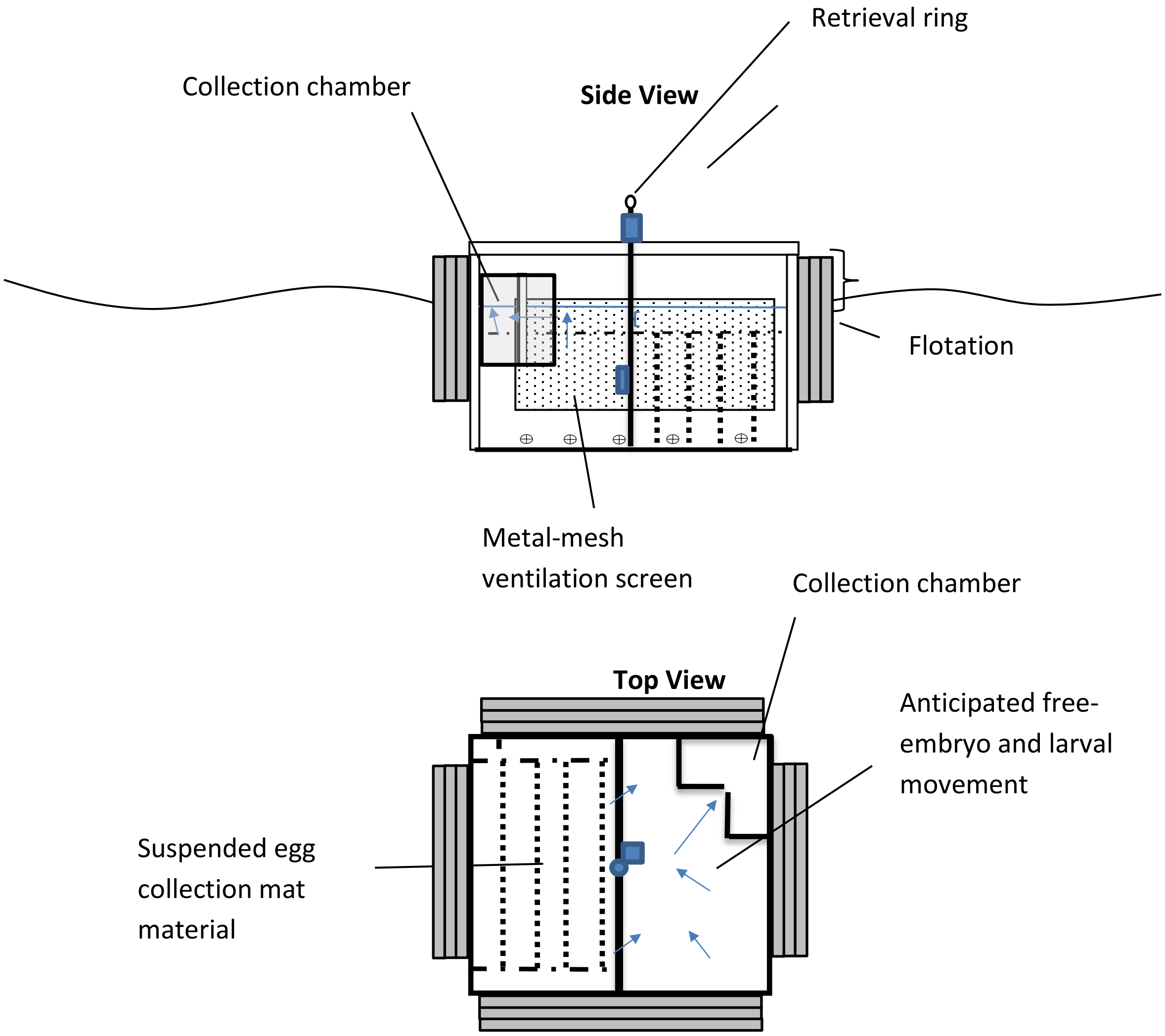

Figure 4 **Design of the prototype *in situ* White Sturgeon egg incubator used to incubate White Sturgeon eggs captured in Wanapum Reservoir below Rock Island Dam in 2020.**

Figure 5 The *is situ* incubator (exterior left paned; interior right panel) used to incubate wild spawned White Sturgeon eggs in 2020.

2.5 Juvenile White Sturgeon Population Indexing

The methods used during the 2020 juvenile White Sturgeon population indexing program were the same standardized methodology applied during the indexing studies conducted in 2016, 2017, 2018, and 2019 (Golder 2020). 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 baited with pickled squid. 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 (i.e., defined an "overnight set" or approximately 24-hours) and were retrieved and reset the following day.

Consistent with previous study years, set line locations in 2020 were selected 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 4.0.2; R Core Team 2020). The 2020 survey used the same sample multi-density reservoir categories ("lower", "middle", and "upper" sections) used in previous study years (Golder 2020). 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 2020, set line deployment and retrieval, catch processing, and data recording were conducted in a manner identical to the previous indexing studies in 2016, 2017, 2018, and 2019 (Golder 2020).

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: $Ws = 2.735\text{ E-6} * FL^{3.232}$ (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 calculations 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), 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.

2.6 Juvenile White Sturgeon Growth, Survival and Abundance Estimation

Age and length data from recaptured hatchery-released fish were used to construct von Bertalanffy growth curves (length-at-age curves). The curves were used to tests whether 1) growth differed significantly between brood years, and 2) whether growth differed significantly between reservoirs of release and reservoirs of recapture. To answer the second question, fish were assigned a recapture reservoir, where if a fish entrained from Wanapum Reservoir into Priest Rapids Reservoir between its original release in Wanapum Reservoir and its last recapture, its entire growth was attributed to have occurred in Priest Rapids Reservoir. That is, the analysis did not take into account the timing of the entrainment. All analyses were performed using the package FSA (Ogle et al. 2020) in the statistical environment R v. 4.0.2 (R Core Team 2020).

In the analysis of difference in growth between brood years, a “common” von Bertalanffy growth model was constructed for all brood years combined. In addition, a model where each brood year was allowed to have a different value of model parameters (L_∞, K, and t_0) was constructed. The two models were then compared using a likelihood-ratio test to assess whether the brood-year-specific model was significantly different from the pooled-data model. A lack of significance ($P>0.05$) would be interpreted as lack of significant differences in growth rates between brood years.

In the analysis of difference in growth between release and recapture reservoirs, a “common” von Bertalanffy growth model was constructed for all data combined. In addition, a second model was constructed, where each combination of release and recapture reservoirs was allowed to have a different value of model parameters (L_∞, K, and t_0). Since only a single sturgeon was documented to have moved from Priest Rapids Reservoir into Wanapum Reservoir, this combination of release and recapture reservoirs was omitted from the analysis (and the one fish was removed from the dataset used for this analysis). The model therefore had three growth curves – for fish released in Wanapum Reservoir that remained in Wanapum Reservoir, fish released in Priest Rapids Reservoir and remained in Priest Rapids Reservoir, and fish released in Wanapum Reservoir and entrained into Priest Rapids Reservoir. The two models (common and reservoir-specific) were then compared using a likelihood-ratio test to assess whether the reservoir-specific model was significantly different from the pooled-data model. A lack of significance ($P > 0.05$) would be interpreted as lack of significant differences in growth rates between release or recapture reservoirs.

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. 4.0.2 (R Core Team 2020), 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 2020 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 not recorded for 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. one value of survival for first year post-release and a different value for all subsequent years
    b. as an additive function of brood year and first year post-release and all subsequent years – i.e., the survival for first year post-recapture survival is allowed to be different than survival in all subsequent years, however the difference in survival by brood year is assumed to be the same for both first year post-recapture and all subsequent years.
    c. as a multiplicative function of release reservoir and whether the period was in the first year post release or in all subsequent years – i.e., survival for first year post-release and all subsequent years was allowed to differ independently by reservoir.
b) Recapture:
    a. as function of age (as a categorical variable)
    b. as a linear function of age (as a continuous variable) – i.e., recapture rate is assumed to increase with age, or assumed to decrease with age
    c. as a parabolic function of age (as a continuous variable) – i.e., recapture rate is assumed to increase with age, until a peak is reached, followed by a decrease in recapture rate, as fish mature out of the gear
    d. as a multiplicative function of release reservoir and age (as a categorical variable) – i.e., recapture by age is allowed to vary independently by release reservoir.
    e. as a multiplicative function of release reservoir and age (as a continuous variable with a linear effect) – i.e., the trend of recapture by age is allowed to differ between release reservoirs.
    f. as a multiplicative function of release reservoir and age (as a continuous variable with a parabolic effect) – i.e., the parabolic trend by age is allowed to differ between release reservoirs.

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 2020. Estimation of survival and recapture was only possible for brood year releases with one or more years at large and could not be estimated for the 2019BY released in 2020. To account for the 2019BY abundance, the number of 2019BY fish released in 2020 was used as the abundance of that brood year.

2.7 General Data Recording and Analysis

Custom field databases were designed and used to record field data for specific study components. In 2020, 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 2020 study into a single database that contained all indexing data recorded in the PRPA from 2014 to 2020. 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. 4.0.2 (R Core Team 2020). 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.

3.0 Results

3.1 Discharge and Temperature During Study Components

In 2020, peak mean daily flows in the PRPA, as measured in Wanapum Reservoir below Rock Island Dam, were recorded on June 4 (6,839 m³/s; DART 2020). Lowest mean daily discharge was recorded on September 19 (1,209 m³/s). Peak mean daily water temperature was recorded on September 6 (19.7°C). The lowest mean daily water temperature was recorded on February 21 (3.3°C; Figure 6).

2019BY Hatchery Juvenile White Sturgeon Release

Hatchery juveniles are typically released into the PRPA in late spring to time the release with the rising hydrograph and when the receiving water temperatures range from 8°C to 12°C. Due to the COVID-19 pandemic, release of the 2019BY was delayed and proceeded on July 23 during the descending limb of the hydrograph. At release, the mean daily discharge was 4,053 m³/s and the water temperature was 17.4°C.

White Sturgeon Spawning Assessment

The average of mean daily discharge over the duration of the monitoring period was 5,929 m³/s (SD = ±424 m³/s). Mean daily discharge during the spawning assessment ranged between 5,269 m³/s on June 22 and 6,477 m³/s on June 28. The average of the mean daily water temperatures over the monitoring period was 14.4°C (SD = ±0.3°C) and ranged between 13.9°C and 15.0°C.

Juvenile White Sturgeon Population Indexing

Juvenile White Sturgeon indexing in 2020 was conducted from August 31 to October 6 when flows approached seasonal lows and water temperatures were at or near the seasonal high (Figure 6). During sampling, average mean daily discharge was 2,079 m³/s (SD = ±398 m³/s) and ranged from a low of 1,209 m³/s on September 19 to a high of 2,829 m³/s on October 2. 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 18.7°C (SD = ±0.5°C) and ranged between 17.9°C and 19.7°C.

Figure 6 **Mean daily discharge (black line), mean hourly discharge (light blue ribbon), and mean hourly water temperature (red line) of the Columbia River in the Priest Rapids Project Area, as measured below Rock Island Dam in 2020. The vertical red line denotes the 2019BY juvenile White Sturgeon release date. The vertical blue and green columns denote the timing of the spawning assessment and juvenile White Sturgeon indexing, respectively.**

3.2 2019BY Hatchery Juvenile White Sturgeon Marking and Release

The 2020 Grant PUD juvenile White Sturgeon release was limited to individuals from a single maternal family of 2019BY that tested negative for spontaneous autopolyploidy. As the 2020 release was limited to a single family, only 672 fish were released in the Project area, which was approximately 21% of the normal annual hatchery juvenile White Sturgeon release (i.e., a maximum of 3,250 fish) prescribed under the Priest Rapids White Sturgeon Stocking SOA.

In accordance with the SOA, approximately 62% of the release (412 fish) were released in Wanapum Reservoir at the Frenchman Coulee boat launch (RM426.5) and 38% (261 fish) in Priest Rapids Reservoir at the Wanapum Dam tailrace boat launch (RM415.6; Table 3). Mean fork length of the 2019BY when tagged was 355 mm (SD ± 52 mm) and mean weight was 288 g (SD ± 106 g) .

All fish were released on July 23, 2020, approximately 16 days after tagging. Shed PIT tags were not found in the rearing tanks after the holding period when the tanks were drained and cleaned. Mortalities were not recorded during the post-tagging holding period (personal communication, D. Miller, YNSH, December 22, 2020).

During transport of the fish to Wanapum Reservoir, the fish were transferred by net from the hatchery holding pens to Grant PUD transport vehicles. The oxygen levels and water temperature in the hatchery holding pens (DO =7.56 mg/L; Temperature =14.6°C) and transport vehicles (DO = 8.56-9.17 mg/L; Temperature = 14.6°C) were nearly identical during the transfer. The holding tank oxygen level onboard the Grant Transport hatchery truck was 9.33 mg/L on departure from the hatchery, ranged between 9.81 and 9.93 mg/L at the two travel check stops, and 10.1 mg/L upon arrival at the Wanapum Reservoir release site, Frenchman Coulee boat launch (RM424.5). At release, water temperature in the holding tanks was 15.1°C and the fish were released into receiving water with a temperature of 19.4°C. During transport of fish to Priest Rapids Reservoir, the holding tank oxygen level onboard the Grant Transport trailer was 10.23 mg/L on departure from the hatchery, ranged between 12.25 and 12.58 mg/L at the two travel check stops, and 11.38 mg/L upon arrival at the Priest Rapids Reservoir release site, the Wanapum Dam Tailrace boat launch (RM415.6). At release, water temperature in the trailer holding tank was 16.4°C and the fish were released into receiving water with a temperature of 18.1°C. One shed PIT tag was found in the transport trailer after release and was removed from the release list of PIT tags. All fish were successfully released alive and post-release mortalities were not evident.

Table 3 Number of 2019BY juvenile White Sturgeon released in Wanapum and Priest Rapids reservoirs and the mean fork length (FL) and mean weight of fish in each release. July 23, 2020.

	2020 White Sturgeon 2019BY Release		
Release Location Reservoir (River Mile)	**No. of Fish**	**Mean FL (± SD) mm**	**Mean Weight (± SD) g**
Wanapum (424.5)[1]	411	358 (53)	292 (107)
Priest Rapids (415.6)[2]	261	351 (50)	282 (104)
Total	672	355 (52)	288 (106)

[1] Frenchman Coulee boat launch

[2] Wanapum Dam Tailrace boat launch

During tagging, taggers noted that nearly all the 2019BY had one or more fin deformities. As recorded in previous brood year releases, deformities were most often evident in the pectoral fins and caudal fins, with less evidence of deformity in the other fins. To be consistent with previous assessments, deformity of the anal fin was not included in the summary below in that a deformed anal fin was assumed to have a minimal effect on swimming performance (Table 4). In total, one or more fin deformities were recorded for 97% (654 of 672 fish) of the 2019BY, with 64% of fish (n = 428) with deformity recorded in two or more fins that include both a pectoral fin and the caudal fin.

Table 4 **Fin deformity type and occurrence noted during processing of 2019BY juvenile White Sturgeon that were released in the Priest Rapids area on July 23, 2020.**

2019BY Primary Fin Deformity	Fin Deformity Sub-type	No. of fish with Primary Deformity	No. of fish with Sub-type Deformity
caudal deformity only		140	
	One deformed, curled, or damaged fin		140
caudal deformity and other		15	
	One deformed, curled, or damaged fin		3
	Two deformed, curled, or damaged fins		8
	Three deformed, curled, or damaged fins		4
pectoral deformity only		47	
	One deformed, curled, or damaged fin		12
	One missing fin		2
	Two deformed, curled, or damaged fins		27
	One deformed, curled, or damaged fin; one missing fin		6
pectoral deformity and other		8	
	One deformed, curled, or damaged fin; one missing fin		1
	Three deformed, curled, or damaged fins		6
	Two deformed, curled, or damaged fins, one missing fin		1
both caudal and pectoral deformity		428	
	Two deformed, curled, or damaged fins		124
	One deformed, curled, or damaged fin; one missing fin		37

2019BY Primary Fin Deformity	Fin Deformity Sub-type	No. of fish with Primary Deformity	No. of fish with Sub-type Deformity
	Two missing fins		3
	Three deformed, curled, or damaged fins		209
	Two deformed, curled, or damaged fins, one missing fin		55
caudal and pectoral and other		14	
	Three deformed, curled, or damaged fins		8
	Two deformed, curled, or damaged fins, one missing fin		6
other deformities		2	
	One or more deformed, curled, or damaged pelvic or dorsal fin		2
no fin deformity		18	
	No obvious deformities, all fins present		18
Total fish with fin deformities		654 (97%)	
Total fish without fin deformity		18 (3%)	
Total 2019BY Release		672	

3.3 White Sturgeon Spawning Investigations

3.3.1 Egg Collection

White Sturgeon spawning activity was monitored in Wanapum Reservoir below Rock Island Dam from June 21 to July 2, 2020. In total, 1,613 White Sturgeon eggs were captured during 4,359 mat-hours of sample effort (Table 5).

Mean daily water temperature approached 14.0°C at the start of spawn monitoring on June 21 and remained between 14.0 and 15.0°C for the duration of the monitoring period. Mean daily water temperature increased gradually to a maximum temperature of 15.0°C by June 27, after which water temperature cooled again and remained near 14°C for the remainder of the monitoring effort.

Substantial fluctuations in discharge were recorded during spawn monitoring. Mean daily discharge decreased from the seasonal high recorded on June 4 (6,839 m^3/s) to lower levels on June 22 (5,269 m^3/s) at the start of monitoring, which allowed sample sites to be positioned closer to Rock Island Dam than would have been possible at higher flows. However, after June 22, flows substantially increased and approached levels comparable to the seasonal maximum discharge level recorded earlier in June. The high flows resulted in unanticipated delays and gear loss due to entanglement of the sampling gear in the large riprap substrate and damage to both the shore and float retrieval lines. The mat material of the egg collection mats was also frequently damaged during a 24-hour deployment period and had to be frequently replaced. When possible, lost gear was either repaired or replaced and redeployed; however, at certain sites, the sampling gear either could not be retrieved or was routinely damaged. At these sites, the sampling gear was either left in place for later retrieval once flows reduced or a reduced amount of sampling gear was deployed (i.e., one mat instead of two) to reduce the risk of gear loss and simplify future retrieval efforts. However, even with these contingencies, high flows, combined with a change in gate operations at Rock Island Dam that directed flows toward the left downstream bank (i.e., the bank that the mats were deployed along), were sufficient to prevent inspection of sampling gear at some sample sites during some sessions. The sites where retrieval was the most difficult included RI-M1, RI-3, RI-8, and RI-10. By July 1, discharge decreased temporarily, allowing retrieval of sampling gear from upstream sample locations (i.e., RI-3 through RI-6) and retrieval of damaged sampling gear at the downstream sites (RI-8 and RI-10).

Eggs were first captured on June 26, four days after initial deployment of the egg mats (Figure 7). These eggs were captured from RI-5 to RI-11, with the majority of eggs (n = 35 of 51) captured at RI-11. Egg collection mats at RI-1, RI-2, RI-8, RI-10 could not be inspected due to either damage to the retrieval lines (RI-8 and RI-10) or time limitations (RI-1 and RI-2).

On June 27, eggs were captured at RI-2 (n = 33), RI-5 (n = 74), RI-6 (n = 13), RI-7 (n = 40), RI-9 (n = 63), and RI-11 (n = 24). The remaining sample sites were not inspected due to time limitations. The capture of eggs at RI-2 suggests that at least one spawning event occurred upstream of RI-2.

The largest egg capture event was recorded on June 28 with eggs captured at RI-1 (n = 7), RI-2 (n = 37), and substantially larger egg catches at RI-4 (n = 450) and RI-5 (n = 250). Egg catch on RI-4 and RI-5 were too numerous to count without risking egg desiccation and the total egg catches were estimated for these sites. Based on catch alone, another spawning event likely occurred at a location upstream of RI-1. Due to time requirements to transfer these eggs to the downstream incubator (see Section 3.6.3), the remaining sample sites could not be inspected.

On June 29, a moderate number of eggs were captured at RI-5 (n = 46), RI-6 (n = 32), RI-7 (n = 65), RI-9 (n = 144), and RI-11 (n = 71). Inspection of the eggs captured determined that all the eggs were at a developmental stage that corresponded to the previously identified spawning events. High flows and unsafe conditions prevented inspection of the sites upstream of RI-5. Total egg catch after June 29 decreased substantially with only 23 eggs captured on June 30, 27 egg captured on July 1, and no eggs captured on July 2. All eggs captured after June 29 were older eggs associated with previous spawning events.

Overall CPUE was 9.0 eggs/24 mat-hours and eggs were captured at all shore-based sites, with the two largest total number of eggs captured at site RI-4 (n = 532 eggs; CPUE = 31.9 eggs/24 mat-hours) and RI-5 (n = 465 eggs; CPUE = 26.4 eggs/24 mat-hours), and moderate catch success at RI-9 (n = 214 eggs; CPUE = 10.0 eggs/24 mat-hours), R-11 (n = 144 eggs; CPUE = 6.8 eggs/24 mat-hours), and RI-7 (n = 132 eggs; CPUE = 6.4 eggs/24 mat-hours; Table 10). Sample sites with either no catch or reduced sample effort were limited to locations where gear could not be readily retrieved and the gear was lost when a final retrieval was attempted at lower flows near the end of the program.

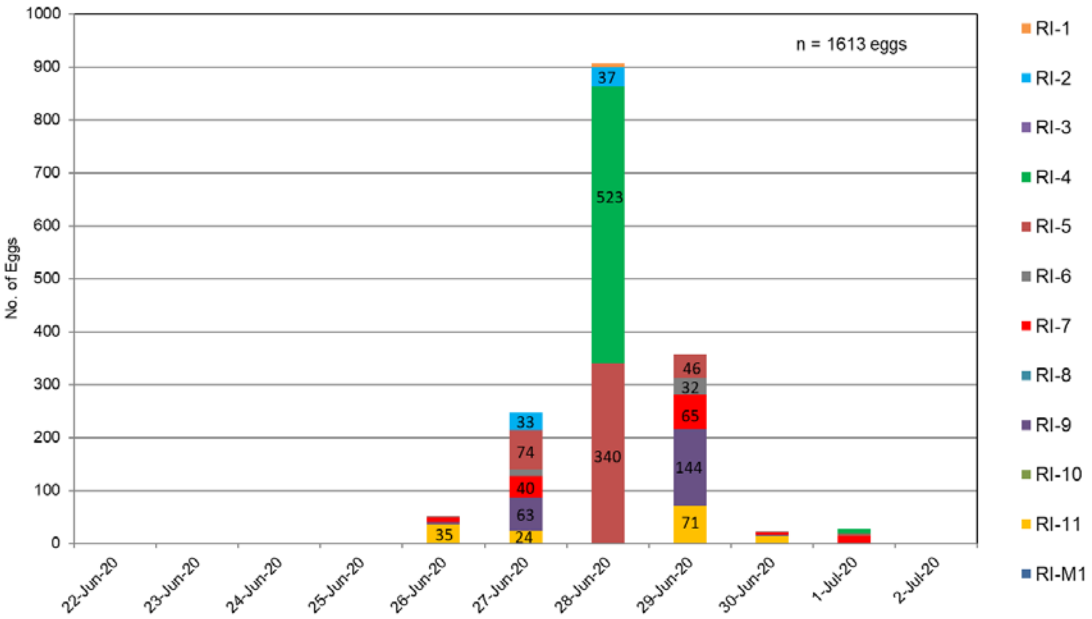

Figure 7 White Sturgeon egg catch distribution by capture location and date of capture below Rock Island Dam in Wanapum Reservoir. Only capture events with greater than 20 eggs are labelled.

Table 5 Total White Sturgeon egg capture effort, number of eggs captured, and catch-per-unit-effort at each capture location in Wanapum Reservoir, 2020.

Station	Total Effort (mat-hours)	Total Egg Catch	CPUE/24 mat-hours
RI-1	522	7	0.3
RI-2	521	70	3.2
RI-3	193	0	0.0
RI-4	400	532	31.9
RI-5	422	465	26.4
RI-6	455	49	2.6
RI-7	496	132	6.4
RI-8	51	0	0.0
RI-9	516	214	10.0
RI-10	206	0	0.0
RI-11	507	144	6.8
Total	**4317**	**1613**	**9.0**

Spatially, eggs were captured over the full extent of the study area, with the most eggs captured where flows from Rock Island Dam converge on the riprap bank between RI-3 and RI-6 (Figure 8). Flows within this section of the study area were at times strongly affected by the standing waves of the spill discharge and flows were fast and less predictable. Upstream of RI-3, RI-1 and RI-2 were encompassed within a partial recirculating hydraulic (back eddy) that formed as flows cycled back upstream along the shore in the lee of a riprap/bedrock outcrop located at RI-1. Based on limited field observations, the size and strength of the back eddy was strongly affected by which spillways was used at Rock Island Dam, with the eddy at its largest when the west spillways were operated as opposed to the mid-river spillways. From RI-6 downstream, flows were fast, but more predictable and less turbulent.

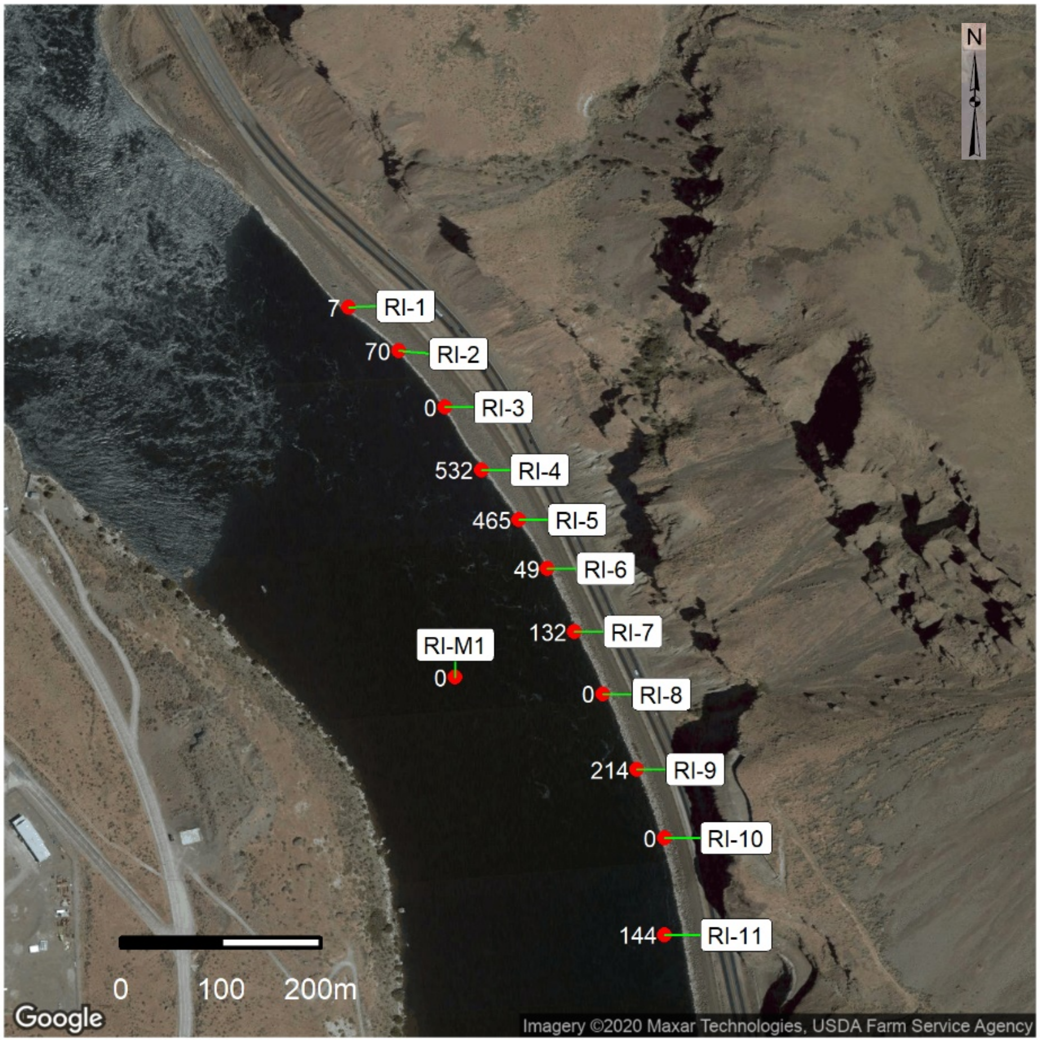

Figure 8 **White Sturgeon egg catch number and distribution by capture location in Wanapum Reservoir, 2020.**

3.3.2 Egg Development Staging and Spawning Events

At the time of capture, a subsample of eggs was photographed and examined to determine developmental stage based on stage descriptions and the amount of time required to attain the developmental stage at a given water temperature (Beer 1981). Using this developmental information, the number of White Sturgeon spawning events and approximate date of each event was estimated. A single spawning event was assumed to represent one or more females releasing their entire egg mass within a 24-hour period. On this basis, three discrete spawning events were detected below Rock Island Dam in 2020. The back-calculated spawn times for each event are provided in Table 6. These spawning events were estimated to have occurred on June 26, 27, and 28 (Figure 9). Mean daily water temperature gradually increased prior to the onset of spawning and approached 15°C during the first and second spawning events. After the second spawning event, total river discharge increased and water temperature decreased below 15°C, and these conditions persisted for the remainder of the monitoring period. Water temperatures during the recorded spawning activity was near the lower end of the optimum temperature range for White Sturgeon egg development (14°C to 16°C; Wang et al. 1985) and river temperatures remained within this optimum range until July 12.

Table 6 Estimated number and timing of White Sturgeon spawning events in Wanapum Reservoir below Rock Island Dam, 2020

Spawning Event	Egg Collection Date/Time	Water Temp. at Capture (°C)	Egg Stage at Capture[a]	Estimated Spawning Date/Time	Water Temp. at Spawning (°C)	Mean Daily Discharge at Spawning (m^3/s)
1	26/Jun/20-12:00	14.9	12	26/Jun/20 12:00	14.9	6,337
2	27/Jun/20-12:00	15.0	12	27/Jun/20 12:00	15.0	6,080
3	28/Jun/20 12:00	14.6	14	28/Jun/20 7:00	14.6	6,447

[a] Based on Beer 1981.

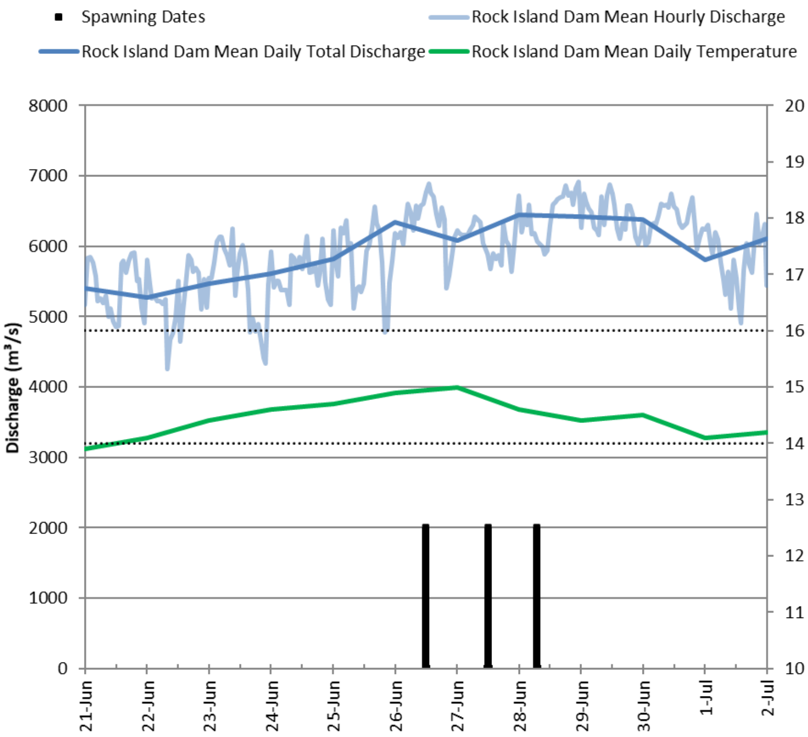

Figure 9 **Mean daily water temperature and discharge of the Columbia River in Wanapum Reservoir below Rock Island Dam from June 21 to July 2, 2020. Vertical black bars indicate estimated dates of White Sturgeon spawning events. Horizontal dotted lines represent the optimal egg incubation temperature range for White Sturgeon egg development (14-16 °C; Wang et al. 1985).**

3.3.3 White Sturgeon Egg Incubation

In total, 1,563 of the 1,613 eggs captured during the assessment were transported and incubated within the *in situ* incubator. Time of hatch of incubated eggs was estimated based on known White Sturgeon egg developmental rates in relation to water temperature. These estimates indicated that the eggs were unlikely to hatch by the end of scheduled monitoring and would require additional time to incubate. Approximately 700 of the 1,563 eggs incubated were left adhered to the egg collection mats and were not physically handled. These eggs were captured at sites RI-4 and RI-5 on June 28 and the mat material was removed and promptly suspended inside the incubator to reduce handling and stress on the eggs. The remaining eggs, which were captured in lower numbers at many sites over several days were manually removed from the mats. These eggs were incubated either within the bioballs lining the bottom of the incubator (n = 488) or within incubation cassettes (n = 375).

Inquiries were made by Grant PUD to determine if a local hatchery would accept these wild-spawned White Sturgeon larvae. In the event a recipient was identified, the incubator would have been left installed until mid-July to allow all eggs to hatch and the larvae to develop prior to retrieval and transport to the hatchery. Despite the inquiries, hatcheries either did not have space or interest in this opportunity and the eggs were returned to the river on July 2.

During removal of the eggs, the number of live and dead eggs within each incubation cassettes was determined, and this measure was assumed as the overall survival rate of all eggs incubated within the incubator by all methods. In total 274 eggs remained alive of the 375 eggs incubated in incubation cassettes (73%). Among the incubation cassettes, the survival rate ranged between 52% and 88%. Water temperature within the incubator was similar to the river water temperature and indicated that sufficient water exchange likely occurs between the incubator and external environment to keep the eggs at ambient water temperature and well oxygenated.

3.4 Juvenile White Sturgeon Population Indexing

3.4.1 Sample Effort

Juvenile White Sturgeon population indexing in Wanapum and Priest Rapids reservoirs was conducted from August 31 to October 6, 2020. The GRTS study design assigned sample sites in equal numbers to each of the three defined sections (i.e., lower, middle, and upper sections) in Wanapum and Priest Rapids reservoirs (Table 7).

The mean depth and the range of depths sampled was greater in Wanapum Reservoir (mean = 20.0 m; range = 7.0 to 40.5 m) than in Priest Rapids Reservoir (mean = 11.3 m; range = 2.8 to 24.5 m). Mean water depths at sample sites in the upper sections of both Wanapum and Priest Rapids reservoirs were slightly less compared to mean depth recorded in lower and middle sections. At some sample sites, minimum water depths less than the bathymetric minimum depth criteria for each reservoir (i.e., 15 m in Wanapum Reservoir and 6 m in Priest Rapids Reservoir) were recorded due to variation in bathymetry over the length of the set line.

All set lines were intended to be deployed overnight for approximately 24 hours, but actual deployment duration varied between 17.7 and 45.9 hours. Sample durations less than 24 hours were due to variations in deployment and retrieval order, likely in situations where there was a logistical reason to retrieve these set lines out of order. Sample durations of greater than 40 hours were due to poor weather conditions that prevented retrieval of the set line. When these delays occurred, retrieval of these set lines was given priority for retrieval when conditions improved.

Table 7 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 31 to October 6, 2020.

	Reservoir							
	Wanapum (15 m Bathymetric Contour)				**Priest Rapids (6 m Bathymetric Contour)**			
	Lower	**Middle**	**Upper**	**All**	**Lower**	**Middle**	**Upper**	**All**
Number of GRTS sites sampled	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)								

	Reservoir							
	Wanapum (15 m Bathymetric Contour)				Priest Rapids (6 m Bathymetric Contour)			
	Lower	**Middle**	**Upper**	**All**	**Lower**	**Middle**	**Upper**	**All**
mean	21.5	20.8	17.8	20.0	13.3	11.4	9.2	11.3
min	11.3	9.1	7.0	7.0	7.0	2.8	5.0	2.8
max	40.5	37.2	38.0	40.5	24.5	21.2	14.5	24.5
Sample duration (h)								
mean	25.4	21.5	21.5	22.8	27.3	23.5	21.7	24.2
min	18.6	17.8	17.7	17.7	21.3	20.0	19.0	19.0
max	45.9	23.7	24.8	45.9	45.0	26.2	23.9	45.0

3.4.2 2019 Juvenile White Sturgeon Indexing Catch

In total, 627 White Sturgeon were captured and processed during the juvenile indexing program in Wanapum (n = 484) and Priest Rapids (n = 143) reservoirs (Figure 10; Table 8).
These captures represented 610 individual fish, with 13 fish captured twice and one fish captured three times in Wanapum Reservoir, and two fish captured twice in Priest Rapids Reservoir. Incidental captures were primarily Northern Pikeminnow (*Ptychocheilus oregonensis*; n = 75 in Wanapum Reservoir; n = 45 in Priest Rapids Reservoir). Within Priest Rapids Reservoir, incidental catch of Largescale Sucker (*Catostomus macrocheilus*; n = 2), Channel Catfish (*Ictalurus punctatus;* n = 7), and sculpin (*Cottus sp.*, n = 1) were also recorded.

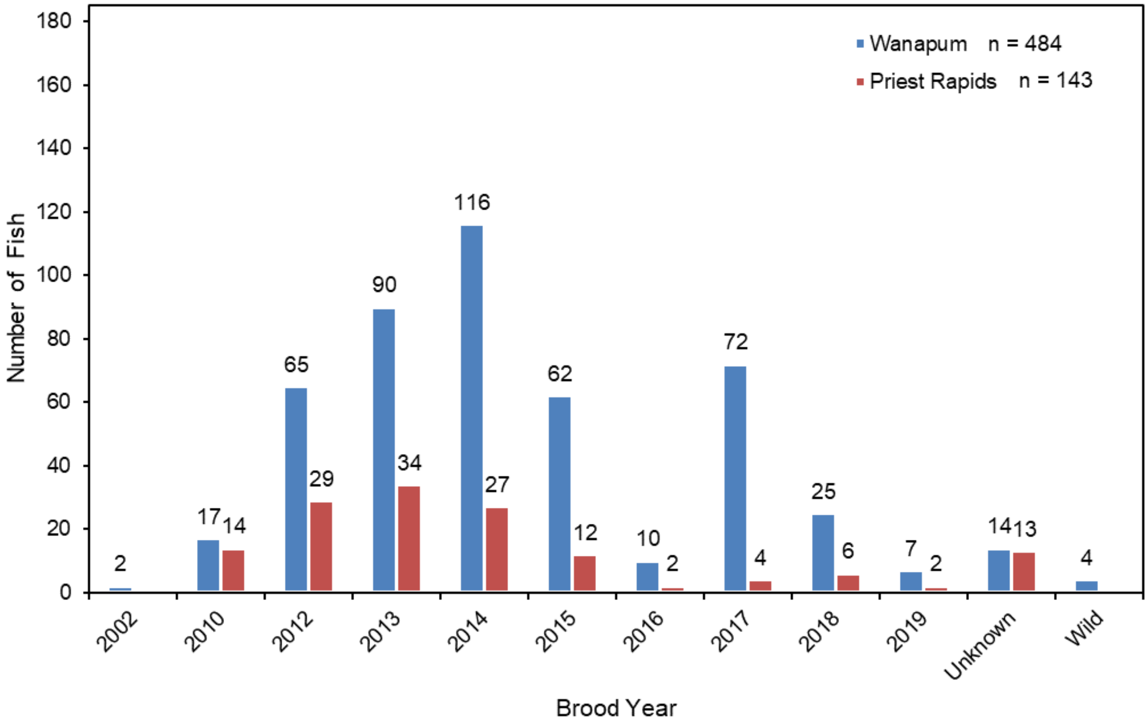

Figure 10 **Hatchery and wild White Sturgeon captured in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020. The Unknown category represents fish suspected to be of hatchery origin but without a PIT tag to allow identified of origin and brood year.**

3.4.2.1 Wanapum Reservoir Catch

The 484 White Sturgeon captured in Wanapum Reservoir consisted of hatchery origin fish released in Wanapum Reservoir (n = 464) and low numbers of entrained hatchery fish that had been released in Rock Island Reservoir (2002BY; n = 2), wild fish (n = 4), and fish of unknown origin (n = 14; Figure 10; Table 8). All fish captured from the nine hatchery brood years that were released in the PRPA since 2011 were originally released in Wanapum Reservoir. Entrained fish from releases of these brood years in upstream reservoirs (e.g., Rocky Reach) were not captured. The 2014BY (n = 116 or 24% of total catch) and 2013BY (n = 90 or 20%) were the dominant brood years caught in Wanapum Reservoir in 2020, followed by 2017BY (n = 72), 2012BY (n = 65), 2015BY (n = 62), 2018BY (n = 25), 2010BY (n = 17), 2016BY (n = 10) and 2019BY (n = 7). 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 (Golder 2017, 2018, 2019, 2020). Differences in catch proportion of each of the sub-groups identified for these brood years noted in previous reports were also evident in the 2020 juvenile indexing data, but were not investigated in detail and were assumed to be consistent with previous findings.

Table 8 **Hatchery and wild White Sturgeon captured in the Priest Rapids Project Area during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.**

					Capture Reservoir		
Brood Year	**Release Reservoir**	**Release Location**	**Date**	**Number Released**	**Wanapum**	**Priest Rapids**	**Total**
2002	Rock Island	Unknown	Unknown	20,600	2	--	2
2010	Wanapum	Columbia Siding	27-29-Apr-11	7,015	17	7	24
	Priest Rapids	Wanapum tailrace	28-Apr-11	2,101	--	7	7
			Total	9,116	17	14	31
2012	Wanapum	Columbia Siding and Columbia Cliffs	14-May-12	2,264	65	4	69
	Priest Rapids	Wanapum tailrace	14-15May 2013	1,717	--	25	25
			Total	3,981	65	29	94
2013	Wells	Unknown	10-Apr-14	--	--	1	1
	Wanapum	Rocky Coulee	6-May & 18-Sep-14	5,092	90	21	111
	Priest Rapids	Wanapum tailrace	5-May & 17-Sep-14	1,500	--	12	12
			Total	6,592	90	34	124
2014	Wanapum	Frenchman Coulee	30-Apr & 1-May-15	5,007	116	9	125
	Priest Rapids	Wanapum tailrace	1-May 2015	1,495	--	18	18
			Total	6,502	116	27	143
2015	Wanapum	Frenchman Coulee	28-Apr-16	2,005	62	3	65
	Priest Rapids	Wanapum Dam Tailrace	28-Apr-16	1,253	--	9	9
			Total	3,258	62	12	74
2016	Wanapum	Frenchman Coulee	2-May-17	1,999	10	1	11
	Priest Rapids	Wanapum Dam Tailrace	2-May-17	1,249	--	1	1
			Total	3,248	10	2	12
2017	Wanapum	Frenchman Coulee	1-May-18	1,983	72	1	73
	Priest Rapids	Wanapum Dam Tailrace	1-May-18	1,241	--	3	3
			Total	3,224	72	4	76
2018	Wanapum	Frenchman Coulee	7-May-19	1,767	25	--	25
	Priest Rapids	Wanapum Dam Tailrace	7-May-19	890	--	6	6
			Total	2,657	25	6	31
2019	Wanapum	Frenchman Coulee	20-Jul-19	412	7	--	7
	Priest Rapids	Wanapum Dam Tailrace	20-Jul-19	261	--	2	2
			Total	673	7	2	9
Unknown[1]	Unknown	Unknown	Unknown	n/a	14	13	27
Wild	n/a	n/a	n/a	n/a	4	--	4
All Sturgeon					484	143	627

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

In 2020, the following differences in catch proportion of brood year release groups in Wanapum Reservoir were identified:

- 2010BY: Although this brood year was released in greater numbers than subsequent brood years, total catch of 2010BY was approximately 0.24% (n= 17) of the initial release (n = 7,015 fish) and only 3.5% of the total catch in Wanapum Reservoir.

- 2012BY: Catch of the 2012BY (n = 65) contributed 13.4% to the total Wanapum catch and equated to 2.9% of the initial release (n = 2,264), which exceeded the catch proportion of some of the younger brood years that were released at greater densities.
- 2013BY: As the second largest brood year release in Wanapum Reservoir (n = 5,092), catch of this brood year in 2020 (n = 90) contributed 18.6% to the total catch, which was lower than the 2014BY and equated to only1.8% of the initial release. In previous studies since 2016, the 2013BY contributed the highest proportion to the total catch (e.g., as high as 36% in 2016; Golder 2017).
- 2014BY: The total releases of the 2014BY (n = 5,007) and 2013BY (n = 5,092) were similar and similar catches of these two brood years was expected. However, in 2020, the 2014BY contributed 24.0% (n = 116) to the Wanapum catch, which equated to a capture of 2.3% of the initial release.
- 2015BY, 2016BY, and 2017BY: These brood years were released in nearly identical numbers and under similar release conditions (i.e., time of year, size at release). Catch of both the 2015BY (n = 62; 12.8% of total catch) and 2017BY (n = 72; 14.9% of total catch) were similar, as were the catch proportion of the initial release (3.1 and 3.6% respectively). However, consistent with previous studies (Golder 2020), the 2016BY continues to be underrepresented in the population. In 2020, the 2016BY contributed only 2.1% (n = 10) to the total catch, which equated to 0.5% of the initial release (n = 1,999).
- 2018BY: The 2018BY were captured in low numbers (n = 25) and contributed 5.2% to the total catch, which equated to 1.4% of the initial release (n = 1,767).
- 2019BY: Due to complications related to the COVID-19 pandemic, the 2019BY release number (n = 412) was the smallest brood year release to date in Wanapum Reservoir. Given the low number of fish released in relation to the reservoir size, capture of 2019BY was not expected; however, the 2019BY were captured in low numbers (n = 7), which equated to 1.7% of the initial release and 1.4% of the total catch. Size at release was greater and time of release was later than most previous brood year releases (see Table 18).

Fourteen White Sturgeon of unknown origin were captured in Wanapum Reservoir. These fish were suspected to be hatchery fish based on scute marks or fin deformities (ranging from mild to severe). Four of these fish were without PIT tags and were subsequently tagged. Five fish were recaptured fish that had been initially caught, processed, and added to the field database in previous indexing studies. The remaining five fish had PIT tags; however, these tags were not recorded within the Grant PUD sturgeon database or the PTAGIS regional database.

Four suspected wild White Sturgeon were captured in 2020. These wild fish did not have fin deformities. The pectoral fins were also proportionally wider than the pectoral fins of hatchery fish. The rostrum of the wild fish also tended to be more elongated compared to most of the hatchery fish caught. As noted in previous studies, the presence of these wild fish indicates continued natural recruitment within the Wanapum Reservoir. After the 2002BY removal effort, which ended in 2018 (Golder 2019), the number of 2002BY was reduced and only low numbers of 2002BY (n = 2) were captured in Wanapum Reservoir in 2020. Furthermore, the remaining individuals of this brood year are large fish and unlikely to be captured by small hook set line gear configured for juvenile capture.

3.4.2.2 Priest Rapids Reservoir Catch

The 2020 catch of 143 White Sturgeon captured in Priest Rapids Reservoir consisted of hatchery fish released directly into Priest Rapids Reservoir (n = 83), hatchery fish entrained from Wanapum Reservoir (n = 46), one fish entrained from Wells Reservoir, and fish of unknown origin (n = 13; Figure 10; Table 8). In 2020, the following differences in catch proportion of brood year release groups in Priest Rapids Reservoir were identified:

- 2010BY: The 2010BY catch in 2020 (n = 14) contributed 9.8% to the total catch and the number of fish captured; however, 50% of the 2010BY catch consisted of fish entrained from Wanapum Reservoir (n = 7). In total, sampling efforts captured a small proportion (0.3%) of the original 2010BY released in Priest Rapids Reservoir (n = 2,101).
- 2012BY; 2013BY; 2014BY: These three brood years were captured in approximately equal numbers in 2020, with slightly higher numbers of 2013BY captured (n = 34) compared to the 2012BY (n = 29) and 2014BY (n = 27). Entrained fish contributed 64.7% (n = 22 of 34) of the 2013BY catch and 33.3% (n = 9 of 27) of the 2014BY catch. One of the entrained 2013BY was originally released in Wells Reservoir. The 2012BY catch consisted primarily of fish released in Priest Rapids Reservoir and entrained fish contributed only 13.8% (n = 4 of 29) to the total 2012BY catch. The 2013BY fish continued to contribute the greatest proportion to the total catch in Priest Rapids Reservoir.
- 2015BY, 2016BY, 2017BY: As in Wanapum Reservoir, these brood years were released in nearly identical numbers and under similar release conditions (i.e., time of year, size at release). Under the SOA, the proportion of the total release allocated to Priest Rapids was also higher (i.e., ~38% after 2016) than in previous brood year releases (i.e., ~23% before 2016). Overall, only 18 fish were captured from these brood years, and of those, five fish were entrained from Wanapum Reservoir. Of the three brood years originally released in Priest Rapids Reservoir, the 2015BY were more frequently captured (n = 9), which equates to 0.7% of the original release (n = 1,253). Both the 2016BY and 2017BY Priest Rapid releases were infrequently captured.
- 2018BY and 2019BY: Both brood years were detected in low numbers and at levels equal or greater than some earlier brood year releases. Unlike the earlier brood year releases mentioned above, all 2018BY and 2019BY fish captured in 2020 consisted of only fish released in Priest Rapids Reservoir. Given the small number of 2019BY released (n = 261), only incidental capture of this brood year was expected; however, 0.7% of initial release 2019BY (n = 2) was captured and the 2019BY contribution to total catch (1.4%) equaled that of older brood year releases (i.e., 2016BY).

Thirteen White Sturgeon of unknown origin were captured in Priest Rapids Reservoir in 2020. These fish were suspected to be hatchery fish based on scute mark patterns or fin deformities (ranging from mild to severe). Seven of these fish were without PIT tags and were subsequently tagged. Two fish were recaptures that had been previously caught, processed, and added to the field database during previous indexing studies. The remaining four fish had PIT tags; however, these tags were not recorded within the Grant PUD sturgeon database or the PTAGIS regional database. Wild fish and 2002BY were not captured in Priest Rapids Reservoir in 2020.

3.4.3 Catch Rates and Distribution

In total, 333,016 hook-hours of set line sample effort was expended during the 2020 juvenile White Sturgeon indexing program (Table 9). Within each reservoir, sample effort was higher in the lower section of each reservoir due to high wind and wave conditions that delayed retrieval of set lines. In total, weather related delays resulted in 16 set lines in Wanapum Reservoir and 6 set lines in Priest Rapids Reservoir with deployment durations greater than 40-hours. The effect on catch of the extended deployment is uncertain; however, the combined effort of these set lines resulted in the capture of 11 fish in Wanapum Reservoir and 8 fish in Priest Rapids Reservoir. Even though these set lines captured fish, the additional sample effort and relatively low catch likely resulted in lower CPUE estimates for the lower section of each reservoir than would have been estimated if the set lines had been retrieved earlier. Overall, CPUE in the PRPA was 0.19 fish/100 hook-hours, with only slightly higher CPUE recorded in Wanapum Reservoir (0.20 fish/100 hook-hours) than Priest Rapids Reservoir (0.17 fish/100 hook-hours). In both reservoirs, the highest CPUEs were recorded in the upper reservoir section, followed by the middle section, with the lowest CPUEs recorded in the lower section of each reservoir.

Overall, the proportion of set lines that captured one or more fish (Ep) was higher in Wanapum Reservoir (all sections, Ep = 0.60) than in Priest Rapids Reservoir (all sections, Ep = 0.44; Figure 11). In Wanapum Reservoir, Ep tracked with CPUE, with a lower Ep recorded in the lower section (Ep = 0.43; CPUE = 0.08 fish/100 hook-hours) and higher Ep in the middle (Ep = 0.62; CPUE =0.21 fish/100 hook-hours) and upper sections (Ep = 0.73; CPUE = 0.32 fish/100 hook-hours). In Priest Rapids Reservoir, the highest Ep was recorded in the upper reservoir (Ep = 0.50), which corresponded with the highest CPUE (0.30 fish/100 hook-hours). The lowest Ep (Ep = 0.37) was recorded in the middle section, followed by the lower section (Ep = 0.47); however, a higher CPUE was recorded in the middle section (CPUE = 0.09 fish/100 hook-hours) than the lower section (CPUE = 0.04 fish/100 hook-hours) largely due to high capture success of two set lines in the middle section.

Table 9 Total set line sample effort, catch, and CPUE in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.

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	91,251	1	75	0	76	0.001	0.08	0.000	0.08
	Middle	77,357	2	158	0	160	0.003	0.20	0.000	0.21
	Upper	77,518	1	245	2	248	0.001	0.32	0.003	0.32
	all	246,126	4	478	2	484	0.003	0.19	0.001	0.20
Priest Rapids	Lower	32,634	0	28	0	28	0.000	0.09	0.000	0.09
	Middle	28,192	0	37	0	37	0.000	0.13	0.000	0.13
	Upper	26,065	0	78	0	78	0.000	0.30	0.000	0.30
	all	86,891	0	143	0	143	0.000	0.17	0.000	0.17
PRPA	Total	333,016	4	621	2	627	0.001	0.19	0.001	0.19

[1] H-123LAD is the field designation of a YNSH juvenile White Sturgeon reared at the YNSH, produced from brood years in 2010, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019 and released the following year.

[2] 2002BY is the field designation of a CRITFC Hatchery juvenile White Sturgeon reared by the CRITFC from a brood year in 2002 and released in 2003.

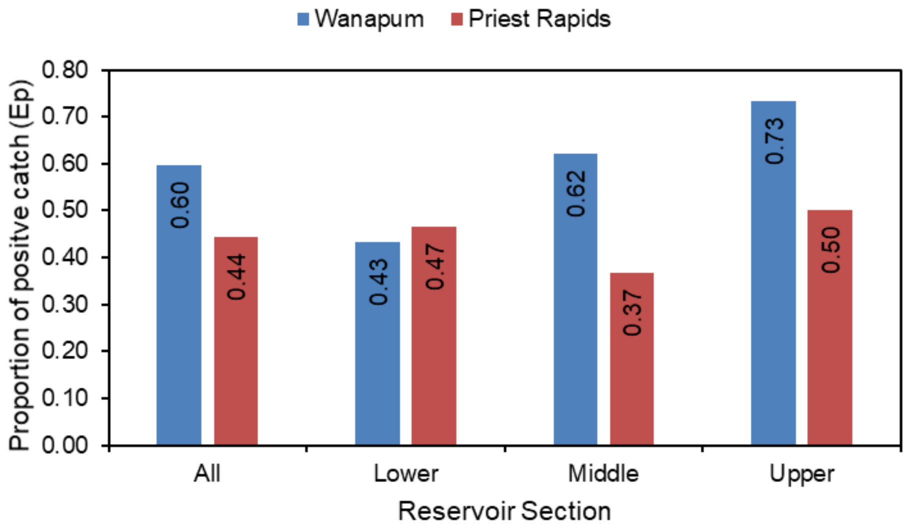

Figure 11 Proportion of positive catches recorded in the Priest Rapids Project area within the lower, middle, and upper section of each reservoir during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.

In Wanapum Reservoir, 109 of the 270 set lines deployed (40.4%) did not catch a fish, with a higher proportion of zero-catch efforts recorded in the lower section of Wanapum Reservoir (56.7%) than in the middle (37.8%) and upper (26.7%) sections of the reservoir (Figure 12). In Priest Rapids Reservoir, 50 of the 90 set lines deployed (55.6%) did not catch a fish, with a higher proportion of zero-catch effort recorded in the middle section (63.3%) than in the lower (53.3%) and upper (50.0%) sections. Due to the aggregatory tendencies of White Sturgeon, a small number of set lines caught a disproportionately high number of fish compared to the overall median catch of one fish per set line for both reservoirs. In Wanapum Reservoir, 3% of set lines deployed (i.e., 8 of 270 set lines) captured between 12 and 20 fish, which contributed 24% to the total catch (i.e., n = 118 of 484 fish). Similarly, in Priest Rapids Reservoir, approximately 3% of the set lines deployed (i.e., 3 of 90 set lines) captured between 10 and 24 fish, which equated to 39% of the total catch (i.e., n = 56 of 143 fish).

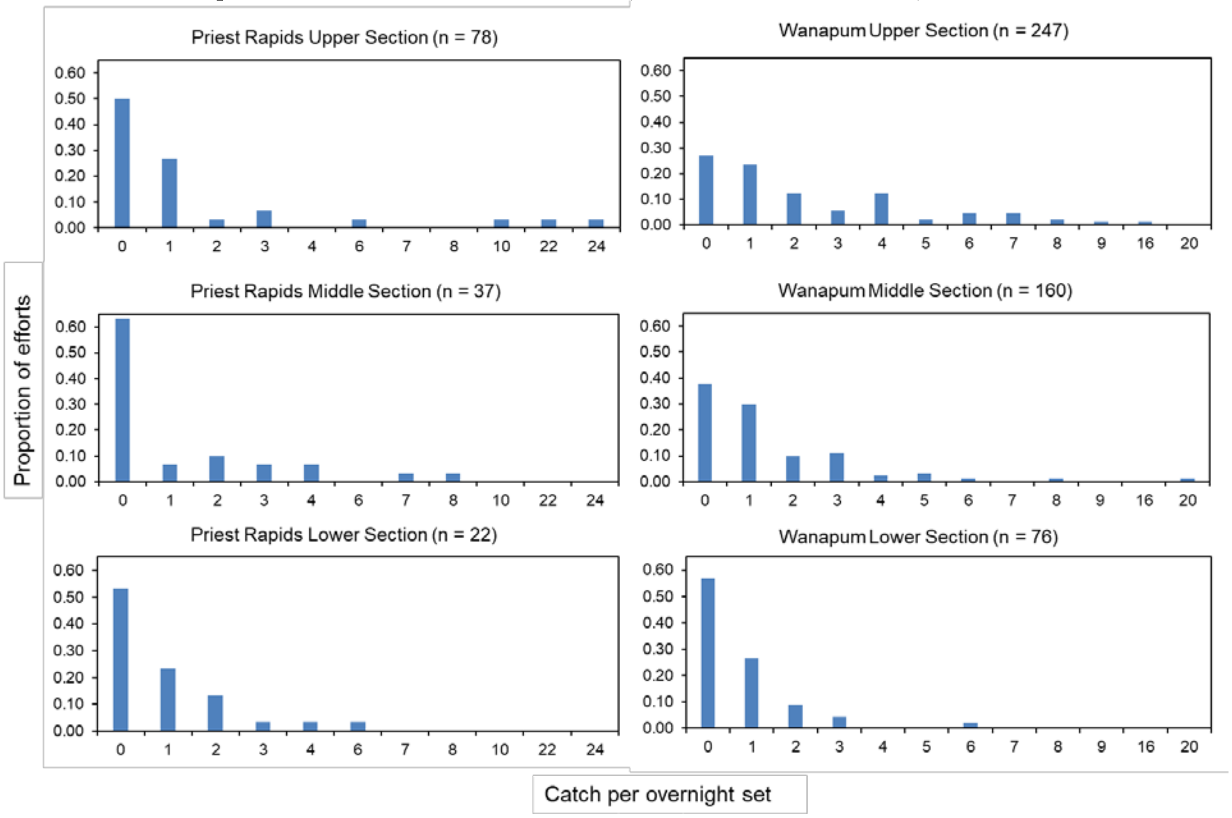

Figure 12 **Frequency histograms of White Sturgeon catch-per-overnight-set in the Priest Rapids Project Area during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.**

The GRTS unstratified unequal probability sample design distributed effort over the geographical area within each reservoir that encompassed the targeted minimum depth sample criteria (i.e., 15 m in Wanapum Reservoir and 6 m in Priest Rapids 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 13). The highest sample effort per river mile was typically in the forebays, where the river was widest. Excluding the immediate forebay area, over the length of each reservoir, sample effort was reduced for a given river mile if habitat within the section of river did not meet the minimum depth criteria. 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. In Wanapum Reservoir, the locations with high catch corresponded to areas that likely provide either suitable holding, rearing, or feeding habitat for White Sturgeon. In Priest Rapids Reservoir, the highest catch was recorded in the tailrace area of Wanapum Dam.

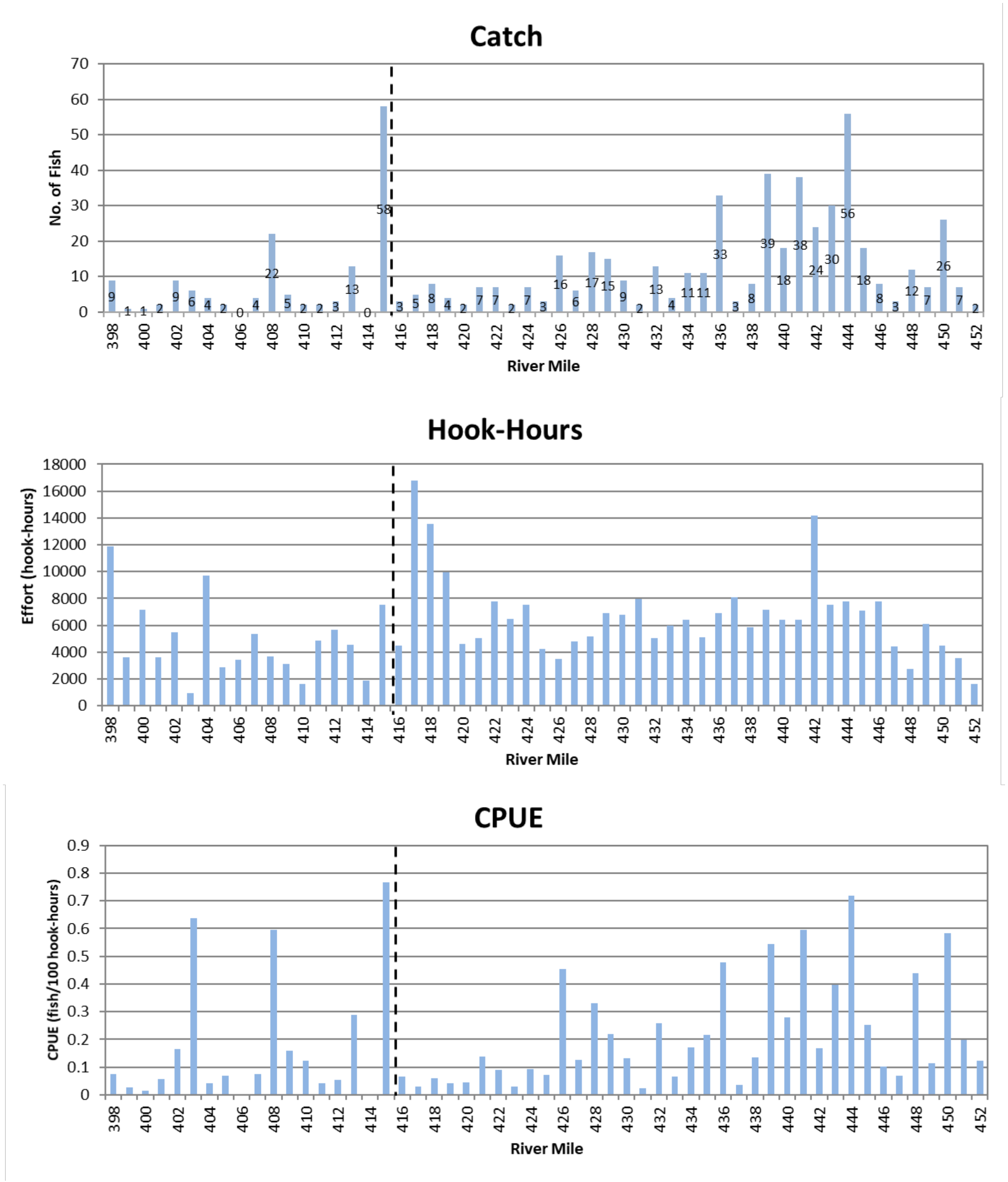

Figure 13 Juvenile White Sturgeon catch, effort, and CPUE distribution by River Mile in the Priest Rapids Project area, during the juvenile White Sturgeon indexing program from August 31 to October 6, 2020. Dash vertical line represents the location of Wanapum Dam.

In Wanapum Reservoir, much higher Eps were recorded for the 2012BY in the upper reservoir section than in the middle and lower sections and suggests a preference for this reservoir section by this brood year (Figure 14). The 2017BY also was captured more often in the upper section of Wanapum Reservoir, but also maintained a presence in the lower section as well. Except for the 2016BY, which was captured more often in the middle section, the highest Eps for all brood year released were recorded in the upper section of Wanapum Reservoir. Out of all the brood year releases, the 2013BY was the most broadly dispersed and captured in moderate numbers in all sections of the reservoir.

In Priest Rapids Reservoir, the highest Eps were recorded in the upper section for the 2010BY and 2012BY, while the 2013BY was more commonly captured in the middle section.
The 2014BY was broadly distributed throughout the reservoir with similar Eps in each reservoir section. Brood years 2015BY and the 2018BY were more common in the lower section of Priest Rapids Reservoir and, although only a few individuals of the younger brood year was captured in 2020, the catch data suggests some use of the lower section of Priest Rapids Reservoir by these age classes.

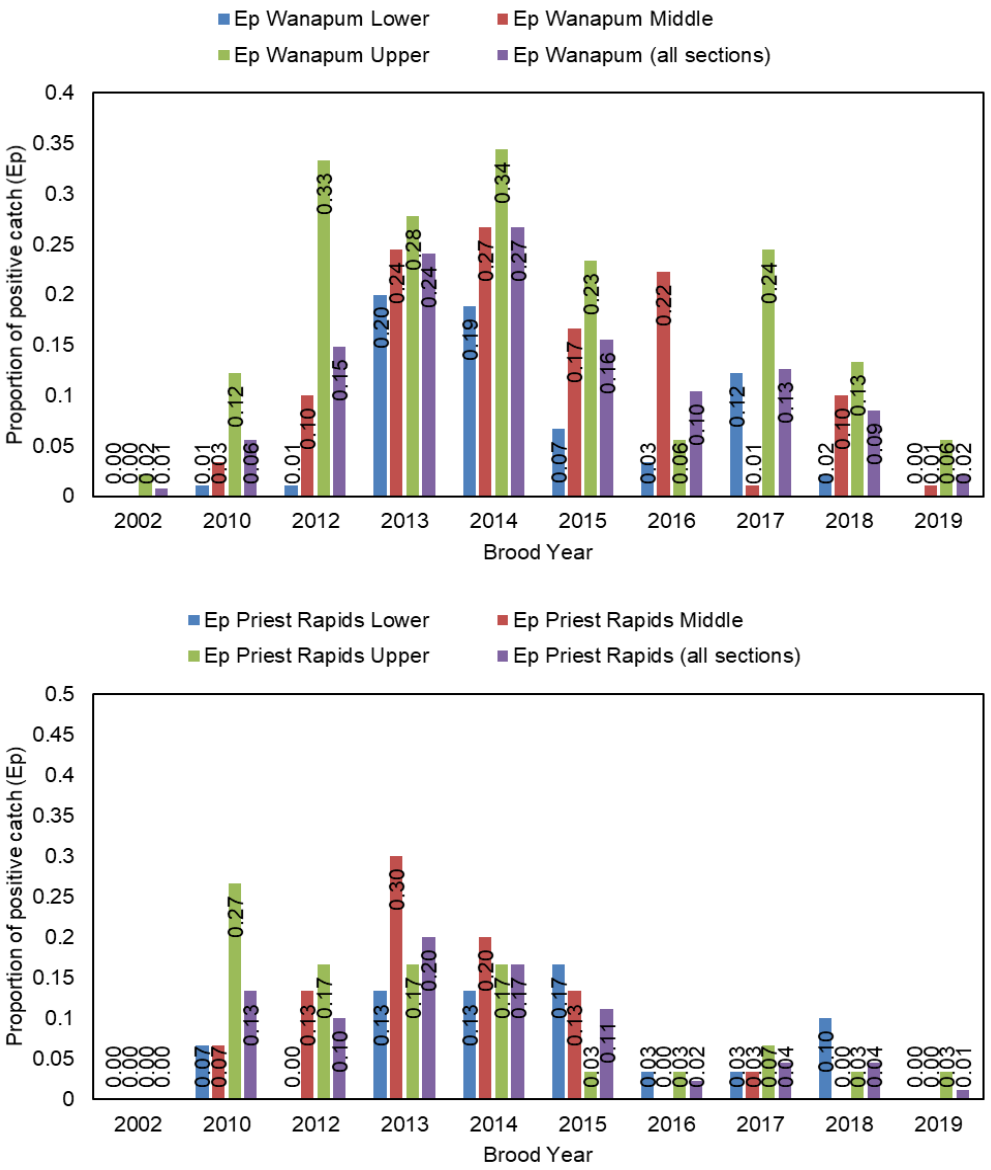

Figure 14 **Proportion of positive catch (Ep) of wild and hatchery White Sturgeon in Wanapum (upper panel) and Priest Rapids (lower panel) reservoirs recorded during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.**

3.4.4 Size, Growth, and Condition

In total, 609 individual White Sturgeon were captured and measured for fork length (FL) during the 2020 juvenile White Sturgeon indexing program in the PRPA. These fish ranged from 34.0 to 118.0 cm FL (mean = 65.9 cm FL; n = 469; Table 10) in Wanapum Reservoir and from 30.0 to 119.0 cm FL (mean = 63.8 cm FL; n = 140) in Priest Rapids Reservoir. In 2020, mean fork length of the 2012BY, 2013BY, and 2014BY was notably larger in Wanapum Reservoir than in Priest Rapids Reservoir (i.e., differences of 8.8, 8.0, and 12.8 cm FL, respectively; t- stat =- 2.6279, $p<0.05$), whereas fork lengths of the 2010BY in the two reservoirs were more similar in mean fork length and range. A similar trend was evident, but less so, in the 2019 catch data and was not evident in the 2018 catch data. The mean fork length of the few (n = 14 fish total) 2016BY to 2019BY captured in Priest Rapid Reservoir was larger than the mean fork length for these brood years in Wanapum Reservoir, but meaningful comparisons were confounded by low catch of these brood years in Priest Rapids Reservoir.

The length-frequency histograms of brood years 2010BY through 2019BY captured in Wanapum and Priest Rapids reservoirs overlapped for fish 30 cm FL and larger (Figure 15). Catch frequency of fish between 40 and 90 cm FL was similar in Wanapum Reservoir (i,e., between 15.1% and 18.8%), with reduced catch frequency of fish smaller and larger than this size range. In Priest Rapids Reservoir, catch frequency of fish between 50 and 60 cm FL was highest (i.e., 31.2%) and greatly exceeded catch frequency of other size classes. Fish less than 40 cm FL were rarely captured in Priest Rapids Reservoir in 2020. As documented in previous studies (Golder 2017-2020), due to differences in growth rate among individuals in a given brood year, fish substantially larger or smaller than the mean fork length of their brood year can be captured for all brood years. As such, length-frequency histograms of almost all brood years released to date overlapped, with the exception of the oldest (i.e., 2010BY) and youngest fish (i.e., 2018BY and 2019BY). A decrease in catch frequency of fish over 90 cm FL, which was more notable in Wanapum Reservoir, 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 10 Fork length (cm) of White Sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020. For individuals captured twice or more during the survey, the fork length recorded during first capture was used.

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	**2**	83.3	10.3	76.0	90.5	-	-	-	-	-	**2**	83.3	10.3	76.0	90.5
Douglas PUD	2013	-	-	-	-	-	**1**	80.0	-	80.0	80.0	**1**	80.0	-	80.0	80.0
Grant PUD	2010	**17**	86.6	19.5	51.5	118.0	**14**	81.7	19.0	54.0	119.0	**31**	84.4	19.1	51.5	119.0
	2012	**62**	70.6	14.8	43.0	99.0	**29**	61.8	11.1	42.0	89.0	**91**	67.8	14.3	42.0	99.0
	2013	**90**	76.4	14.2	43.5	109.0	**30**	68.4	14.3	48.0	100.0	**121**	74.2	14.6	43.5	109.0
	2014	**107**	72.8	11.5	37.5	99.5	**27**	60.0	14.7	40.0	98.0	**134**	70.2	13.2	37.5	99.5
	2015	**61**	63.1	11.2	42.0	88.5	**12**	63.3	13.6	42.0	87.0	**73**	63.2	11.6	42.0	88.5
	2016	**10**	58.0	11.4	46.0	75.0	**2**	62.0	12.7	53.0	71.0	**12**	58.6	11.1	46.0	75.0
	2017	**70**	48.1	7.1	34.5	65.5	**4**	51.0	7.8	45.0	62.0	**74**	48.3	7.1	34.5	65.5
	2018	**25**	39.4	3.3	34.0	47.5	**6**	42.2	6.2	30.0	48.0	**31**	39.9	4.1	30.0	48.0
	2019	**7**	42.4	4.3	37.0	49.5	**2**	42.5	7.8	37.0	48.0	**9**	42.4	4.6	37.0	49.5
Unknown[1]	Unknown	**14**	61.9	16.8	37.0	88.0	**13**	63.5	10.1	41.0	76.0	**27**	62.6	13.8	37.0	88.0
Wild	Wild	**4**	70.1	22.3	41.5	94.0	-	-	-	-	-	**4**	70.1	22.3	41.5	94.0
All Sturgeon	All	**469**	65.9	17.2	34.0	118.0	**140**	63.8	15.6	30.0	119.0	**609**	65.4	16.9	30.0	119.0

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

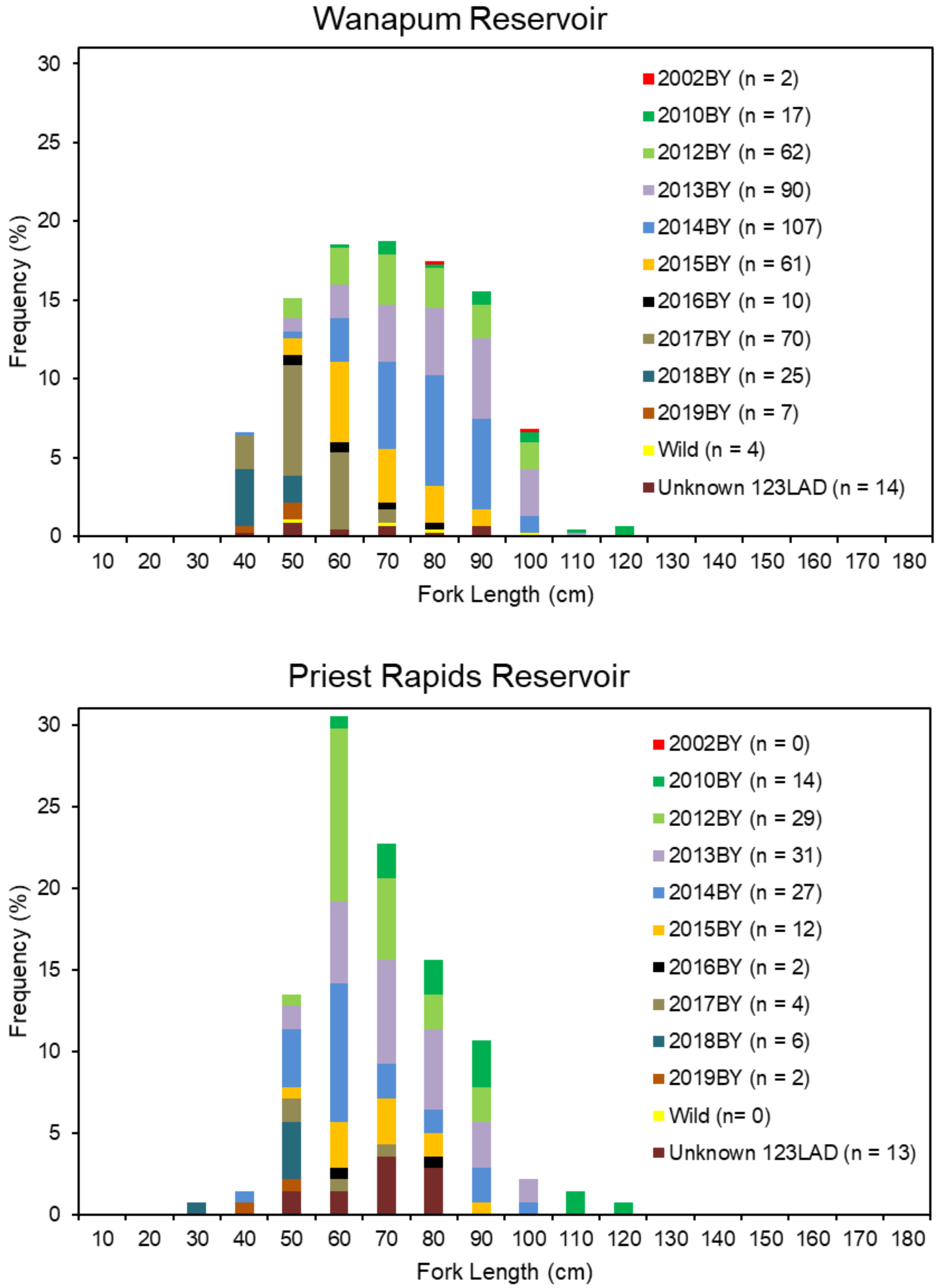

Figure 15 **Length-frequency distribution by brood year for hatchery White Sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.**

In Wanapum Reservoir, fish weight ranged from 195 to 12,200 g (mean = 2,454 g; n = 467). In Priest Rapids Reservoir, the lowest-weight fish captured was 280 g and the largest was 13,250 g (mean = 2,164 g; n = 139; Table 11). Similar to the trend recorded in fork length, the mean weights of the 2012BY, 2013BY, and 2014BY were lower in Priest Rapids Reservoir than weights for the corresponding brood years in Wanapum Reservoir. Similar numbers of 2010BY were captured in each reservoir and these two groups were similar in mean weight and range of weight. Although few 2015BY through 2019BY fish were captured in Priest Rapids, the mean weights of these fish were larger in Priest Rapids Reservoir than in Wanapum Reservoir, although the low catch prevents meaningful comparisons.

Table 11 Weight (g) of White Sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.

Program	Brood Year	Wanapum					Priest Rapids					All				
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
CRITFC	2002	**2**	4,625	368	4,365	4,885	-	-	-	-	-	**2**	4,625	368	4,365	4,885
Douglas PUD	2013	-	-	-	-	-	**1**	4,750	-	4,750	4,750	**1**	4,750	-	4,750	4,750
Grant PUD	2010	**17**	5,248	3,383	750	12,200	**14**	4,515	3,592	920	13,250	**31**	4,917	3,440	750	13,250
	2012	**62**	2,720	1,844	485	7,155	**29**	1,650	977	700	4,780	**91**	2,379	1,689	485	7,155
	2013	**89**	3,773	2,068	515	9,140	**31**	2,635	2,051	780	10,100	**120**	3,479	2,115	515	10,100
	2014	**107**	2,906	1,411	405	6,755	**26**	1,667	1,331	520	5,720	**133**	2,664	1,475	405	6,755
	2015	**61**	1,846	1,080	485	5,330	**12**	2,173	1,390	740	4,840	**73**	1,900	1,132	485	5,330
	2016	**10**	1,462	931	595	3,035	**2**	1,530	863	920	2,140	**12**	1,473	882	595	3,035
	2017	**69**	723	376	195	1,915	**4**	925	547	520	1,720	**74**	736	383	195	1,915
	2018	**25**	402	143	240	850	**5**	636	82	560	740	**30**	441	161	240	850
	2019	**7**	394	121	250	625	**2**	440	226	280	600	**9**	404	133	250	625
Unknown[1]	Unknown	**14**	2,084	1,747	295	5,320	**13**	1,773	658	800	2,750	**27**	1,934	1,323	295	5,320
Wild	Wild	**4**	3,240	2,762	405	6,810		-	-	-	-	**4**	3,240	2,762	405	6,810
All Sturgeon	All	**467**	2,454	1,982	195	12,200	**139**	2,164	1,950	280	13,250	**606**	2,387	1,977	195	13,250

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

Annual growth rate was calculated for each brood year based on the difference in fork length between release and capture, divided by the time at large (Table 12). For all brood years, growth rate decreases by more than 50% after one full year at large and then remained 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 approximately eight years after release. Higher annual growth was recorded in Wanapum Reservoir compared to Priest Rapids Reservoir for the 2010BY (6.3 cm/year Wanapum Reservoir; 5.6 cm/year Priest Rapids Reservoir), 2012BY (5.6 cm/year Wanapum Reservoir; 4.5 cm/year Priest Rapids Reservoir), 2013BY (7.6 cm/year Wanapum Reservoir; 6.4 cm/year Priest Rapids Reservoir), and 2014BY (7.4 cm/year Wanapum

Reservoir; 5.5 cm/year Priest Rapids Reservoir). Younger brood years continue to exhibit rapid growth in both reservoirs, with the highest growth rates associated with the 2019BY in both Wanapum Reservoir (27.1 cm/year; n = 7) and Priest Rapids Reservoirs (23.4 cm/year; n = 2) since their release on July 23 and subsequent capture in September (0.2 years).

Table 12 **Time at large (years) and growth, expressed as change in fork length (FL; cm) and growth rate (FL; cm·y^{-1}), for YNSH fish captured during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.**

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	Grant PUD	2010	**17**	9.4	0.0	9.4	9.4	59.3	21.5	21.5	93.0	6.3	2.3	2.3	9.9
		2012	**62**	7.4	0.0	7.3	7.4	41.1	15.4	11.5	70.6	5.6	2.1	1.6	9.6
		2013	**90**	6.3	0.1	6.0	6.4	48.2	15.8	13.6	85.2	7.6	2.5	2.1	13.4
		2014	**107**	5.4	0.0	5.3	5.4	41.5	11.5	9.7	65.7	7.7	2.1	1.8	12.2
		2015	**61**	4.4	0.0	4.4	4.4	32.5	11.7	9.6	59.3	7.4	2.7	2.2	13.5
		2016	**10**	3.4	0.0	3.4	3.4	31.6	9.9	17.9	47.9	9.3	3.0	5.3	14.3
		2017	**70**	2.4	0.0	2.3	2.4	19.7	8.3	5.2	56.6	8.2	3.5	2.2	24.1
		2018	**25**	1.4	0.0	1.3	1.4	12.4	4.6	2.4	22.5	9.1	3.3	1.7	16.4
		2019	**7**	0.2	0.0	0.1	0.2	4.4	1.1	2.0	5.2	27.1	6.2	14.0	32.2
Priest Rapids	Douglas PUD	2013	**1**	5.42	-	5.42	5.42	49.9	-	49.9	49.9	9.2	-	9.2	9.2
Priest	Grant PUD	2010	**14**	9.4	0.0	9.4	9.5	52.7	20.1	27.0	93.0	5.6	2.1	2.9	9.9
		2012	**29**	7.4	0.0	7.4	7.4	33.2	11.6	10.2	61.4	4.5	1.6	1.4	8.3
		2013	**31**	6.4	0.1	6.0	6.4	40.8	13.4	25.0	70.6	6.4	2.2	3.9	11.8
		2014	**27**	5.4	0.0	5.3	5.4	29.7	14.6	11.1	66.2	5.5	2.7	2.0	12.4
		2015	**12**	4.4	0.0	4.3	4.4	32.6	13.0	13.2	53.7	7.4	3.0	3.0	12.3
		2016	**2**	3.4	0.0	3.4	3.4	34.0	15.9	22.7	45.2	10.0	4.8	6.6	13.4
		2017	**4**	2.4	0.0	2.3	2.4	24.2	11.5	12.9	39.3	10.2	5.0	5.3	16.8
		2018	**6**	1.4	0.0	1.3	1.4	15.1	7.4	0.5	20.2	11.0	5.4	0.4	15.0
		2019	**2**	0.2	0.0	0.2	0.2	4.8	0.8	4.2	5.4	23.4	4.1	20.4	26.3
All	Grant PUD	2010	31	9.4	0.0	9.4	9.5	56.3	20.8	21.5	93.0	6.0	2.2	2.3	9.9
		2012	91	7.4	0.0	7.3	7.4	38.6	14.7	10.2	70.6	5.2	2.0	1.4	9.6
		2013	121	6.3	0.1	6.0	6.4	46.3	15.5	13.6	85.2	7.3	2.5	2.1	13.4
		2014	134	5.4	0.0	5.3	5.4	39.1	13.0	9.7	66.2	7.3	2.4	1.8	12.4
		2015	73	4.4	0.0	4.3	4.4	32.5	11.8	9.6	59.3	7.4	2.7	2.2	13.5
		2016	12	3.4	0.0	3.4	3.4	32.0	10.2	17.9	47.9	9.5	3.1	5.3	14.3
		2017	74	2.4	0.0	2.3	2.4	19.9	8.5	5.2	56.6	8.3	3.6	2.2	24.1
		2018	31	1.4	0.0	1.3	1.4	12.9	5.2	0.5	22.5	9.4	3.8	0.4	16.4
		2019	9	0.2	0.0	0.1	0.2	4.5	1.0	2.0	5.4	26.3	5.8	14.0	32.2

Overall (all brood years combined), growth rate was higher in Wanapum Reservoir than in Priest Rapids Reservoir. Relationships between log^{10} FL and log^{10} weight were highly significant and regression slope parameter estimates for Wanapum Reservoir (slope = 3.3) were greater than estimates for Priest Rapids Reservoir (slope = 3.0; Figure 16). Relative weight was slightly lower in Wanapum Reservoir (mean = 93%; n = 446) and ranged from 41% to 168%, compared to Priest Rapids Reservoir (mean = 95%; n = 124), with a range of 65% to 153% (Figure 17). In Wanapum Reservoir, a greater proportion of the 2010BY, 2012BY, 2017BY, and 2019BY had lower relative weight in relation to their estimated standard weight based on fork length (Ws; Beamesderfer 1993). In Priest Rapids Reservoir, lower relative weight was also evident in a greater proportion of the 2010BY and 2012BY compared to other brood years (Figure 18).

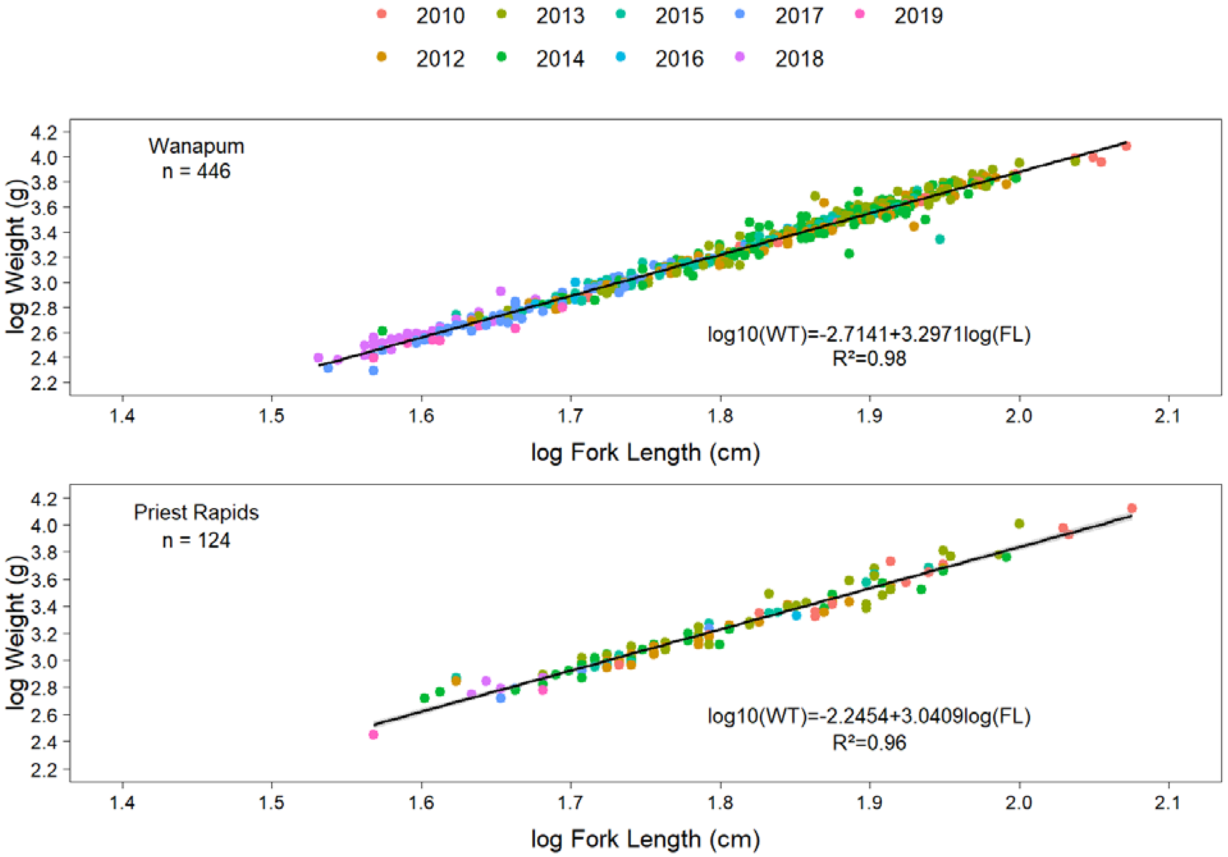

Figure 16 Linear regression of log10 fork length and log10 weight for hatchery juvenile White Sturgeon of each brood year captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.

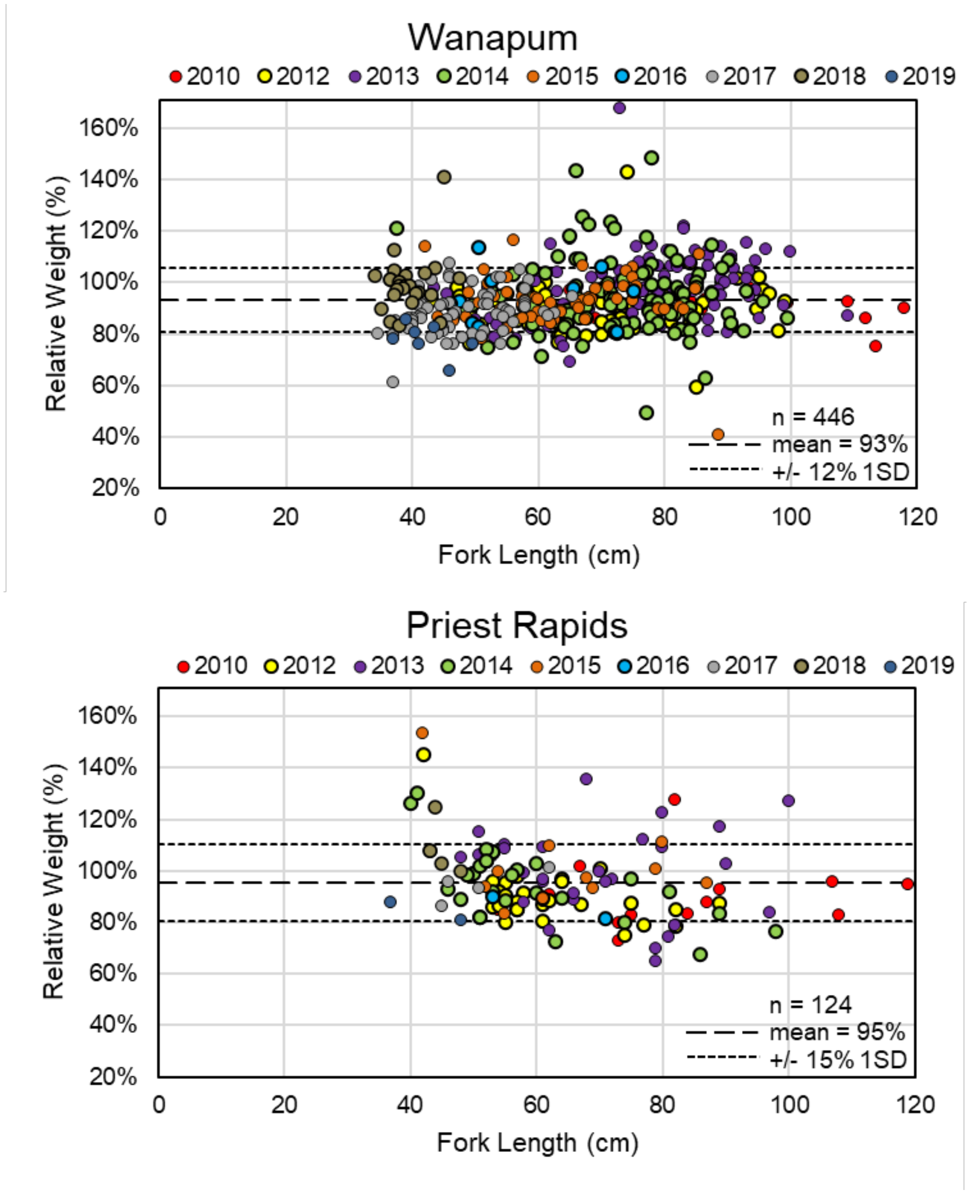

Figure 17 **Combined relative weight and fork length relationship for hatchery juvenile White Sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.**

Figure 18 **Relative weight and fork length relationship for each brood year of hatchery juvenile White Sturgeon of captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020. The black horizon line denotes the overall mean relative weight of White Sturgeon (94%) for the Project area in 2020.**

3.4.5 Assessment of Density Dependent Growth

In the analysis of fish growth, brood year was found to be a significant predictor of growth (*P*<0.001). The combined PRPA population of hatchery-reared sturgeon did not exhibit clear signs of density-dependent growth (Figure 19). While the 2010BY generally had the highest growth of the early brood years, and while the 2012BY had depressed growth in comparison, later brood years (2013BY, 2014BY, and 2015BY) had growth rates that fell between those of 2010BY and 2012BY, and were nearly identical. This suggests no overall decreasing trend in growth as more fish are released in the PRPA. The later brood years analyzed (2016BY and 2017BY) appear to have growth rates similar to 2015BY.

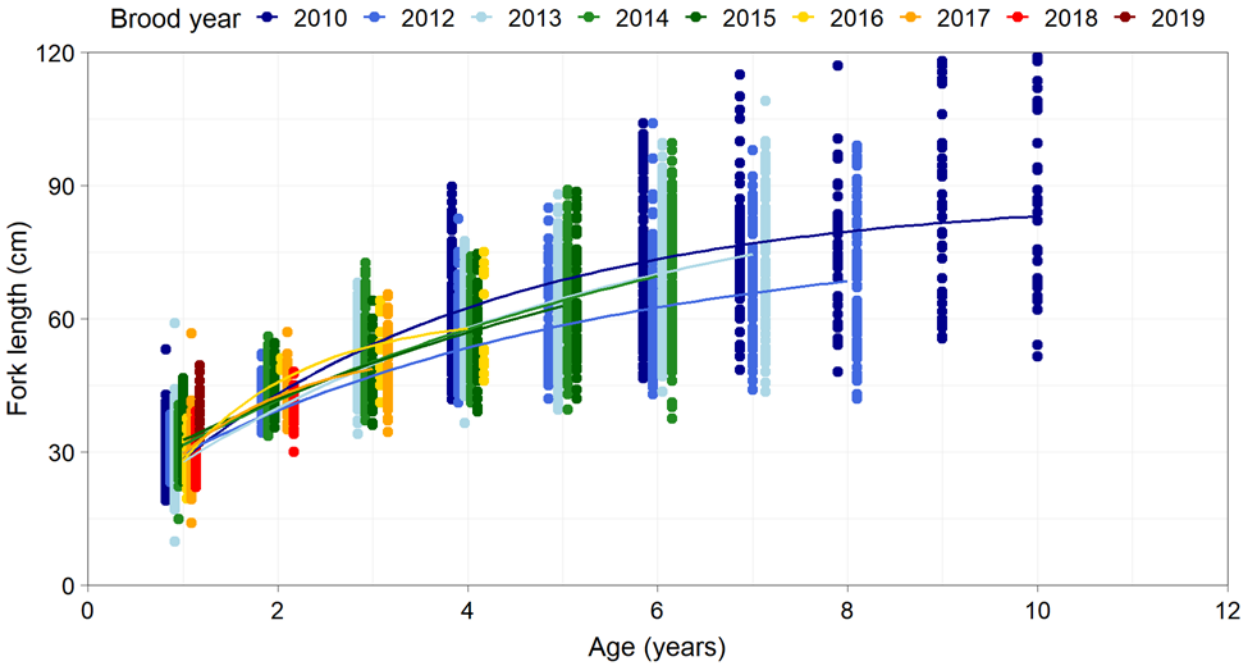

Figure 19 **Estimated growth of hatchery juvenile White Sturgeon by brood year of all fish released in the Project area.**

When the brood-year-specific models were fit to data separated by release reservoir, brood year was also found to be a significant predictor of growth (*P*<0.001 for both Wanapum and Priest Rapids reservoirs). In Wanapum Reservoir, 2010BY had the highest growth rate (Figure 20), similar to the combined PRPA model. However, the growth rates of 2013BY and 2014BY were very similar to that of 2010BY, generally suggesting no overall decreasing trend in growth as more fish are released into Wanapum Reservoir. The 2016-2019BY need to be sampled for several more years before their growth curves can be better evaluated.

Growth differed from fish released in Wanapum Reservoir and fish released in Priest Rapids Reservoir. Fish released in Priest Rapids Reservoir had plateaued growth earlier (e.g., 2010BY growth slowed down by age-6 in Priest Rapids Reservoir but did not slowdown in Wanapum Reservoir). In Priest Rapids Reservoir, 2010BY also had the highest growth rate, followed by 2012BY, 2013BY, and 2015BY. In comparison, 2014BY had the lowest growth rate, estimated to reach only 56 cm by age-6, whereas 2010BY were estimated to reach 76 cm by the same age. While the curve for 2016BY was estimated to be similar to that of 2010BY, it was influenced by a single 2016BY fish caught at age-4. More recaptures are required to better evaluate the growth rate of this brood year. Overall, in Priest Rapids Reservoir, differences in growth were observed between brood years, and it is not currently understood whether density-dependent growth reduction is occurring. Once growth of the younger brood years (2016BY-2019BY) can be assessed, it will become clearer whether the slow growth of 2014BY is also seen in the younger brood years or whether it was a single brood year affected by factors other than sturgeon density.

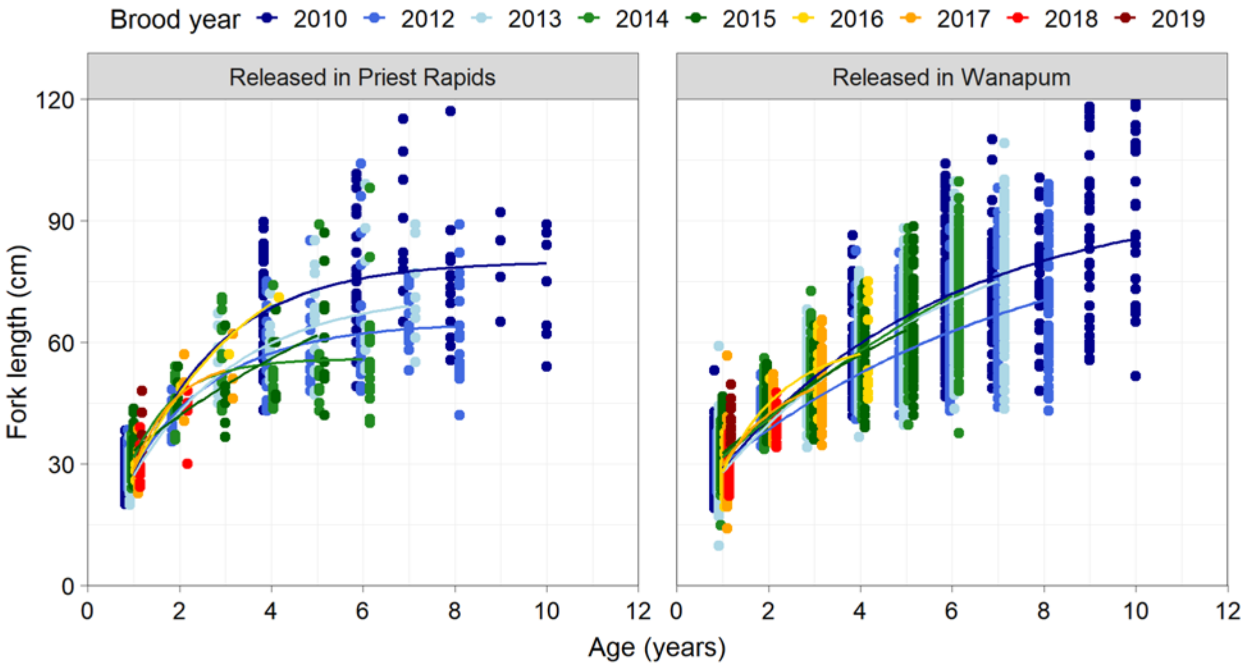

Figure 20 **Estimated growth of hatchery juvenile White Sturgeon by brood year, within each release reservoir.**

In the analysis of fish growth, reservoir of release was found to be a significant predictor of growth (*P*<0.001), whereas the reservoir of recapture was not (*P*=0.9; Figure 21). Thus, for fish released in Wanapum Reservoir, there was no significant difference in growth between fish that remained in Wanapum Reservoir and fish that were entrained into Priest Rapids Reservoir. Conversely, a significant difference was found between fish released in Priest Rapids Reservoir and those released in Wanapum Reservoir. Overall, fish released in Priest Rapids Reservoir slowed their growth earlier than those released in Wanapum Reservoir, resulting in smaller lengths attained – for example, 69 cm vs. 77 cm at age-8, and 71 cm vs. 83 cm at age-10.

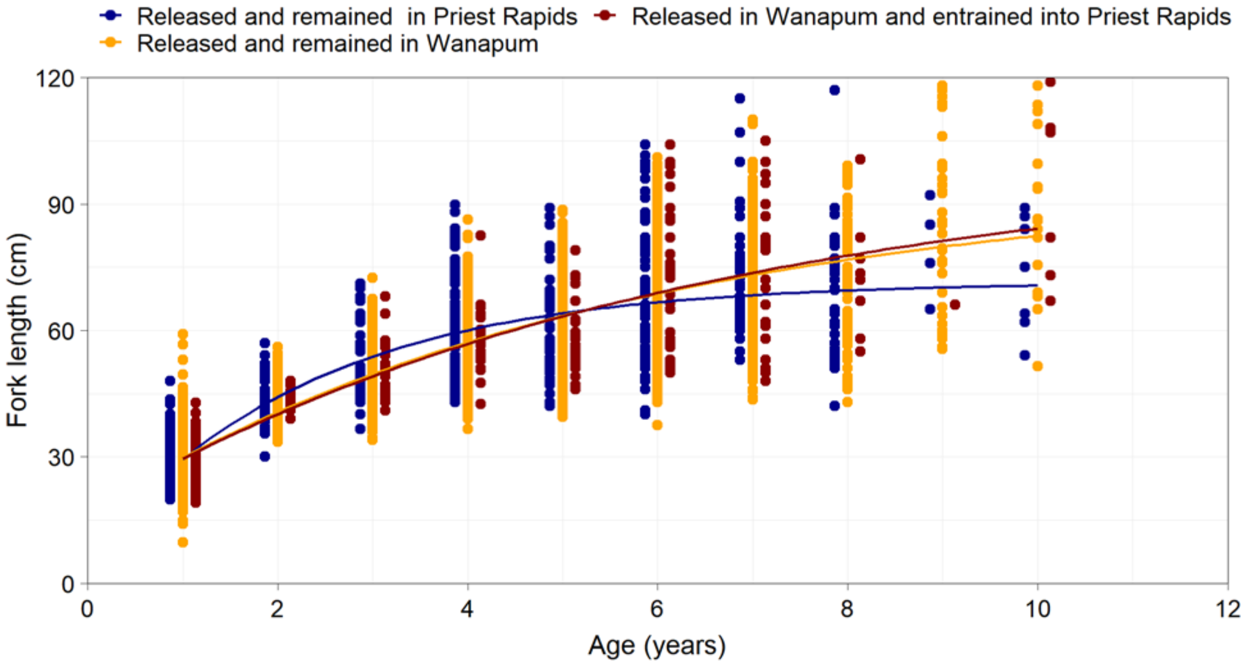

Figure 21 **Estimated growth of hatchery juvenile White Sturgeon by reservoir of release and recapture.**

3.4.1 Gear Performance

In total, 92 gangions (11.5% of the Wanapum Reservoir gear inventory) were lost and/or damaged in Wanapum Reservoir, with approximately equal numbers of 2/0 and 4/0 hooks (Table 13). Lost hooks, where the leader broke or the gangion detached from the set line, represented less than 1% (3 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 = 10,800 gangions fished) was 0.9%.

Gear was lost in Priest Rapids Reservoir at a slightly higher rate than in Wanapum Reservoir, with 61 of the 400 hooks (15.3%) damaged. Approximately equal numbers of 2/0 and 4/0 hooks were damaged. Lost hooks represented 1% (n = 4 of 400 hooks) of the gear allotment for Priest Rapids Reservoir. Lost and damaged hooks in relation to the number of hooks deployed in Priest Rapids Reservoir over the study (n = 3,599 gangions fished) was 1.7%.

The 4/0 hook size caught 57% of the catch (n = 276 of 484 fish) in Wanapum Reservoir and 62% of the catch (n = 88 of 143 fish) in Priest Rapids Reservoir. The catch size range was similar for both hook sizes; however, the mean catch of the 4/0 hooks was higher in each reservoir and indicates that the 4/0 hooks were marginally more effective in the capture of larger fish (Table 14).

Table 13 **Hook rate and overall gangion damage in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.**

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**	5,400	400	47	1	48	0.9	12.0
	4/0	5,400	400	42	2	44	0.8	11.0
Total		10,800	800	89	3	92	0.9	11.5
Priest Rapids	**2/0**	1,800	200	27	2	29	1.6	14.5
	4/0	1,799	200	30	2	32	1.8	16.0
Total		3,599	400	57	4	61	1.7	15.3
PRPA		14,399	1,200	146	7	153	1.1	12.8

Table 14 **White Sturgeon catch by hook size in the Priest Rapids Project Area during the juvenile White Sturgeon indexing program, August 31 to October 6, 2020.**

Reservoir	Hook Size	Catch	Fork Length (cm)			
		n	Mean	SD	Min	Max
Wanapum	2/0	208	63.9	16.7	34.0	113.5
	4/0	276	67.5	17.2	34.5	118.0
Priest Rapids	2/0	55	59.1	12.6	37.0	89.0
	4/0	88	66.8	16.6	30.0	119.0

3.4.2 Hatchery Juvenile White Sturgeon Abundance Estimates

Capture success during the 2020 juvenile White Sturgeon indexing program was sufficient to construct a set of Cormack-Jolly-Seber models to estimate survival and recapture probabilities of juvenile hatchery White Sturgeon released in Priest Rapids and Wanapum reservoirs. Of the 18 models constructed, 14 converged and were used to calculate model-averaged values of recapture and survival estimates. Of these 14 models, 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 age (as a categorical variable) and release reservoir. The weighting for this model was 1.0, indicating no support for other models.

For all brood years, mean survival estimates were lower in the first year post-release than in subsequent years at large (Figure 22; Table 15). Survival in the first year post-release was generally similar for 2010BY-2015BY, with mean estimates ranging between 0.268 and 0.342, and had low uncertainty (95% confidence intervals equaling 13%-30% of the mean).

Survival of 2016BY was estimated to be much lower, at 0.070, followed by an increase for 2017BY-2018BY, with mean values of 0.449 and 0.300, respectively. Survival in all subsequent years was generally similar between all brood years except for 2016BY, with mean estimates ranging from 0.916 (2015BY) to 0.960 (2017BY) and with low uncertainty (95% confidence intervals equaling 6%-11% of the mean). The 2016BY had a much lower survival in all subsequent years, estimated at 0.692, with higher uncertainty (95% confidence intervals equaling 33% of the mean).

Recapture probabilities generally increased with fish age and began decreasing once fish reached approximately age-7, although the decrease was less pronounced in Priest Rapids Reservoir (Figure 23; Table 16). Overall, recapture probabilities in Wanapum Reservoir were two to three 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 2020 (Figure 24; Table 17). 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 24). From 2015 (for Priest Rapids Reservoir) and 2016 (for Wanapum Reservoir) to 2019, the estimated population abundance of hatchery White Sturgeon in each reservoir remained steady, followed by a decline between 2019 and 2020, when only 672 fish were released into the PRPA, which was not sufficient to compensate for the mortality of previously released fish. With the release of the 2019BY, the 2020 hatchery fish abundance estimate in Wanapum Reservoir was 6,190 fish (95% CI = 4,878–7,502) or 22.5% of total hatchery releases to date (n = 27,544 fish). In Priest Rapids Reservoir, the 2020 hatchery fish abundance estimate was 2,759 fish (95% CI = 2,203– 3,315) or 23.6% of total hatchery releases to date (n = 11,707 fish).

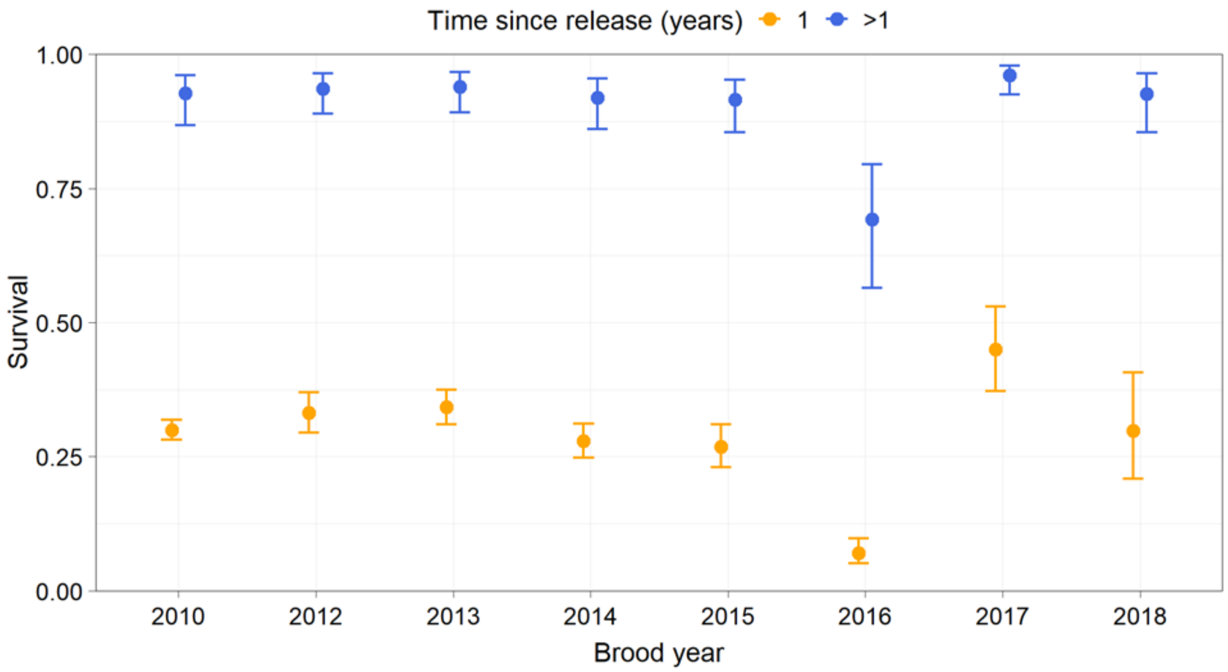

Figure 22 Estimated survival of hatchery juvenile White Sturgeon by brood year, and age class (i.e., first year post-release or in any subsequent year combined).

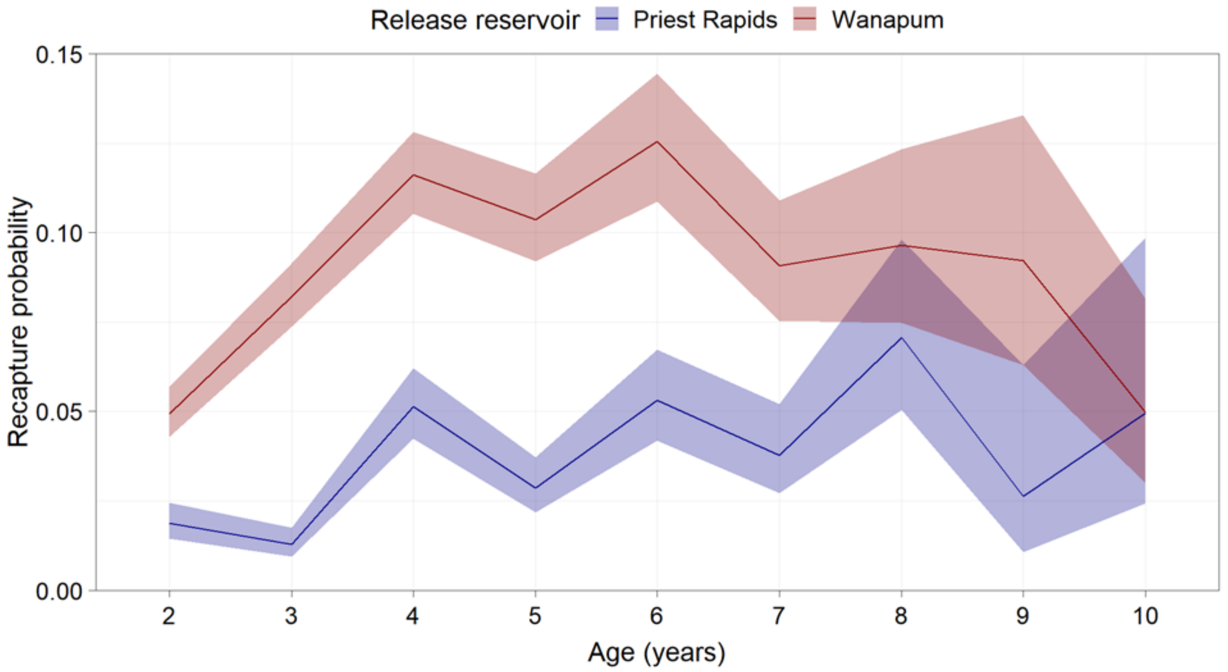

Figure 23 Estimated probability of recapture of hatchery juvenile White Sturgeon by age and release reservoir.

Table 15 **Cormack-Jolly-Seber model estimates of annual survival parameters for hatchery juvenile White Sturgeon in Priest Rapids and Wanapum reservoirs.**

Parameter	Mean survival (95% confidence interval
2010BY-First year post-release	0.300 (0.281-0.319)
2010BY-All subsequent years	0.927 (0.867-0.961)
2012BY-First year post-release	0.331 (0.295-0.369)
2012BY-All subsequent years	0.936 (0.889-0.964)
2013BY-First year post-release	0.342 (0.311-0.375)
2013BY-All subsequent years	0.939 (0.892-0.966)
2014BY-First year post-release	0.278 (0.248-0.311)
2014BY-All subsequent years	0.919 (0.861-0.955)
2015BY-First year post-release	0.268 (0.23-0.31)
2015BY-All subsequent years	0.916 (0.854-0.953)
2016BY-First year post-release	0.07 (0.05-0.098)
2016BY-All subsequent years	0.692 (0.565-0.795)
2017BY-First year post-release	0.449 (0.372-0.529)
2017BY-All subsequent years	0.96 (0.925-0.979)
2018BY-First year post-release	0.298 (0.208-0.407)
2018BY-All subsequent years	0.926 (0.854-0.964)

Table 16 **Cormack-Jolly-Seber model estimates of annual recapture parameters for hatchery juvenile White Sturgeon in Priest Rapids and Wanapum reservoirs.**

Age (years)	Mean recapture rate (95% confidence interval)	
	Priest Rapids	Wanapum
2	0.019 (0.014-0.024)	0.049 (0.043-0.057)
3	0.013 (0.009-0.018)	0.082 (0.074-0.091)
4	0.051 (0.042-0.062)	0.116 (0.105-0.128)
5	0.029 (0.022-0.037)	0.104 (0.092-0.117)
6	0.053 (0.042-0.067)	0.126 (0.109-0.144)
7	0.038 (0.027-0.052)	0.091 (0.075-0.109)
8	0.071 (0.050-0.098)	0.096 (0.075-0.123)
9	0.026 (0.011-0.063)	0.092 (0.063-0.133)
10	0.050 (0.024-0.099)	0.050 (0.030-0.081)

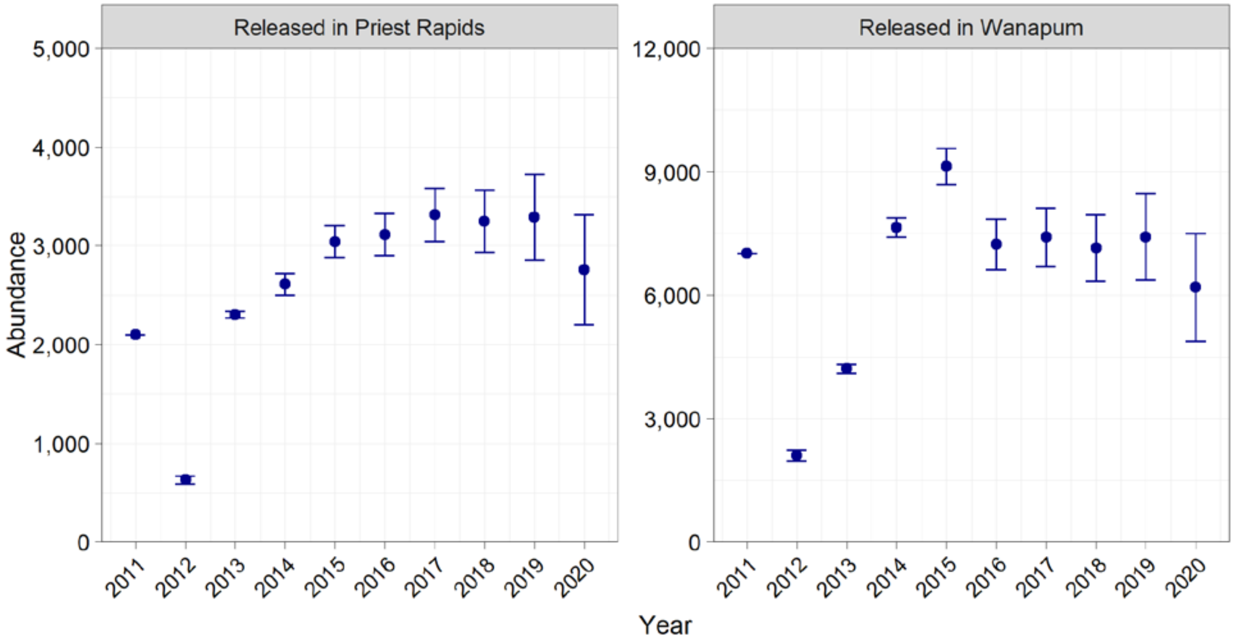

Figure 24 Estimated abundance of hatchery juvenile White Sturgeon (based on survival of 2010BY to 2018BY releases) by calendar year for Wanapum and Priest Rapids reservoirs, 2011 to 2020.

Table 17 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 2020.

	Calendar Year									
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Pool	**Abundance Estimate (95% CI)**									
Wanapum	**7,015** (7,015 – 7,015)	**2,102** (1,970 – 2,234)	**4,212** (4,102 – 4,323)	**7,647** (7,409 – 7,884)	**9,123** (8,680 – 9,566)	**7,241** (6,625 – 7,857)	**7,405** (6,696 – 8,115)	**7,143** (6,334 – 7,953)	**7,417** (6,373 – 8,460)	**6,190** (4,878 – 7,502)
Annual Hatchery Release No.	7,015	0	2,264	5,092	5,007	2,005	1,999	1,983	1,767	411
Cumulative Release No.	7,015	7,015	9,279	14,371	19,378	21,383	23,382	25,365	27,132	27,543
Priest Rapids	**2,101** (2,101 – 2,101)	**629** (590 - 669)	**2,300** (2,267 – 2,334)	**2,609** (2,499 – 2,719)	**3,041** (2,878 – 3,204)	**3,113** (2,901 – 3,325)	**3,317** (3,048 – 3,585)	**3,248** (2,934 – 3,563)	**3,291** (2,855 – 3,726)	**2,759** (2,203 – 3,315)
Annual Hatchery Release No.	2,101	0	1,717	1,500	1,495	1,253	1,249	1,241	890	261
Cumulative Release No.	2,101	2,101	3,818	5,319	6,814	8,067	9,316	10,566	11,446	11,707

The estimated abundance values reported above were calculated by release reservoir. Throughout the Project, a total of 137 fish entrained from Wanapum Reservoir into Priest Rapids Reservoir, and a single fish was recorded to move from Priest Rapids Reservoir to Wanapum Reservoir (i.e., via fish ladders), where it was captured in 2016. To account for the movement between the two reservoirs, and to estimate abundance by reservoir (rather than by reservoir of release), an average entrainment value was calculated. For each sampling year, the cumulative number of fish that were recaptured in a reservoir that differed from their release reservoir was calculated. The proportion of fish that changed reservoirs (whether entrained from Wanapum Reservoir into Priest Rapids Reservoir or moved upstream from Priest Rapids Reservoir into Wanapum Reservoir) was then applied to the abundance estimates developed above. The proportion of fish entrained was subtracted from Wanapum Reservoir estimates and added to Priest Rapids Reservoir estimate. The proportion of fish that moved upstream was subtracted from Priest Rapids Reservoir estimate and added to the Wanapum Reservoir estimates. As a result, abundance estimates decreased for Wanapum Reservoir (Figure 25). For example, in 2020, the abundance estimate that was based on release only was 6,190 fish (95% CI of 4,878-7,502), while accounting for movement between the reservoirs decreased this estimate to 5,843 fish (95% CI of 4,605–7,082). On the other hand, accounting for movement between reservoirs resulted in a mirroring increase in Priest Rapids Reservoir estimates. For example, in 2020, the abundance estimate that was based on release only was 2,759 fish (95% CI of 2,203–3,315), while accounting for movement between the reservoirs increased this estimate to 3,105 (95% CI of 2,475–3,734).

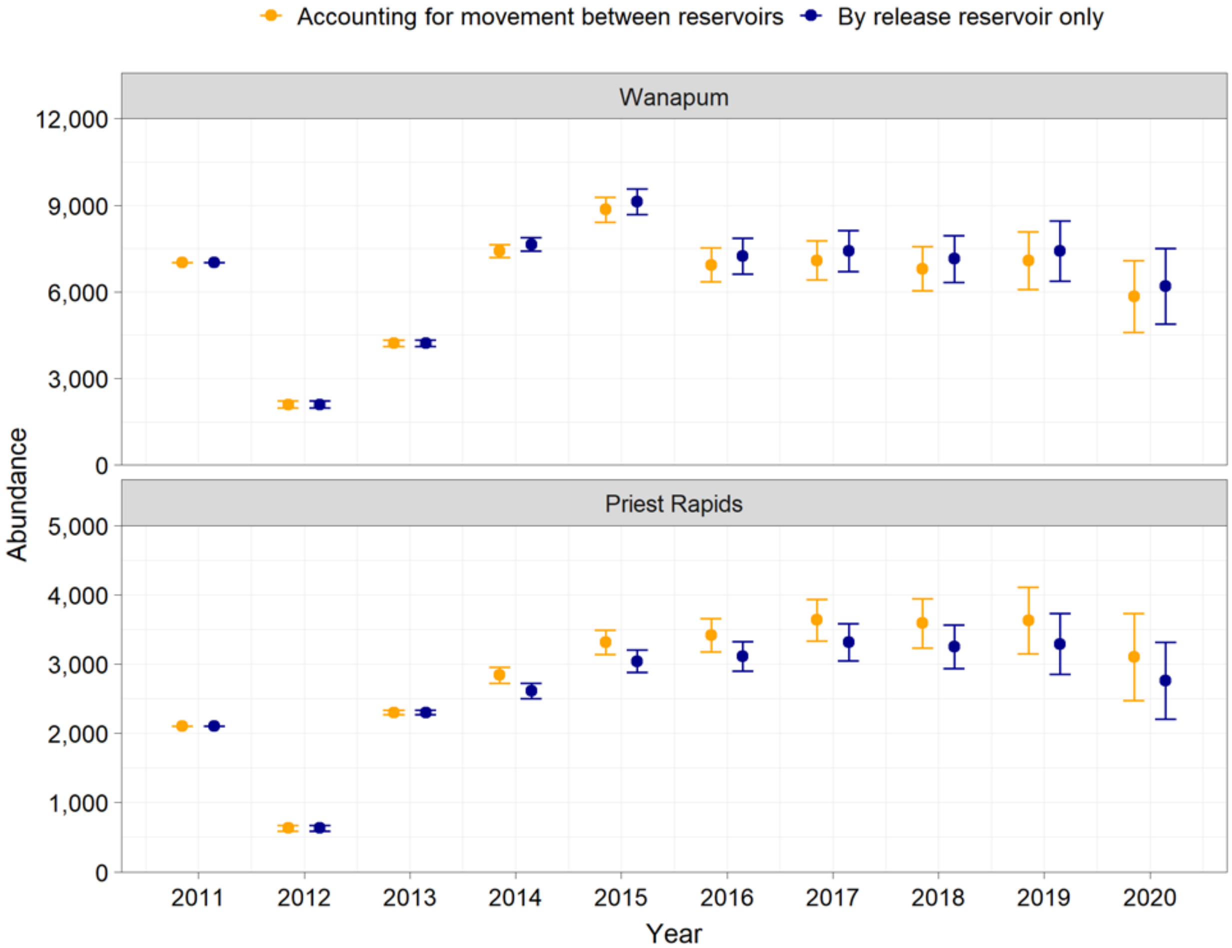

Figure 25 **Estimated abundance of hatchery juvenile White Sturgeon (based on survival of 2010BY to 2018BY releases) by calendar year for Wanapum and Priest Rapids reservoirs, from 2011 to 2020, comparing abundance by release reservoir and abundance accounting for movement between reservoirs.**

4.0 Discussion

The following sections provide a discussion of the 2020 (FERC License Year 13) M&E program results for the PRPA in context with previous study results. In 2020, activities included the tagging and release of 2019BY juvenile White Sturgeon, an assessment of White Sturgeon natural spawning, and juvenile White Sturgeon population indexing.

4.1 Discharge and Temperature

Monthly total discharge volumes in May, June, and July were above average in 2020, with peak freshet discharge volume of 22,648 kilo-acre feet (KAF) compared to the peak average discharge volume of 19,648 KAF in the Project area from 2010 to 2019 (Figure 26). Freshet flows in 2020 were protracted and peak flows occurred slightly later than the peak of the historical average discharge. Indicative of a high flow year, the 2020 water temperature tracked lower than the 2010-2019 average water temperature from mid-May to early August. Peak water temperature was attained by September and was only slightly lower than the 2010-2019 average (Figure 27). Potentially, the higher discharge regime and cooler water temperatures in the spring and summer may have affected the results of study components conducted during this period (i.e., spawning assessment, 2019BY release) compared to other similar studies conducted in an average flow year. During juvenile indexing in the late summer and fall of 2020, mean monthly total discharge volume and mean month water temperature were consistent with the 2010-2019 average and likely did not have a substantial effect on the study results.

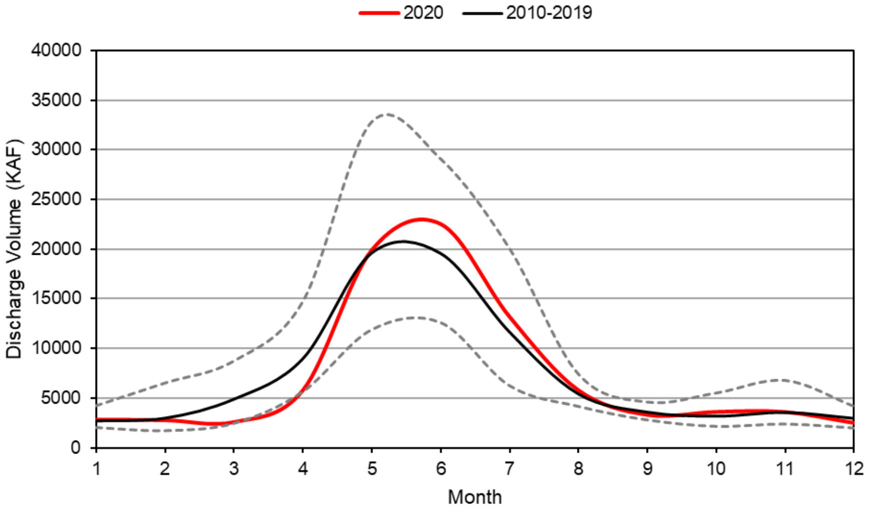

Figure 26 **The 2020 mean monthly discharge volume (red line) in comparison with the 10-year average (black line) and minimum and maximum (dashed line) of mean monthly discharge in the Project area from 2010 to 2019, as recorded at Rock Island Dam.**

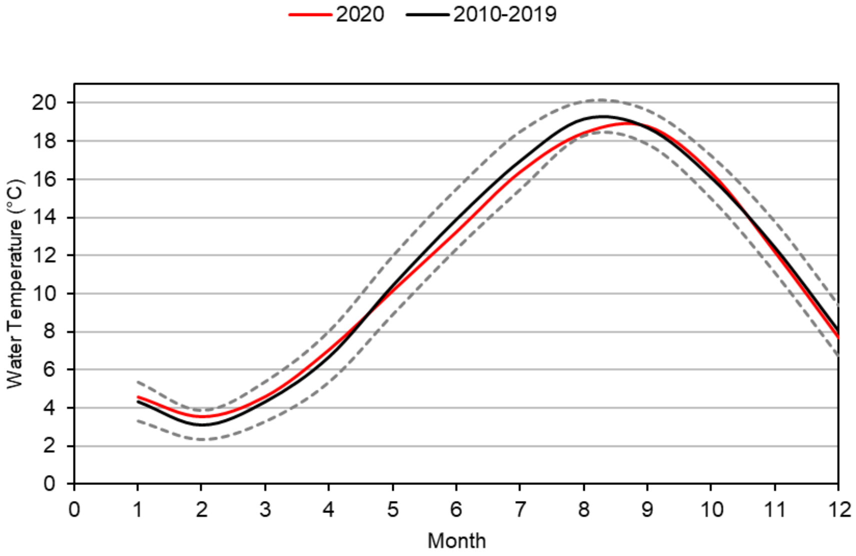

Figure 27 **The 2020 mean monthly water temperature (red line) in comparison with the 10-year average (black line) and standard deviation (dashed line) of mean monthly water temperature in the Project area from 2010 to 2019, as recorded at Rock Island Dam.**

4.2 Juvenile White Sturgeon Processing and Release (2019BY)

Due to COVID-19, tagging and marking of the 2019BY was delayed until July 7, 2020, whereas brood tagging efforts in previous study years were typically completed by mid-April of the release year. Consequently, the mean fork length (35.5 cm) and weight (288 g) of the 2019BY at tagging was substantially greater than the combined average of all brood year hatchery fish released to date (29.0 cm FL and 159 g; Table 18). These fish were likely larger when released on July 23 after the 16-day post-tagging recovery period. The length and weight of fish at the time of their release may be a variable that influences post-release survival, in that smaller fish may experience higher rates of predation and higher post-release mortality than larger fish. In terms of size at release, the 2019BY were comparable to a genetic family of the 2010BY (i.e., the 2010BY LCC; see Table 18) and a similar survival rate would be expected for the 2019BY if size at release affects survival. However, due to limited data, survival estimates specific to this genetic family of 2010BY are not available (Golder 2012, Golder 2013). Survival of the 2019BY released in 2020 was assumed to be similar or slightly higher than previous brood year releases based on their larger size at release and the capture of moderate numbers of this brood year during 2020 juvenile index sampling (i.e., 9 of 672 fish released in the Project area).

During tagging of the 2019BY, fin deformities were observed and recorded in 97% of fish (n = 654 of 672). This fin deformity rate was substantially higher than the 2018BY (31%) released in 2019. Intra-specific aggression (chewing fins) and mechanical damage during the early stages of rearing have been assumed as the likely cause of these deformities (Golder 2017). As discussed in previous reports, 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 (Golder 2018). These capture data suggest that fin deformities do not appear to 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 18 Summary by brood year of hatchery White Sturgeon juveniles released in the Project area.

							Fork Length (cm)		Weight (g)	
Brood Year	**Reservoir**	**Release Location**	**River Mile**	**Brood Source**	**Release Date**	**Number Released[4]**	**Mean**	**SD**	**Mean**	**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 Apr 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	--	5,092 (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**
2019	Wanapum	Frenchman Coulee	424.5	MCW	23-Jul-20	411 (0)	35.8	5.3	292	107
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	23-Jul-20	261 (0)	35.1	5.0	282	104
				Total 2019		**672 (0)**	**35.5**	**5.2**	**288**	**106**
				Total 2010-2019		**39,250 (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] In years applicable, brackets indicated the number of fish in a release group that were implanted with acoustic tags.

4.3 Spawn Monitoring and *in situ* Egg Incubation

Evidence of White Sturgeon spawning activity below Rock Island Dam was obtained during the 2020 spawn monitoring program with the collection of 1613 eggs. Three individual spawning events were identified in 2020 based on the date of egg capture, egg developmental stage, and water temperature at the time of capture. Daily inspection of the egg collection mats allowed the collection of early-stage eggs, approximately on the day they were spawned, which facilitated the identification of new spawning events. If the inspection interval had been longer (e.g., a 48-hour interval), identification of new spawning events would have been more difficult as time of spawning estimates based on eggs in later developmental stages (e.g., greater than 24 hours) are less reliable. Daily inspections also allowed necessary repairs to sampling gear that was frequently damaged by high flows during the 2020 survey. Spawn monitoring was conducted under similar high flow conditions in 2010 (Golder 2011a) and 2013 (Golder 2014) and sampling gear during these studies was also frequently damaged or lost. Most of the sampling effort during the 2010 and 2013 studies was conducted in late June and July when flows were lower; however, sampling effort in 2020 was maintained through the high flow period. High flows and greater than anticipated water depths reduced the number of mid-channel sets deployed in 2020 compared to previous studies; however, the number of shore-based sample sites established along the left bank, where most of the eggs were previously captured (Golder 2016), exceeded all previous study years.

Spawn monitoring began on June 22 based on the assumption that peak spawning would start in late June (Golder 2011a, 2014, and 2016). This assumption was correct, and the first spawning event was detected on June 26, which was the same date spawning was first detected in 2010 (Table 19). Except for 2015, which was a low flow year, the onset of spawning has occurred between June 26 and June 30 each year (i.e., five of the six study years) that spawning was assessed. The cues that initiate White Sturgeon spawning below Rock Island are unclear. Previous studies speculated that in a “typical” flow year, the onset of spawning is initiated by a rapid increase in total river discharge (Golder 2011a). The 2020 data appears to support this hypothesis. However, in a low flow year, such as 2015, when flows were very low, spawning still initiated in late June (i.e., June 20) and suggests that photoperiod may also be a potential spawning cue. Previous studies identified a multiple spawning events in July each year. Given that the hydrograph and water temperatures in 2020 were similar to 2010 and 2013, July spawning likely would have also been detected in 2020 had monitoring continued beyond July 2 (Figure 28).

Incubation success of wild spawned eggs within the incubator could not be assessed in 2020 as most of the eggs were captured near the end of the monitoring program and insufficient time was available for the eggs to develop and hatch. Furthermore, water temperature, which affects egg development rate, was at the low end of the optimal temperature range for egg development (i.e., 14°C, Wang et al. 1985), which slowed egg development. The incubator, however, performed as expected and allowed suspension of egg-ladened mat material, which reduced handling time, the risk of desiccation, and potential mechanical damage associated with manual removal of eggs from the mat material. Loose eggs that were incubated with the bioballs that lined the bottom of the incubator may potentially have high survival and hatch success, but hatch success is difficult to quantify with this system. Incubation cassettes, which have high egg hatch success (Golder 2011b), suspended in the incubator would allow hatch success to be estimated, and may be a reliable proxy. The use of incubation cassettes would require small numbers of eggs to be manually removed from the egg collection mats.

Table 19 The number and date of White Sturgeon spawning events in Wanapum Reservoir below Rock Island Dam in 2000, 2002, 2010, 2013, 2015 and 2020.

Spawning Event Number	2000	2002	2010	2013	2015[1]	2020[1]
1	29-30 June	27-28 June	26 June	29 June	20 June	26 June
2	1-2 July	29 June	29 June	4 July	21 June	27 June
3	9-10 July	30 June	8 July	5 July	22 June	28 June
4	13 July	5 July	10 July	7 July	26 June	
5	23-24 July	15-17 July	11 July 7:52	8 July	27 June	
6		19 July	14 July	10 July	28 June	
7					29 June	

[1] Assessments were not conducted in July

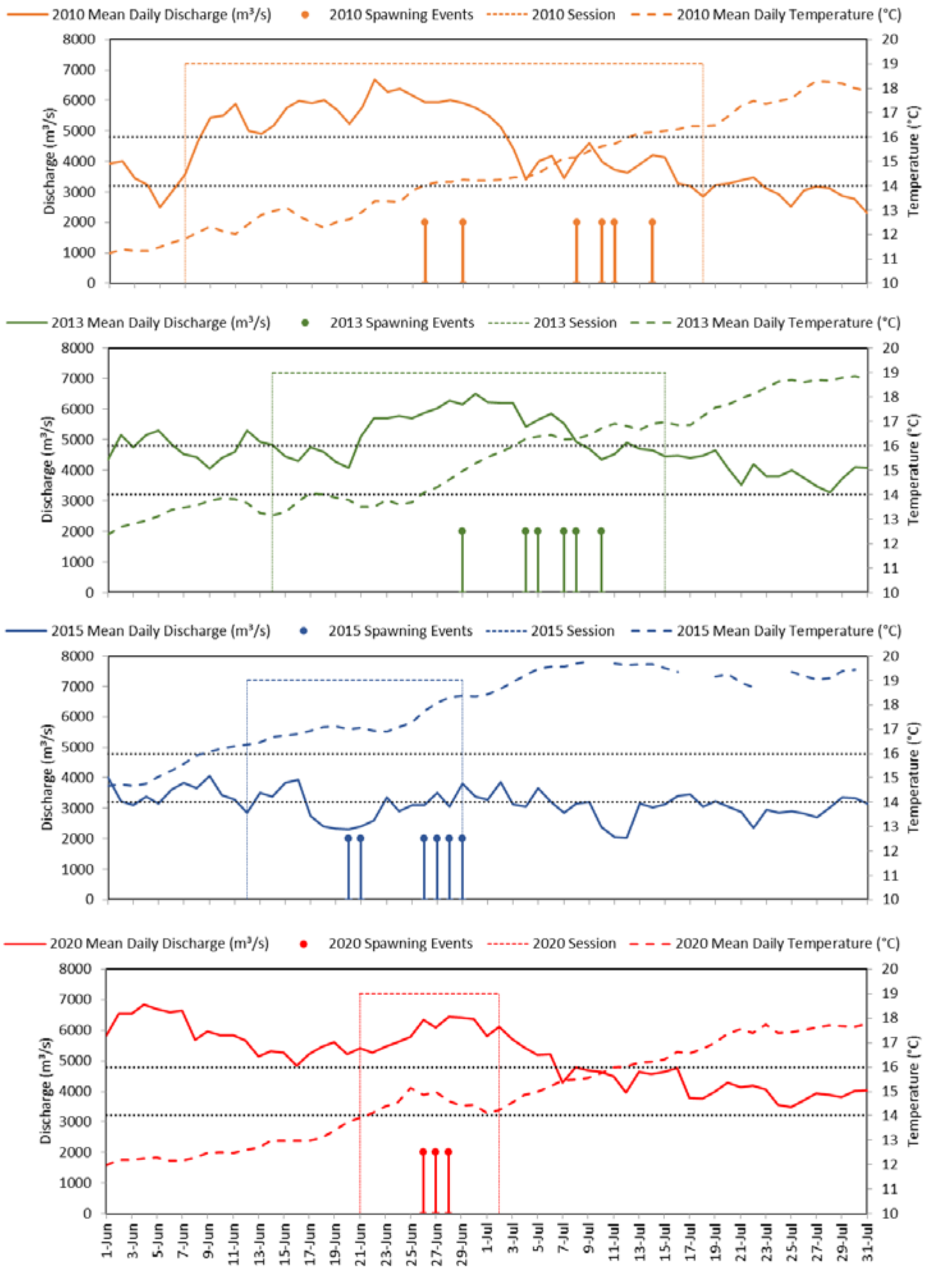

Figure 28 **White Sturgeon spawning events recorded in the upper section of Wanapum Reservoir below Rock Island Dam, in relation to discharge and water temperature, during spawning assessments conducted in 2010, 2013, 2015, and 2020. Dotted horizontal lines denote the water temperature rate for optimal White Sturgeon egg development.**

4.4 Juvenile Indexing Sampling Effort and Catch

The 2020 juvenile White Sturgeon population indexing study design and sample effort was consistent with previous indexing studies conducted annually since 2016. This consistency could make it easier in future study years to identify environmental variables that affect the abundance and distribution of the juvenile White Sturgeon in the PRPA. Since the start of systematic indexing in 2016, 3,284 White Sturgeon have been captured in the PRPA, consisting of 3,175 fish from the 2010BY to 2019BY, 81 fish from the 2002BY, and 28 wild fish (Table 20). The reduction in catch after 2016 was partially attributed to removal efforts conducted in the lower and middle sections of each reservoir to catch and remove the 2002BY, with a large proportion of the effort conduct in late fall 2016 after the 2016 index program. One unforeseen consequence of the removal effort was the loss of larger individuals from other brood years and the wild population that were within the slot limit range set for the removal effort (Golder 2018). Unlike previous assessments, hatchery fish initially released into Rocky Reach Reservoir were not recorded in the PRPA in 2020.

The total number of White Sturgeon captured in Wanapum Reservoir in 2020 (n = 484) was similar to the number of fish captured during previous study years. Catch in Wanapum Reservoir decreased in 2020 compared to 2019, but was similar to the catch results in 2017 and 2018. The 2020 catch in Wanapum Reservoir potentially could have been higher, but a high proportion of the set lines in the lower section of Wanapum Reservoir did not catch fish (“no catch”; 56.7%), which was higher compared to set lines with no catch in previous indexing studies in 2017 (47.8%), 2018 (45.6%), and 2019 (38.9%) in the lower section. The reduced catch in the lower section in 2020 may have, in part, been related to high wind days that delayed retrieval of 16 set lines, resulting in some sets being deployed for more than 40 hours. In total, 11 fish were caught on these set lines, with two set lines catching two fish and seven set lines catching one fish; five set lines had no catch. These set lines may have potentially caught more fish, but catch was possibly reduced due to the prolonged set duration that allowed fish more time to escape. Generally, windy and wavy conditions during sampling of the lower reservoir section may have also affected deployment of the set lines, as most would have been set with prevailing wind direction (i.e., instead of river current), but the effect on catch is unknown. Since the start of systematic indexing in 2016, 2740 White Sturgeon have been captured in Wanapum Reservoir, consisting of 2641 fish from 2010BY to 2019BY, 72 fish from 2002BY, and 27 wild fish.

Table 20 **White Sturgeon catch by reservoir in the Priest Rapids Project area during juvenile White Sturgeon indexing conducted from 2016 to 2020.**

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
2020	484	143	627
All Years	**2,740**	**544**	**3,284**

The 2020 total catch in Priest Rapids Reservoir (n = 143) exceeded the previous highest annual catch. Consistent with previous indexing studies, the highest densities of White Sturgeon were captured in the Wanapum Dam tailrace area. Three set lines in the Wanapum Dam tailrace area captured 39% of the total catch in Priest Rapids Reservoir (n = 56 of 143 fish). Catch per set line at other sample sites in each of the reservoir sections was low, with 50% or more of the set lines not catching fish. Similar to Wanapum, high wind and waves hampered sampling in the lower section of Priest Rapids Reservoir and six set lines were deployed for more than 40 hours. Since the start of systematic indexing in 2016, 544 White Sturgeon have been captured in Priest Rapids Reservoir, consisting of 534 fish from 2010BY to 2019BY, 9 fish from 2002BY, and 1 wild fish.

4.4.1 Catch Distribution by Brood Year and Reservoir

Wanapum Reservoir

In 2020, the 2014BY contributed the largest portion of the catch in Wanapum Reservoir (24%; n = 116 of 484 fish), followed by the 2013BY that contributed a slightly lower proportion of the total catch (19%; n = 90 of 484 fish). This result is inconsistent with previous indexing studies. During previous studies, the 2013BY were consistently captured in greater numbers than other brood years. In 2017, the 2013BY contributed 41% of the total catch. In each subsequent year, this proportion decreased; 38% in 2018, 29% in 2019, and 19% in 2020. This decrease in catch proportion was likely due to a gradual reduction in catchability as the 2013BY increased in size. Conversely, the catch proportion of the 2014BY increased gradually, with catch proportions of 21% in 2017, 22% in 2018, and 23% in 2019. Based on the 2013BY and 2014BY catch results over time, catchability of a given brood year of juvenile White Sturgeon tends to increase sharply after 2.5 years at large and peaks at approximately 4.5 to 5.5 years at large, after which, catchability gradually decreases. Catchability of the older brood years (e.g., 2010BY through 2013BY) was likely lower due to reduced effectiveness of the small hook set line gear to capture these older, larger fish (i.e., greater ability to bend and straighten hooks).

The 2015BY, 2016BY, and 2017BY, which were released in nearly identical numbers, contributed similar proportions to the total catch in 2019 (2015BY n = 42; 2016BY n = 10; 2017BY n = 60) and in 2020 (2015BY n = 62; 2016BY n = 10; 2017BY = 72) and these proportions likely reflect their relative abundance in Wanapum Reservoir. Based on change in catch since release, both the 2015BY and 2017BY recruited to the juvenile indexing gear from between 1.5 years to 2.5 years at large. Even though they are younger and smaller, the 2017BY have been consistently captured in greater numbers than the 2015BY and have the highest first year post-release survival rate of all brood years (0.449). Conversely, the 2016BY have the lowest first year post-release survival rate (0.07) of all brood years. The 2016BY were detected in low numbers in 2020 and in similar catch proportions as previous indexing studies. The low abundance of the 2016BY in Wanapum Reservoir potentially indicates low post-release survival or high emigration out of the Project area (Golder 2020).

Between 2017 and 2019, the proportion of positive catch (Ep) of Wanapum Reservoir varied between a low of 0.62 in 2017, 0.65 in 2018, and a high of 0.70 in 2019. Consistent in each year, the highest Ep was recorded in the middle section (0.69 in 2017; 0.73 in 2018; 0.76 in 2019), slightly lower Ep in the upper section (0.66 in 2017; 0.68 in 2018; 0.73 in 2019), and the lowest in the lower section (0.52 in 2017; 0.54 in 2018; 0.61 in 2019). These changes in Ep were generally mirrored by similar changes recorded in CPUE in each reservoir section. In 2020, the overall Ep recorded in Wanapum Reservoir was lower than all previous study years (Ep = 0.60), with substantially lower Eps in the lower (Ep = 0.43) and middle sections (Ep = 0.62) compared to Eps recorded in these sections in previous studies. The highest Ep was recorded of the upper reservoir section in 2020 (Ep = 0.73). The low Eps in the lower and middle sections of Wanapum were partially attributed to poor sampling conditions and a possible shift in the distribution of sturgeon to the upper section of the reservoir. Prior to 2020, the Ep of the 2010BY, 2012BY, and 2017BY was highest in the upper section, whereas the Eps of the other brood years were higher in the middle and/or lower sections. In 2020, nearly all brood years had higher Eps recorded in the upper section compared to the middle and downstream sections. Additional catch data in future indexing studies will confirm whether this change in White Sturgeon distribution in Wanapum Reservoir was either a transient change associated with environmental conditions, specific to 2020, or indicative of a long-term shift in fish distribution.

Priest Rapids Reservoir

Compared to Wanapum Reservoir, fewer fish are captured in Priest Rapids Reservoir as 2/3 less sample effort is expended in Priest Rapids Reservoir and approximately 2/3 fewer fish are released in Priest Rapids Reservoir. However, relative abundance among brood years within Priest Rapids Reservoir would be expected to align with trends observed in Wanapum Reservoir and any substantial deviation in trends may relate to different environmental conditions between the two reservoir that could affect survival and abundance. As documented in previous indexing studies (Golder 2020), a substantial proportion of the fish captured in Priest Rapids Reservoir were entrained from upstream reservoirs (e.g.,Wanapum Reservoir).

In Priest Rapids Reservoir, the 2020 catch (n = 143) was greater than the 2017 (n = 78), 2018 (n = 109 fish), and 2019 (n = 73) catches and slightly exceeded the previous highest catch recorded in 2016 (n = 141). Even though total catch has varied considerably among study years, the catch proportion among brood years has remained consistent. In 2016, the 2010BY were captured in the highest catch proportion of all brood years. After the 2002BY removal effort in 2015 and 2016, which likely also captured some 2010BY fish, the 2013BY were the predominant brood year in the catch composition in 2017 (25%; n = 20 of 78 fish), 2018 (29%; n = 32 of 109 fish), 2019 (26%; n = 19 of 78 fish) and 2020 (24%; n = 34 of 143 fish) with all other brood years individually contributing 21% or less to the catch. Consistent catch proportions of the 2012BY and the 2014BY, with slightly higher numbers of the 2012BY than the 2014BY captured, were recorded each year in 2017, 2018, 2019, and 2020. With continued growth, the older brood years will become less susceptible to capture and catch proportion among brood years will likely change in future studies.

In all previous indexing studies, Priest Rapids Reservoir catch has consisted of a moderate number of fish entrained from upstream reservoirs. In 2020, a similar trend was recorded, as 36% of fish captured in 2020 (n = 47 of 143 fish) were entrained from upstream reservoirs. The majority of these fish were released in Wanapum Reservoir (n = 46) and one individual was released in Wells Reservoir. In previous study years, the highest number of entrained fish were from the 2013BY initially released into Wanapum Reservoir. In 2020, the 2013BY contributed 65% (n = 21 of 34 fish) to entrained fish captured in Priest Rapids Reservoir.

Catch of the 2015BY, 2016BY, and 2017BY, which were released in approximately equal numbers and contributed 33% of all fish released in Priest Rapids Reservoir (n = 3,743 of 11,707 fish released), contributed only 13% of the total catch (n = 18 of 143 fish) and of these, five fish were entrained from Wanapum Reservoir. The majority of fish in this group were 2015BY (n =12), whereas very few 2016BY (n = 2) and 2017BY (n = 4) were captured. The catch proportion of the 2017BY in Priest Rapids Reservoir contrasts sharply with the corresponding catch of this brood year in Wanapum Reservoir where the 2017BY contributed

15% (n = 72 of 484 fish) of the total catch. The apparent low abundance of 2017BY in Priest Rapids Reservoir suggests either low survival of this brood year within Priest Rapids Reservoir or emigration out of the Project area due to entrainment downstream of Priest Rapids Dam.

Unequal catch distribution in Priest Rapids Reservoir (i.e., most of the fish are captured in the Wanapum Dam tailrace area) reduced the comparability between CPUE and Ep estimates in 2020. The highest Ep in Priest Rapids Reservoir was recorded in 2016 (Ep = 0.53), with lower values recorded in 2017 (Ep = 0.39), 2018 (Ep = 0.41) and 2019 (Ep = 0.33). The Ep for Priest Rapids Reservoir in 2020 (Ep = 0.44) was lower than in 2016 even though catch was similar in both years. In previous studies, Ep was higher in the middle and upper sections than in the lower section. In 2020, Ep in the lower reservoir section (Ep = 0.47) was higher than the middle section (Ep = 0.37) and almost equal to the upper section (Ep = 0.50); however, the lowest CPUE was recorded in lower section (CPUE= 0.09 fish/100 hook-hours) compared to the middle (CPUE= 0.13 fish/100 hook-hours) and upper section (CPUE= 0.30 fish/100 hook-hours). Although both Ep and CPUE are informative metrics to quantify and compare catch within and between study years, these metrics become less informative and potentially misleading when applied to highly aggregated populations.

Since 2016, total catch in Priest Rapids Reservoir has contributed between 11% and 19% to the total annual catch in the Project area. In 2020, catch in Priest Rapids Reservoir contributed 23% to the total catch, due primarily to high catch associated with three sites that contributed 39% to the total Priest Rapids Reservoir catch. These high-catch sites were located in the upper section of the reservoir immediately downstream of, or adjacent to, the Wanapum Dam spillways. In previous studies, catch success in the tailrace area varied and was highly dependent on flow conditions at the time of sampling. In high flow years, or in years where juvenile indexing was conducted in August instead of September (to avoid overlap with adult indexing), flow conditions in the tailrace area may have limited or prevented deployment of sampling gear. Due to the unequal distribution of White Sturgeon in Priest Rapids Reservoir, during future study years, variation in sampling effort within the upper section, and specifically sample effort near Wanapum Dam, will potentially result in large variations in total annual catch among studies based on the GRTS site selection method used. Alternate study designs could be considered in future studies to address this issue (e.g., further stratification).

4.4.2 Growth

Substantial variation in growth among individuals within individual brood years was evident in previous indexing studies and is well documented (Golder 2017-2020). Similar to previous indexing studies, the 2020 length-frequency histograms of most brood years substantially overlapped, with the exception of the oldest (i.e., 2010BY) and youngest fish (i.e., 2018BY and 2019BY). For most of the brood years, the smallest individuals in the older brood years were equal or smaller than the largest individuals of younger brood years. In the length-frequency histogram of older brood years, a decrease in catch frequency of fish over 90 cm FL likely represents the maximum effective capture size for the juvenile indexing set line gear, in that fish greater than 90 cm FL were more likely to straighten hooks, reducing their catchability. Based on regression of log weight and log length, overall growth rates were higher in Wanapum Reservoir than in Priest Rapids Reservoir. In Wanapum Reservoir, lower relative weights were recorded for the 2010BY, 2012BY, 2017BY, and 2019BY. These brood years were captured in greater numbers in the upper section of Wanapum Reservoir, which is more riverine than the downstream sections. The low relative weight of these brood years was assumed to be a consequence of the higher energetic costs required to inhabit this section of the river.

Low relative weights of the oldest brood years, and the 2010BY specifically, may be related to limitation of the sampling gear and reduced catchability of larger individuals in these brood years.

A cursory review of the 2020 length and weight data identified a significant difference ($p<0.05$) in the mean fork length between the older brood year releases (i.e., 2010BY, 2012BY, 2013BY and 2014BY) in Wanapum and Priest Rapid reservoirs, with a higher mean fork length and estimated growth rate in Wanapum Reservoir than in Priest Rapids Reservoir for these brood years. For the 2015 and younger brood years in both reservoirs, a substantial difference in mean fork and growth rate were not evident based on inspection of the empirical data. This finding warranted more investigation and length-at-age modeling of the available data to assess if density dependent growth was evident in fish released in the Project area and within each reservoir.

Wanapum Reservoir

Length-at-age growth curves in Wanapum Reservoir were consistent with previous findings (Golder 2020) with the highest growth rate recorded for the 2010BY and slightly lower growth rates for the 2013BY, 2014BY, and 2015BYs. A comparison of the growth curves indicated that the 2012BY are growing more slowly than the other older brood years. The slower growth of the 2012BY was readily evident in the growth curves (see Figure 20) and was attributed to the section where most 2012BY fish were captured. In all previous indexing studies, the 2012BY were captured in greater numbers in the upper section of Wanapum Reservoir where water velocities are higher compared to the middle and lower sections. Consequently, the energy requirements for the fish are also higher, potentially reducing growth rates. In addition to brood year, a preliminary review of the 2020 mean brood year growth rates by reservoir section indicated that section of capture may be a reliable predictor of growth (Table 21; Figure 29). Mean growth rates of all brood years were highest in the lower section, lower in the middle section, and lowest in the upper section. This apparent relationship between growth rate and capture section also implies a certain amount of fidelity by these fish to a specific section of river where they were captured. In previous studies, telemetry data identified seasonal movement between reservoir sections for some fish, but also identified long periods of time when movement was reduced and the fish remained near a specific location within a section of the river (Golder 2020).

Table 21 **Growth of the 2010BY to 2019BY by reservoir section in Wanapum Reservoir during juvenile White Sturgeon indexing from August 31 to October 6, 2020**

Brood Year	Wanapum Lower Section Growth (cm FL/year)					Wanapum Middle Section Growth (cm FL/year)					Wanapum Upper Section Growth (cm FL/year)				
	n	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**
2010	1	**8.9**	-	8.9	8.9	3	**8.8**	1.9	6.5	9.9	13	**5.5**	1.9	2.3	9.4
2012	1	**9.2**	-	9.2	9.2	12	**7.5**	1.5	5.0	9.6	49	**5.0**	1.9	1.6	9.0
2013	21	**9.4**	1.5	6.0	11.3	31	**8.3**	1.7	5.5	12.2	38	**6.1**	2.6	2.1	13.4
2014	21	**9.2**	1.7	4.7	11.5	42	**8.0**	1.5	5.0	10.8	44	**6.7**	2.3	1.8	12.2
2015	7	**10.0**	3.0	4.9	13.5	25	**8.3**	1.9	4.9	11.9	29	**6.0**	2.3	2.2	11.8
2016	3	**12.4**	1.7	11.1	14.3	2	**10.5**	3.4	8.1	12.9	5	**7.1**	1.1	5.3	8.0
2017	15	**11.9**	4.1	7.6	24.1	24	**8.2**	2.7	3.3	12.8	31	**6.5**	2.3	2.2	12.5
2018	2	**13.2**	4.4	10.1	16.4	9	**10.9**	2.4	7.1	14.9	14	**7.2**	2.6	1.7	11.8
2019						1	**14.0**	-	14.0	14.0	6	**29.3**	2.4	25.4	32.2

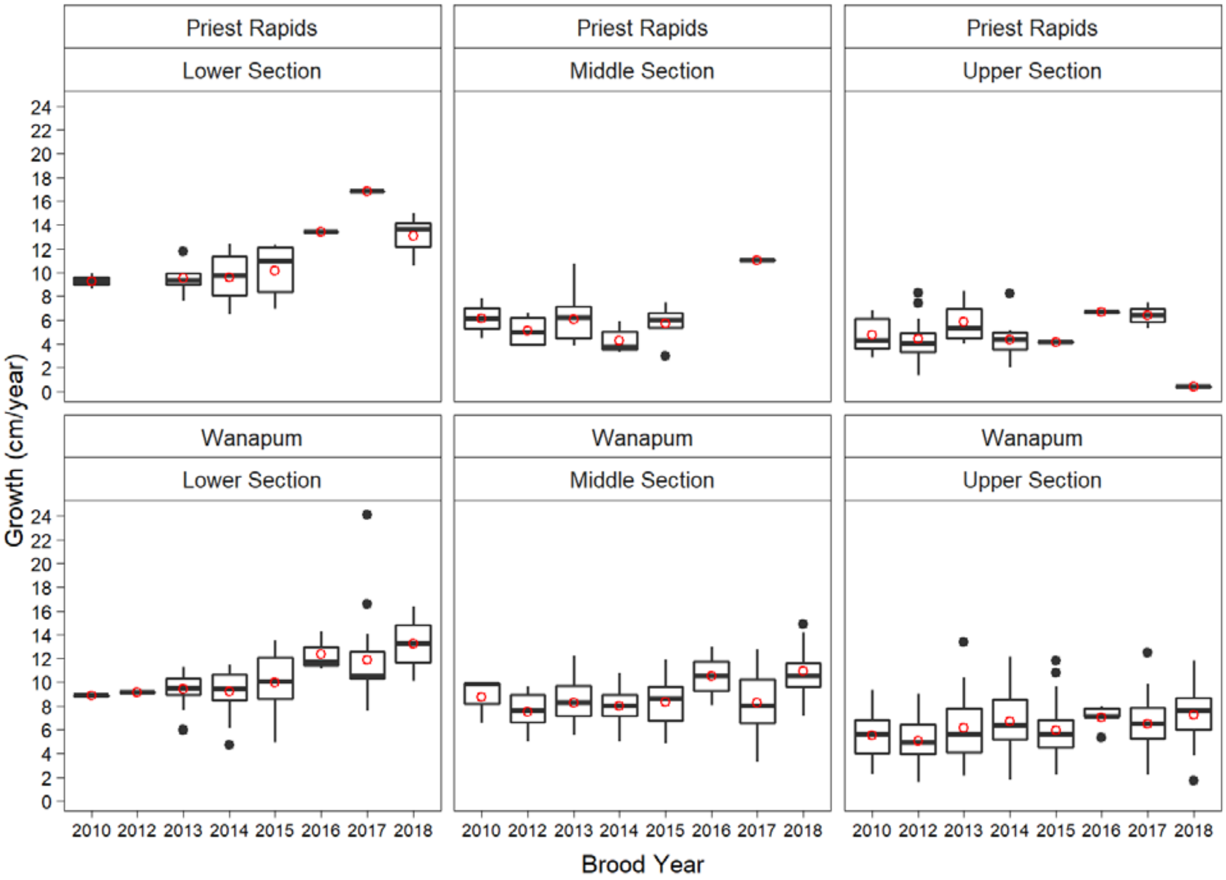

Figure 29 **Growth rates of brood years 2010 through 2018 (fish one year at large) in the lower, middle, and upper sections of Priest Rapids and Wanapum reservoirs, 2020. Red circle is mean growth.**

Priest Rapids Reservoir

In Priest Rapids Reservoir, the length-at-age growth curves of fish five or more years at large (age-6; 2014BY and older) plateaued as growth rates of these older fish decreased, with the slowest growth recorded in the 2014BY. Growth rate of younger fish released in Priest Rapids Reservoir did not plateau and was higher than the growth rate for the same brood year released in Wanapum Reservoir (see Figure 20). However, the growth rate estimates of young age classes in Priest Rapids Reservoir were based on the capture of relatively few fish and additional data are required to confirm these initial findings. The lower growth rates of older fish in Priest Rapids Reservoir, when compared to fish of the same age in Wanapum Reservoir, could potentially be attributed to higher water velocities in the upper and middle sections in Priest Rapids Reservoir and that 80% of the total Priest Rapids catch (n = 115 of 143 fish) was captured within these sections. Reduced growth in older and larger fish after age-6, compared to younger and smaller fish, likely related to a greater ability of smaller fish to use interstitial habitats as velocity refugia to reduce energy expenditures. In addition to brood year as a predictor of growth, a preliminary review of the 2020 indexing capture data indicated that reservoir section was also a likely a predictor of growth (Table 22; Figure 29). Mean growth rates of all brood years were highest in the lower section, lower in the middle section, and lowest in the upper section of Priest Rapids Reservoir. In both the middle and upper reservoir sections, water velocities are higher than in the lower section and sturgeon that reside in these sections likely have greater energetic expenses compared to fish in the lower section of the reservoir. Lower growth rates in the upper and middle sections of Priest Rapids Reservoir may also be due density dependence as a result of higher use of these sections by sturgeon compared to the lower section. In brood years where higher numbers of fish were captured in 2020 to allow a meaningful comparison, growth rates in the middle and upper section were similar for these brood years (i.e., 2013BY an 2014BY) and suggests that the populations of sturgeon in these sections may mix. This assumption is supported by telemetry data in Priest Rapids Reservoir from previous studies, which identified frequent movements by juvenile White Sturgeon between the upper and middle sections (Golder 2020). As in Wanapum Reservoir, this apparent relationship between growth rate and reservoir section implies fidelity by these fish to a specific section of reservoir where most aspects of their life history take place.

Table 22 Growth of the 2010BY to 2019BY by reservoir section in Priest Rapids Reservoir during juvenile White Sturgeon indexing from August 31 to October 6, 2020

Brood Year	Priest Rapids Lower Section Growth (cm FL/year)					Priest Rapids Middle Section Growth (cm FL/year)					Priest Rapids Upper Section Growth (cm FL/year)				
	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
2010	2	**9.3**	0.9	8.6	9.9	2	**6.1**	2.4	4.5	7.8	10	**4.7**	1.4	2.9	6.8
2012	-	-	-	-	-	4	**5.1**	1.4	3.8	6.6	25	**4.4**	1.6	1.4	8.3
2013	5	**9.5**	1.5	7.6	11.8	15	**5.9**	1.9	3.9	10.7	11	**5.8**	1.7	4.0	8.5
2014	6	**9.6**	2.3	6.5	12.4	7	**4.3**	1.0	3.3	5.9	14	**4.3**	1.5	2.0	8.3
2015	5	**10.2**	2.4	7.0	12.3	6	**5.7**	1.5	3.0	7.5	1	**4.1**	-	4.1	4.1
2016	1	**13.4**	-	13.4	13.4	-	-	-	-	-	1	**6.6**	-	6.6	6.6
2017	1	**16.8**	-	16.8	16.8	1	**11.0**	-	11.0	11.0	2	**6.4**	1.6	5.3	7.5
2018	5	**13.1**	1.8	10.6	15.0	-	-	-	-	-	1	**0.4**	-	0.4	0.4
2019	-	-	-	-	-						2	**23.4**	4.1	20.4	26.3

Reservoir of initial release was identified as a predictor of growth of fish in Priest Rapids Reservoir, in that fish entrained from Wanapum Reservoir into Priest Rapids Reservoir grew faster after age-6 than fish of the same age that were originally released in Priest Rapids Reservoir (see Figure 21). Intuitively, for a given brood year, if a fish is entrained from Wanapum Reservoir into Priest Rapids Reservoir within a few months of its release into Wanapum Reservoir, the growth rate of this fish would be dependent on the environmental conditions within Priest Rapids Reservoir and growth rates similar to a fish of the same brood year released in Priest Rapids Reservoir would be expected. If a difference in growth exists between these fish, this difference would likely be due to genetic or behavioral differences of the entrained fish. The fact that these Wanapum-released fish were entrained while others in their release group were not, could be considered as evidence in support of a behavioral difference in entrained fish. If so, once within Priest Rapids Reservoir, these entrained fish may exhibit some behavioral aspect (e.g., use of higher quality habitats, greater foraging efficiency) that results in above average growth compared to other fish within the same brood year. Additional data are required to further investigate this aspect of juvenile White Sturgeon growth in Priest Rapids Reservoir.

Overall, density dependent growth was not evident based on growth rates estimated for each brood year for the entire population of hatchery-reared sturgeon in the Project area. In Wanapum Reservoir, growth rates of the brood year releases examined did not exhibit clear signs of density-dependent growth. This suggests no overall decrease in growth as more fish were released into Wanapum Reservoir. In Priest Rapids Reservoir, growth rates were lower than rates in Wanapum Reservoir and large differences in growth were observed between brood years. The extent of density-dependent growth is unclear. If density does affect growth, reduced growth may be limited to fish occupying the upper reservoir section and to fish occupying the immediate Wanapum Dam tailrace area.

4.4.3 Juvenile White Sturgeon Population Estimates

Brood-year specific survival estimates did not vary substantially between Priest Rapids Reservoir and Wanapum Reservoir, as there was no support for any of the models tested that included reservoir of capture as an explanatory variable factor. This result allowed use of model-averaged estimates for the Project area to estimate brood year survival in first year after release (i.e., less than one year at large) and for all subsequent years (i.e., greater than 1 year at large).

With an additional year of data and refinement of the model, separate survival estimates were possible for the 2016BY and 2017BY, whereas in 2019, catch numbers of these brood years were low and only a combined survival estimate was generated. The low first year survival of the 2016BY was supported by the empirical catch data of this brood year in both reservoirs. In contrast, the first year survival of the 2017BY was the highest (0.449) of all brood years released to date. Although this survival estimate was for both reservoirs, based on the model used, the catch proportion of the 2017BY in Wanapum Reservoir (15%; n = 72 of 484 fish) was substantially higher than in Priest Rapids Reservoir (3%; n = 4 of 143 fish). Similar catch proportions would be expected if survival was identical in both reservoirs. As such, the combined survival estimates for the Project area maybe more applicable to older brood years and less applicable for more recent releases until sufficient data are obtained. In the 2020 model, after the release year, estimated survival of juvenile sturgeon was in excess of 0.9 for most brood years.

Recapture probability estimates for all brood years and ages were substantially lower in Priest Rapids Reservoir than in Wanapum Reservoir in the 2020 model and were comparable with estimates generated in previous modeling efforts (Golder 2019, 2020). The reason for this difference is uncertain but may relate to limited dispersal of juvenile fish through Priest Rapids Reservoir after they are released. Due to exclusion areas near Wanapum Dam (for safety reasons) and the challenges of deploying sampling gear in fast and turbulent river, fish that reside in the upper section of Priest Rapids Reservoir maybe less susceptible to capture.

With the inclusion of the 2020 catch data and updating of the model, population estimates were generated for 2011-2020 (Table 17). A comparison of estimated 2019 population abundance between the current model and previous 2019 model was conducted (Golder 2020). Based on the 2020 model results for Wanapum Reservoir in 2019 (7,417 fish), the previous model had underestimated the 2019 population abundance in Wanapum Reservoir (5,262 fish). Similarly, the previous abundance estimates for 2019 in Priest Rapids Reservoir (2,239 fish) increased in the updated model (3,291 fish). The 2020 abundance estimates decreased in both reservoirs as the smaller release size of the 2019BY in 2020 (n = 672) was not sufficient to compensate for the mortality of previously released fish. With the release of the 2019BY, the 2020 hatchery fish abundance estimate in Wanapum Reservoir was 6,190 fish (95% CI = 4,878–7,502) or 22.5% of total hatchery releases to date (n = 27,544 fish). In Priest Rapids Reservoir, the 2020 hatchery fish abundance estimate was 2,759 fish (95% CI = 2,203–3,315) or 23.6% of total hatchery releases to date (n = 11,707 fish).

Overall, the 2020 model results indicate that prior to 2020, abundance was relatively constant, whereas previous models indicated slowly decreasing abundances in both reservoirs. Release numbers below the levels required to compensate for natural mortality, combined with the uncertainty in the survival in more recent releases, may result in future declines in abundance estimates. As juvenile fish from older brood years grow, they will become less susceptible to capture by the juvenile sampling gear and recapture rates of the oldest brood year will continue to decrease in the next few years. Once older brood years are less susceptible to the juvenile indexing gear, the model in its current form will no longer accurately account for all hatchery-reared fish released in the Project area. In order to accurately estimate survival, recapture probabilities, and abundance of older brood years, future modeling will likely need to include hatchery catch data from the adult indexing program.

4.4.4 Alternative Stocking Strategy for Priest Rapids Reservoir

Given the unequal distribution of juvenile White Sturgeon in Priest Rapids Reservoir and evidence indicating low survival of the 2016BY and 2017BYs, a revised strategy may be recommended for consideration for future juvenile releases. To date, all hatchery fish have been released into the Wanapum Dam tailrace area. Beyond convenient logistics, there were several valid biological reasons to justify the release of juvenile fish into the tailrace that included: 1) the tailrace area contained habitats that were highly used by sturgeon; 2) there is lower risk of downstream entrainment through Priest Rapids Dam; 3) the fish are released near deep water and can descend quickly to depth; and 4) reduced risk of avian predation due to water depth, turbulence, and bird deterrent systems (wires).

An initial assumption was that fish released into the tailrace would eventually move downstream and occupy suitable habitat throughout the reservoir; however, evidence collected to date suggests that when fish are released directly into the riverine section of a reservoir, a substantial portion of the fish released tend to remain in that section of the reservoir (e.g., the 2010BY and the 2012BY). Another potential consequence of residency in faster flowing riverine sections of a reservoir is slower growth, which was associated with the 2012BY in Wanapum Reservoir (Golder 2020; see Section 4.4.2). At high densities, fish in upper riverine sections of reservoirs may also experience lower growth due to density-dependent factors such as increased competition for limited food resources. Based on catch and telemetry data of fish released into the lower section of Wanapum Reservoir, fish released into the downstream (lentic) section of the reservoir will tend to move upstream and disperse more evenly throughout the reservoir. Furthermore, preliminary growth data suggest that fish in the lower sections of both Wanapum and Priest Rapids reservoirs have higher growth rates than fish of the same cohort that reside in upstream sections of these reservoirs.

In Priest Rapid Reservoir, the amount of suitable habitat for White Sturgeon adjacent to the release site in the Wanapum Dam tailrace area may be limited to discrete locations within the tailrace area. This habitat likely varies in size and quality in relation to flow and may become limited under certain flow conditions. Consequently, if fish do not disperse from the tailrace area, each successive juvenile brood year release may be released into an environment where space and resources are limited. If so, newly released juvenile fish will need to compete with older and large juveniles from previous brood year releases that did not disperse downstream.

A potential alternative release strategy for Priest Rapids Reservoir would be to conduct future brood year releases at release locations in the lower section of Priest Rapids Reservoir. Both the Desert Aire and Buckshot boat launches maintained by Grant PUD could serve as potential release sites and allow fish to be released either directly to water or allow access to deeper water locations where fish could be transferred by dipnet to the reservoir. Future indexing studies would monitor the dispersal and growth rates of these release groups.

4.5 Summary

In 2020, mitigation measures and precautions taken in response to the COVID-19 pandemic resulted in a reduction in the number of hatchery fish released in the Project area. This reduction was likely temporary and a return to normal stocking numbers is expected in future years. Supplementation based on conservation aquaculture continues to be a viable approach to provide hatchery juvenile White Sturgeon for release into the Project area. White Sturgeon spawning activity in Wanapum Reservoir below Rock Island Dam was detected in 2020 and the onset time of spawning was consistent with previous studies. The juvenile sampling methodology based on small-hook set line sampling provided 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 2020 indexing study, the model to estimate the juvenile White Sturgeon population was revised to calculate survival probability estimates by brood year for the Project area and recapture probabilities by age class for both reservoirs. Other metrics, like CPUE and Ep estimates, were calculated for each brood year to infer differences in survival and abundance among brood years and to support the population model results. The model analysis was limited to brood year hatchery fish that were one year or more at large. To account for the reduction in captures of larger fish as fish recruit away from the juvenile gear, the recapture rate was allowed to vary with age. This specification of the model allowed to account for the change in recapture rates between brood years, and informed the model, so that survival of older brood years was not artificially deflated due to fish recruiting away from gear. Future juvenile indexing studies will address sample gear bias by assessing the size selectivity of the juvenile sampling gear. Catch data from the adult indexing program, which uses large-hook sampling gear, will also be included in future modeling efforts to reduce the effect of gear bias on survival and abundance estimates.

Mean annual growth rates recorded in 2020 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. Lower growth rates were evident for individuals of brood years that reside in the upper sections of each reservoir and were attributed to high water velocity and associated higher energetic costs for these fish. Historically, in Priest Rapids Reservoir, all juvenile White Sturgeon releases were in the upper section of the reservoir and this release strategy was considered as a possible reason why growth rates were notably lower for fish older that age-6 in Priest Rapids Reservoir compared to Wanapum Reservoir. In future juvenile indexing studies, hatchery brood year growth analysis will also include capture data from the adult indexing program to account for the effect of sampling gear bias on growth estimates of older brood years. An alternative release strategy for Priest Rapids Reservoir was proposed and recommended that future brood year releases should be conducted in the lower section of Priest Rapids Reservoir. The proposed release strategy would allow an assessment of the effect of release location on growth, dispersal, and survival of juvenile White Sturgeon in Priest Rapids Reservoir.

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Appendix A
Washington Department of Ecology's March 17, 2021 Approval Letter

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
1250 West Alder Street • Union Gap, Washington 98903-0009 • (509) 575-2490

March 17, 2021

Mr. Tom Dresser
Fish, Wildlife and Water Quality Manager
Grant County PUD
PO Box 878
Ephrata, WA 98823

RE: Request for Ecology Review and Comments – *2020 White Sturgeon Management Plan Annual Report.*
Priest Rapids Hydroelectric Project No. 2114

Dear Mr. Dresser:

The Department of Ecology (Ecology) has reviewed the *2020 White Sturgeon Management Plan Annual Report* sent via email to Ecology on February 9, 2021.

Ecology has **no comments** for the *2020 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 have any questions.

Sincerely,

Breean Zimmerman

Breean Zimmerman
Hydropower Projects Manager
Water Quality Program

ec: Chris Mott, Grant County PUD

Appendix B
Stakeholder Comments

From: Heironimus, Laura B (DFW)
To: Deb Firestone; Lewis, Stephen; Ralph Lampman; Donnella Miller; Alyssa Buck; Jason McLellan (Jason.McLellan@colvilletribes.com); Kirk Truscott (Kirk.Truscott@colvilletribes.com); Tracy Hillman (Tracy.hillman@bioanalysts.net); Verhey, Patrick M (DFW); Zimmerman, Breean (ECY); Aaron Jackson (AaronJackson@ctuir.org); Carl.Merkle@ctuir.org; Tom Skiles (SKIT@critfc.org); Keith Hatch (keith.hatch@bia.gov)
Cc: Ross Hendrick; Shannon Lowry; Tom Dresser; Chris Mott; Mike Clement; Erin Harris
Subject: RE: Grant PUD"s Draft White Sturgeon Management Plan 2020 Annual Report - For Review and Comment
Date: Thursday, March 11, 2021 5:31:37 PM

Hi Deb,

After reviewing the White Sturgeon Management Plan 2020 Annual Report, I have a few comments, listed below:

- There is an error in the page numbers, after page 69, the page numbers revert back to page 51, causing an issue in the table of contents for locating sections.
- I'm intrigued by the egg incubation idea, and may have missed some discussion on this during the fish forum meeting, but did not notice any discussions in this report of further efforts to retry egg incubation.
- I agree with this statement on the 2nd page 62, "In order to accurately estimate survival, recapture probabilities, and abundance of older brood years, future modeling will likely need to include hatchery catch data from the adult indexing program." Use of available adult index data will be critical in developing future stocking SOA's.
- Overall we are supportive of altering release location in Priest Rapids as identified and are interested in the comparison study on fish dispersal. As a suggestion, you may want to consider splitting releases with the original release location for a few years to use fish released at the upper site as a control for changes in environmental conditions. It will be interesting to see if and how much the change in release location will affect dispersal, recapture probability, and survival rates in future cohorts.

Thank you for the opportunity to review.

Laura Heironimus
Sturgeon, Smelt, Lamprey Unit Lead
Washington Dept. of Fish and Wildlife
Mobile 360.719.0677
Laura.Heironimus@dfw.wa.gov

From: Deb Firestone <Dfirest@gcpud.org>
Sent: Tuesday, February 9, 2021 2:38 PM
To: Lewis, Stephen <Stephen_Lewis@fws.gov>; Ralph Lampman <lamr@yakamafish-nsn.gov>; Donnella Miller <mild@yakamafish-nsn.gov>; Alyssa Buck <Abuck1@gcpud.org>; Jason McLellan (Jason.McLellan@colvilletribes.com) <Jason.McLellan@colvilletribes.com>; Kirk Truscott (Kirk.Truscott@colvilletribes.com) <Kirk.truscott@colvilletribes.com>; Tracy Hillman (Tracy.hillman@bioanalysts.net) <Tracy.hillman@bioanalysts.net>; Verhey, Patrick M (DFW) <Patrick.Verhey@dfw.wa.gov>; Zimmerman, Breean (ECY) <bzim461@ECY.WA.GOV>; Aaron Jackson (AaronJackson@ctuir.org) <AaronJackson@ctuir.org>; Carl.Merkle@ctuir.org; Tom Skiles (SKIT@critfc.org) <SKIT@critfc.org>; Heironimus, Laura B (DFW) <Laura.Heironimus@dfw.wa.gov>;

Keith Hatch (keith.hatch@bia.gov) <keith.hatch@bia.gov>
Cc: Ross Hendrick <Rhendr1@gcpud.org>; Shannon Lowry <Slowry@gcpud.org>; Tom Dresser <TDresse@gcpud.org>; Chris Mott <Cmott@gcpud.org>; Mike Clement <Mclemen@gcpud.org>; Erin Harris <Eharris@gcpud.org>
Subject: Grant PUD's Draft White Sturgeon Management Plan 2020 Annual Report - For Review and Comment

Good afternoon,

Attached please find Grant County PUD's 2020 draft White Sturgeon Management Plan annual report for review and comment.

Please provide your comments to me by March 11, 2021.

If you have questions regarding this report, please contact Mike Clement at Mclemen@gcpud.org or 509-750-3024.

Thanks!

Deb Firestone
Regulatory Specialist II – Environmental Affairs

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Grant PUD

grantpud.org

Appendix C
Grant PUD Response Table to Stakeholder Comments

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
Colville Confederated Tribes (J. McLellan)	2/16/2021	25	Bait?	Grant PUD modified this sentence to provide clarification to this comment.
		30	Would it have been prudent to temper the water in the transport tanks prior to release?	Grant PUD and the PRFF will discuss this recommendation for future juvenile acclimation during release.
		31	The upper Columbia group in WA has a very specific abnormality monitoring criteria that has been in use for more than a decade. If there is interest in standardization, please contact me	Grant PUD and the PRFF will discuss this recommendation for future juvenile abnormality criteria monitoring.
		32	Were there efforts directed at the capture of larvae?	No, capture efforts were not directed at larvae directly. Grant PUD has modified the title for clarification.
		33	This seems to be speculation and not results. A couple of paragraphs below it indicates that the flows are directed at this site. It takes nearly 10 minutes for eggs to become adhesive following fertilization, so under the velocities described they could have spawned in any number of locations within the tailrace and the eggs distributed to the sites where they were captured.	Grant PUD has modified this statement to reflect this recommendation.
		33	Seems speculative, so may not belong in the results. Based on the strong and variable flow conditions in the tailrace it does not appear that egg distribution on the mats may provide much information about actual spawning location	Grant PUD has modified this statement to reflect this recommendation
		33	This should probably be in the discussion.	Grant PUD has modified this statement to reflect this recommendation
		38	I believe this was stated in the methods. May consider removing if it is redundant.	Grant PUD has modified this statement to reflect this recommendation
		41	Were there 125 BY14 fish originally released in Rocky Reach captured in PRPA reservoirs?	Grant PUD has modified this statement to reflect this recommendation
		41	Did they have scute marks, but no detectable PIT tag?	Unknown fish were defined in three categories: fish had a PIT tag but no scute marks, fish had scute mark but no PIT tag, or fish had a PIT tag and scute marks,

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
				but could not be found in PTAGIS.
		41	Discussion?	Grant PUD has modified this statement to reflect this recommendation
		42	Please clarify what is meant by this statement.	Grant PUD has modified this statement to reflect this recommendation
		42	Discussion? (4 locations)	Comment noted. Grant PUD has moved multiple recommendations in this section to reflect this recommendation.
		43	A fair amount of this section appears to be discussion.	Grant PUD has moved this statement to the discussion per the recommendation.
		44	Was this already described in the methods? It could be removed if it is redundant	Grant PUD has modified this statement to reflect this recommendation
		54	Isn't the sampling biased toward the fastest growing young fish if there is a minimum size at which they recruit to the gear? And the opposite for the oldest fish (i.e., the slowest growers are more susceptible to the gear for a longer period of time)?	Grant PUD generally agrees with this statement, however; the juvenile indexing gear has captured fish as small as 27.0 cm FL and the gear appears to be effective at catching small sturgeon. Mean size of hatchery fish at release is approximately 30 cm FL. These fish grow over the 2-3 month period between release and the start of the indexing program and become more susceptible to the sampling gear. The range of growth rates of individuals captured from each brood year suggests the gear effectively captures both slow growing and fast growing individuals. If a bias exists, the effect would be consistent among brood years (as these fish age) and reservoirs and likely not affect interpretation of the data. Future studies will assess size selectivity of the gear. Comparison of estimated growth rates of hatchery fish captured during the 2021 adult

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
				indexing data and juvenile indexing growth rates may help identify and quantify growth rate related bias between the two sample programs in relation to catchability of older brood year fish.
		58	See previous comments about how the sampling gear can bias estimates of growth.	See previous response.
		58	Growth in length or weight? Also should consider gear bias issues mentioned in previous comment	Comment noted. See previous response to #54; all growth analysis was based on length.
		67	Maybe report in m3/s to remain consistent with other areas of the report.	Kilo-acre feet is a volume measurement and is a measure of the total volume discharged by Rock Island Dam for a given month. Grant PUD has modified the text from flow rate to total discharge volume per this recommendation.
		69	Is there a citation to support this?	Grant PUD has modified this statement to reflect this recommendation
		69	Only if survival is only influenced by size at release.	Grant PUD has modified this statement to reflect this recommendation
		69	Survival of BY 2019 fish may not have been greater, but the larger size at release may have increased capture probability due to gear selectivity.	Comment noted. Grant PUD generally agrees that survival was likely influenced by size at release
		71	I think that temperature as a spawning cue is missing. I think temperature is the most consistent variable when comparing across WS populations range wide, with the exception of the Kootenai population.	Grant PUD has modified this section to reflect this recommendation
		78	The gear is biased toward slower growing old fish (BY2010 sample size was small, so hard to compare to them). Also, the upper reservoir sections have the highest densities of fish. I am not sure there is much information in the literature to support an energetic disadvantage in higher velocity areas. The morphology of sturgeon would allow	Grant PUD agrees with this statement. In each reservoir, fish with high and low growth rates were captured and it is assumed these fish are distributed equally throughout each reservoir. Once fish exceed 1 m FL, these fish are rarely collected on the juvenile indexing gear. Future

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
			them to do well in higher velocity areas as they mainly remain near the substrate with large flat pectoral fins. In addition, they often seem to be distributed in velocity breaks (i.e., eddies, current breaks), where they can reduce swimming requirements by holding and food is delivered to them. Fish in the reservoir would may have to swim more and search for food.	studies will include data from the adult indexing to estimate growth rates of brood years as they age and the catchability of older brood years by the small-hook sampling gear decreases. The growth data from previous study years was reviewed and this trend was consistent for all brood years across all study years when large numbers of individuals from the older brood years in question. The diet analysis conducted by Grant PUD identified that a large proportion of the White Sturgeon diet consisted of prey that are not typically part of the diurnal drift (i.e., snails, bivalves, crayfish, lamprey larvae; Grant PUD 2018).
		79	Are fish of the same brood years experiencing differences in velocities between the two reservoirs? I would tend to agree that Priest Rapids has relatively high velocities over a greater proportion of its total length relative to Wanapum, but this does not mean that every fish in Priest Rapids is experiencing higher velocities in Priest Rapids. Some fish may reside in the tailrace of Rock Island and experience velocities similar to any fish in Priest Rapids. It may be worthwhile to consider catch distribution within each reservoir in evaluations of growth before attributing differences to velocities.	Grant PUD generally agrees with this statement and has modified this section to reflect this difference.
		79	The upper sections also had the highest densities of fish. Maybe density is influencing growth rate more so than energetics?	Grant PUD generally agrees with this statement and has modified this section to reflect this difference.
		81	Isn't this already occurring, as it was previously stated that the gear retention peaks at about 4.5 to 5.5 years post release. As such almost half of the releases are older and are now experiencing declining capture rates.	Grant PUD generally agrees with this statement and has modified this section to reflect this recommendation.

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
			Wouldn't this gear selectivity have a negative bias on mark-recapture based estimates of survival and abundance?	
		81	It is unclear if the slower growth is related to energetics, food availability, or fish density.	Grant PUD generally agrees with this statement and has modified this section to reflect this recommendation.
		82	Does the small-hook setline gear provide sufficient data to produce accurate, precise, and unbiased estimates of survival and abundance? It seems that the gear selectivity results in biased estimates and that modifications need to be instituted to reduce the gear selectivity (e.g., institute a proportion of the sampling with a setline configuration that recruits larger fish).	Grant PUD generally agrees with biased gear selectivity results, however, survival and abundance estimates of brood years between age-4 and age-6 are less biased than older and younger brood years. Gear bias is likely only one variable that results in lower catchability and recapture probabilities of younger brood years. Other factors could include feeding behavior, prey preference, habitat selection, and competition. Reduced catchability of older brood years has been acknowledged as a consequence of using small hook set line sampling gear in that recapture probabilities decrease as the fish age out of the gear. In the models, recapture rates were allowed to vary with age, reflecting the changes in recapture as fish mature into the gear and then recruit away from it. Inclusion of large hook sampling gear as part of the juvenile program may provide sufficient data to calculate survival estimates based on both juvenile and adult data sets collected to date. However, changing the juvenile program in this manner is likely to reduce the efficacy of sampling for younger brood years, which would affect the estimation

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
				of survival and abundance. Reducing the accuracy of the estimates of the younger brood year for a marginal increase in the accuracy of age-6 and older fish may not result in an improvement in the overall accuracy of the population estimate. Instead of including large hooks sampling gear as part of the juvenile program, the adult indexing data will be included in future population estimates to address the inherent bias of the small-hook sample methodology as fish age and grow beyond the catchable size range of the gear.
		82	There should be some discussion of mark-recapture model assumptions and how they were addressed in the analysis.	Grant PUD has modified this section to reflect this recommendation.
		82	Sampling gear selectivity and density should also be considered. Would be helpful if there were other literature cited to support.	Grant PUD has modified this section to reflect this recommendation.
Washington Department of Fish and Wildlife (L. Heironimus)	3/11/2021	1	After reviewing the White Sturgeon Management Plan 2020 Annual Report, I have a few comments, listed below	Comment noted.
		1	There is an error in the page numbers, after page 69, the page numbers revert back to page 51, causing an issue in the table of contents for locating sections.	Comment noted. Grant PUD has modified the document formatting to reflect this suggestion.
		1	I'm intrigued by the egg incubation idea, and may have missed some discussion on this during the fish forum meeting, but did not notice any discussions in this report of further efforts to retry egg incubation.	Grant PUD conducts spawning assessments on a 5-year interval (as agreed to by the PRFF) to document natural production within the Project. The incubation method is a pilot evaluation to assess the feasibility of using egg collection as a method for future supplementation. Future egg collection efforts are

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
				currently scheduled for 2025.
		1	I agree with this statement on the 2nd page 62, “In order to accurately estimate survival, recapture probabilities, and abundance of older brood years, future modeling will likely need to include hatchery catch data from the adult indexing program.” Use of available adult index data will be critical in developing future stocking SOA’s.	Comment noted.
		1	Overall, we are supportive of altering release location in Priest Rapids as identified and are interested in the comparison study on fish dispersal. As a suggestion, you may want to consider splitting releases with the original release location for a few years to use fish released at the upper site as a control for changes in environmental conditions. It will be interesting to see if and how much the change in release location will affect dispersal, recapture probability, and survival rates in future cohorts.	Grant PUD generally agrees with this recommendation. Discussion of altering the location for the Priest Rapids reservoir juvenile release will be occurring in future PRFF meetings.