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March 21, 2023

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) – 2022 White Sturgeon Management Plan Annual Report

Dear Secretary Bose,

Please find enclosed Public Utility District No. 2 of Grant County, Washington (Grant PUD) 2022 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 2022 M&E program (FERC License Year 15) were as follows:

1). The release of the 2021 brood year (BY) of hatchery juvenile White Sturgeon in accordance with the stocking target previously approved by the PRFF, as outlined in the Priest Rapids White Sturgeon Stocking Statement of Agreement (SOA) dated March 11, 2016. As part of the juvenile release, a tagging, marking, and release plan was developed and implemented in 2022.

2). The collection of adult White Sturgeon broodstock from John Day reservoir, downstream of McNary Dam, and the transport of candidate fish to the Yakama Nation Sturgeon Hatchery (YNSH) for gamete collection, fertilization, and production of the 2022BY progeny. This work was conducted directly by Grant PUD with coordination and data collection conducted by Blue Leaf Environmental (BLE). A summary of 2022 broodstock collection efforts is provided in Appendix A.

3). Conduct a juvenile White Sturgeon capture and recapture program to estimate survival and provide an index of the population abundance of hatchery juvenile sturgeon released to date. These data are

[1] 123 FERC ¶ 61,049 (2008)

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 as the primary method to capture hatchery juvenile White Sturgeon in the PRPA (Golder 2015–2022). Sampling methods were standardized in 2016 and the same methodology was used in all subsequent years.

4). The FERC license stipulates that progress towards attaining the Specific Biological Objectives identified in the WSMP was to be reviewed and reported every five years after issuance of the Project FERC license in 2008. A status report on the progress made from License Year 11 (2018) to License Year 15 (2022) towards meeting the specific Biological Objectives in the WSMP is provided in Appendix C.

Pursuant to the reporting requirements, Grant PUD provided a complete draft of the PLMP Comprehensive Annual and 15-Year Biological Objectives Status Report to the Priest Rapids Fish Forum (PRFF) on February 6, 2023, for a thirty-day comment period. The PRFF 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 CCT on February 28, 2023, and Grant PUD's responses are in Appendix C. On March 10, 2023, WDOE approved the 2022 WSMP Annual Report. (Appendix D).

FERC staff with any questions should contact Tom Dresser at tdresse@gcpud.org or 509-797-5182.

Sincerely,

Shannon Lowry

Shannon Lowry
License Compliance and Lands Services Manager

CC: Breean Zimmerman – Ecology
Priest Rapids Fish Forum

2022
Annual White Sturgeon Management Plan and Biological Objectives Status 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:

WSP Canada Inc.
201 Columbia Avenue
Castlegar, British Columbia, CA

March 2023

Thank you to the following contributors:

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Paul Grutter	WSP Canada Inc.
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Dustin Ford	WSP Canada Inc.
David Roscoe	WSP Canada Inc.
Corey Wright	Blue Leaf Environmental Inc.

We wish to specifically acknowledge and thank Mike Clement 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
CBH	Columbia Basin Hatchery
Chelan PUD	Public Utility District No. 1 of Chelan County, Washington
CPUE	Catch-Per-Unit-Effort
CRITFC	Columbia River Intertribal Fisheries Commission
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
M&E	Monitoring and Evaluation
PIT	Passive Integrated Transponder
PRFF	Priest Rapids Fish Forum
PRPA	Priest Rapids Project area (Project area)
PTAGIS	PIT-tag Information System
RISFWC	Rock Island Forebay Waterbird Colony
RM	River Mile
SA	Spontaneous Autopolyploidy
SOA	Statement of Agreement
UTM	Universal Transverse Mercator
WSMP	White Sturgeon Management Plan
YNSH	Yakama Nation Sturgeon Hatchery

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). Article 401 of Grant PUD's Federal Energy Regulatory Commission (FERC) license requires that they 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 2022 M&E program (FERC License Year 15) in the PRPA included the following study components; 1) tagging, marking, and release of the 2021BY (Brood Year) hatchery juvenile White Sturgeon, and 2) juvenile White Sturgeon population indexing to estimate survival and the population abundance of hatchery juvenile sturgeon.

Prior to tagging, the 2021BY were tested individually for spontaneous autopolyploidy (SA) and 6 fish with SA were identified. The remaining 2021BY fish without spontaneous autopolyploidy (n = 3,269) were tagged from March 28 to April 1 and were released on April 27, 2022. Adhering to a new release strategy for Priest Rapids reservoir, which was first implemented in 2021, fish were released at the Desert Aire boat launch (RM400.3) in Priest Rapids reservoir (n = 1,259; 38%), and in Wanapum reservoir at the Vantage boat launch (RM420.6) (n = 2,010; 62%). In total, there have been 11 releases of hatchery juvenile White Sturgeon in the PRPA from 10 different brood years (2010BY, 2012BY through 2018BY, 2019BY[a&b], and 2021BY) conducted since 2011. Broodstock collection was successfully completed in late May 2022 to produce a 2022BY based on a 6Fx6M spawning matrix using fish captured downstream of the PRPA below McNary Dam in the Columbia River.

Juvenile White Sturgeon indexing conducted in 2022 consisted of 360 overnight small-hook set line sets deployed in Priest Rapids reservoir (n = 90) and Wanapum reservoir (n = 270) divided equally among the upper, middle, and lower sections of each reservoir. In total, 687 juvenile White Sturgeon were captured in the PRPA. Catch in Priest Rapids reservoir (n = 189) exceeded all previous annual catches with the combined catch of 2014BY (n = 42) and 2013BY (n = 40) fish contributing the highest proportions to the total catch. In Wanapum reservoir, 498 fish were captured, with the 2017BY (n = 91), 2018BY (n =89), and 2014BY (n = 80) contributing the highest proportion to the total catch. In 2022, the overall catch-per-unit-effort (CPUE) in Priest Rapids reservoir (CPUE = 0.25 fish/100 hook-hours) exceeded the CPUE in Wanapum reservoir (CPUE = 0.22 fish/100 hook-hours) and represents the first time since the start of annual population indexing in 2014 that CPUE was higher in Priest Rapids reservoir than in Wanapum reservoir.

The juvenile White Sturgeon Cormack-Jolly-Seber (CJS) population model was revised to calculate survival probability estimates and recapture probabilities by brood year to estimate total White Sturgeon population abundances for each reservoir by calendar year. Other metrics, like catch proportion, length-frequency, CPUE, and Ep estimates, were calculated for each brood year to infer differences in survival and abundance among groups and to support/discount the CJS population model results. To account for the reduction in captures of larger fish as fish recruited away from the juvenile gear, the recapture rate was allowed to vary with age in the CJS population model. This specification of the model accounted for changes 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 the gear. In 2022, the estimated population of hatchery White Sturgeon between 33.0 cm FL and 136.5 cm FL in Wanapum reservoir was 10,809 fish (95% CI = 9,041 – 12,576) and 3,909 fish (95% CI = 3,211 – 4,606) in Priest Rapids reservoir. Future juvenile indexing studies will continue to address sample gear bias by assessing the size selectivity of the sampling gear.

Mean annual growth rates recorded in 2022 for each hatchery brood year were similar to mean annual growth rates recorded during previous study years. In 2022, higher growth rates were recorded in Wanapum reservoir than in Priest Rapids reservoir. In Wanapum reservoir, the 2012BY has the lowest growth rate of all the brood years released, and the mean length and mean weight of the 2012BY was lower than the younger 2013BY and 2014BY brood years. Overall, lower growth rates were recorded for juvenile White Sturgeon in the upper sections of each reservoir across all brood years. Reduced growth in the upper sections of each reservoir was assumed to relate to higher energetic cost due to high water velocity and possibly to localized density dependent growth. In Priest Rapids reservoir, growth slowed for fish older than age-4 and notably plateaued in fish age-6 and older, whereas growth rates did not decrease or decreased only slightly for fish of the same age in Wanapum reservoir. Due to differences in growth between reservoirs, faster growing brood years in Wanapum reservoir had lower catchability when compared to fish of the same age from Priest Rapids reservoir, as evident by the lower recapture probabilities recorded for 2010BY to 2014BY in Wanapum reservoir. Based on length-at-age models, similar growth rates (i.e., overlapping growth curves) were recorded for most brood years in Wanapum reservoir and density dependent growth was not evident. In Priest Rapids reservoir, lower growth rates in older fish may suggest localized density dependent growth in areas with higher densities of older fish, such as the upper section of the reservoir. However, based on high growth rates recorded for younger brood years in the reservoir, the overall effect of density dependent growth on the hatchery White Sturgeon population in Priest Rapids reservoir remains uncertain.

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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 Wanapum and Priest Rapids dams as part of the license for 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 to the FERC license requirement, Grant PUD developed, in consultation with the Priest Rapids Fish Forum (PRFF), 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 amount of aquatic habitat available 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 area; and 3) the level of natural recruitment of White Sturgeon in the Project area. On an annual basis, the M&E program results are reviewed by members of the 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.

The study objectives and tasks completed under the 2022 M&E program (FERC License Year 15) were as follows:

1) The release of the 2021 brood year (BY) of hatchery juvenile White Sturgeon in accordance with the stocking target previously approved by the PRFF, as outlined in the Priest Rapids White Sturgeon Stocking Statement of Agreement (SOA) dated March 11, 2016. As part of the juvenile release, a tagging, marking, and release plan was developed and implemented in 2022.

2) The collection of adult White Sturgeon broodstock from John Day reservoir, downstream of McNary Dam, and the transport of candidate fish to the Yakama Nation Sturgeon Hatchery (YNSH) for gamete collection, fertilization, and production of the 2022BY progeny. This work was conducted directly by Grant PUD with coordination and data collection conducted by Blue Leaf Environmental (BLE). A summary of 2022 broodstock collection efforts is provided in Appendix A.

3) Conduct a juvenile White Sturgeon capture and recapture program to estimate survival and provide an index of 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 as the primary method to capture hatchery juvenile White

Sturgeon in the PRPA (Golder 2015–2022). Sampling methods were standardized in 2016 and the same methodology was used in all subsequent years.

4) The FERC license stipulates that progress towards attaining the Specific Biological Objectives identified in the WSMP was to be reviewed and reported every five years after issuance of the Project FERC license in 2008. A status report on the progress made from License Year 11 (2018) to License Year 15 (2022) towards meeting the specific Biological Objectives in the WSMP is provided in Appendix C.

The following introductory sections summarize the approach and results of the M&E program components conducted in 2022 and the implication of the results in context with Grant PUD management objectives for the White Sturgeon population within the PRPA.

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) downstream of Priest Rapids Dam (Figure 1). Wanapum Dam is located at RM416.0. For the purpose of study design and data analysis, each reservoir was divided into “lower”, “middle”, and “upper” sections. 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. Generally, lotic conditions were more common in the upper reservoir section and lentic conditions were more common in the lower reservoir sections, with the middle section representing a transitional area between the two habitat types. Water velocities were highest in the upper section and lowest in the lower section. In the lower section, environmental factors, such as wind velocity, wind direction, and fetch (reservoir length), have substantial effects on ecosystem processes.

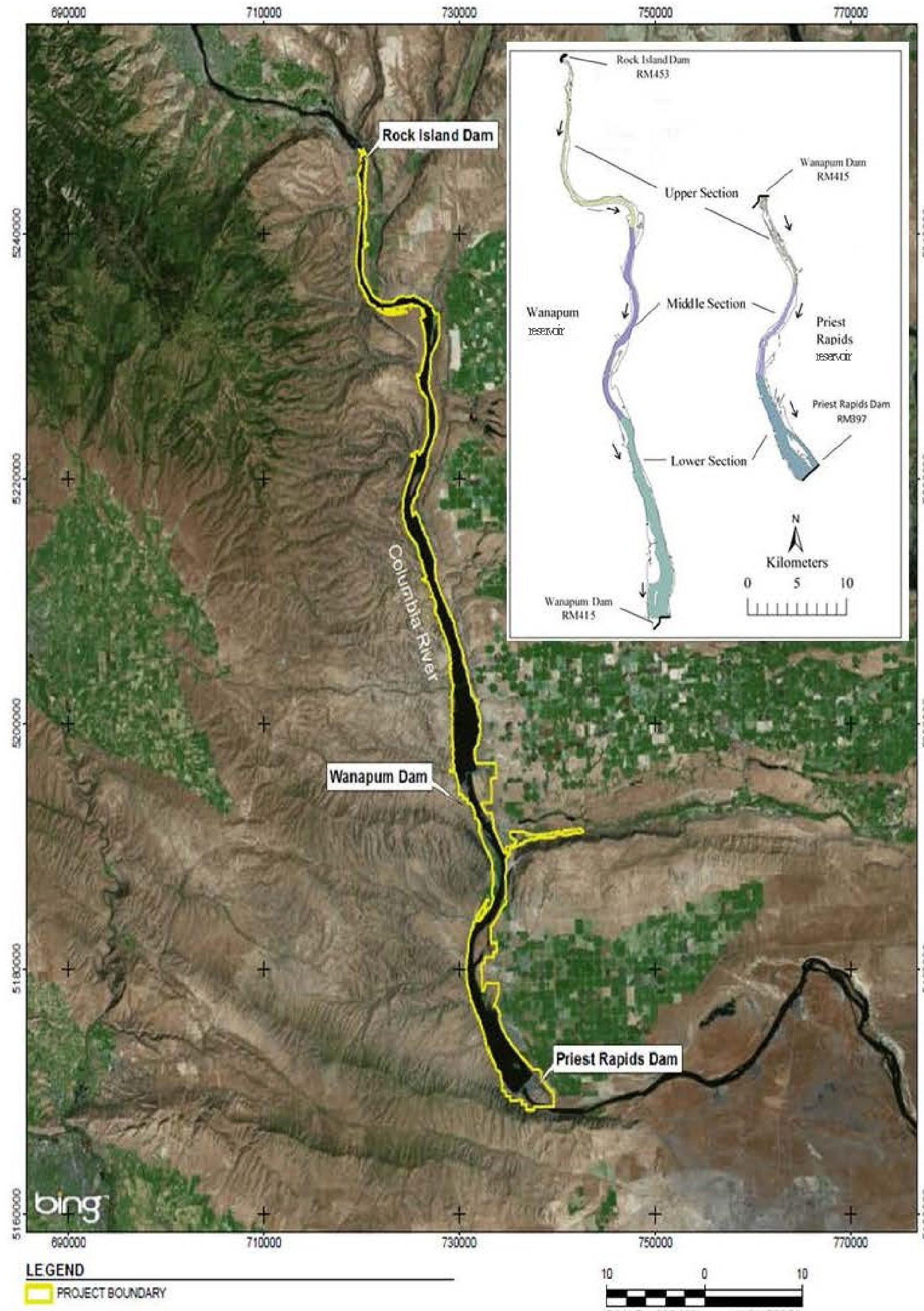

Figure 1 The Priest Rapids Project area. Inset shows the location of the upper, middle, and lower sections in the Priest Rapids and Wanapum reservoirs.

1.1 Consultation

Pursuant to the FERC reporting requirements, Grant PUD provided a complete draft of the WSMP 2 Annual Report to the PRFF on February 9, 2023 for review. Written comments were received from Confederate Tribes of the Colville Reservation on February 23, 2023. A summary of written comments from the PRFF, as received by Grant PUD, on the draft 2022 WSMP Annual Report, have been compiled along with responses from Grant PUD (Appendix B). Washington Department of Ecology approved the 2022 PLMP Annual Report on March 10, 2023.

2.0 Methods

Study methods used in 2022 were similar to previous studies (Golder 2016, 2022), with similar approaches and levels of effort applied for the study components common to each year. The 2022 study components included hatchery juvenile White Sturgeon tagging and release, and juvenile White Sturgeon population indexing.

The following sections provide general descriptions of methods used and details where the 2022 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 12, 2022 were obtained from the Columbia River Data Access in Real Time webpage (DART 2022).

2.2 2021BY Rearing and Marking, and Release

Approximately 3,250 2021BY juvenile hatchery White Sturgeon were reared at the YNSH in 2022. The 2022 release strategy was based on the SOA prescription, with 62% of fish (2,015 fish) released in Wanapum reservoir and the remaining 38% (1,235 fish) released in Priest Rapids reservoir.

The 2021BY juvenile White Sturgeon were the progeny of a 6Fx6M spawning matrix conducted on June 10, 2021 at YNSH. Six females were to be crossed with six males to produce 36 genetic crosses; however, one of the six females yielded only enough eggs to produce a 1Fx2M spawning matrix that resulted in two genetic crosses. In total, 32 genetic crosses were produced for the 2022 supplementation release. The progeny of each maternal family was kept in separate tanks and were reared for approximately 10 months prior to tagging and release in April 2022.

Tagging and marking of the 2021BY held at YNSH was conducted by Grant PUD biologists, YNSH staff, and BLE staff. Prior to tagging, blood samples were extracted from the caudal vein of each fish, prepared, and tested with a Coulter counter to determine if the fish was 8N (i.e., normal genetic composition) or either 10N or 12N (autopolyploidy). Approximately equal numbers of fish from the six maternal families were tested during the 2022 tagging effort. Only fish that tested negative for spontaneous autopolyploidy were processed, tagged, and then transferred to either the Wanapum or Priest Rapids release holding tanks. All 2021BY White Sturgeon received a 12.5 mm, 134.2 kHz ISO full-duplex passive integrated transponder (PIT) tag (Biomark®) inserted on the left side of the fish at the base of the 4th dorsal scute, with the tag oriented with the body axis towards the head of the fish. Each tagged fish was externally marked by removing the three left-lateral scutes anterior of an imaginary vertical line extended downward from the origin of the dorsal fin (Figure 2). This mark was to indicate that the fish was a direct gamete origin hatchery fish. Fish were then measured for fork length, weighed, and assessed for the presence of fin deformities. If a fish was in poor disposition after tagging (e.g., lethargic, unable to maintain orientation), the fish was not released.

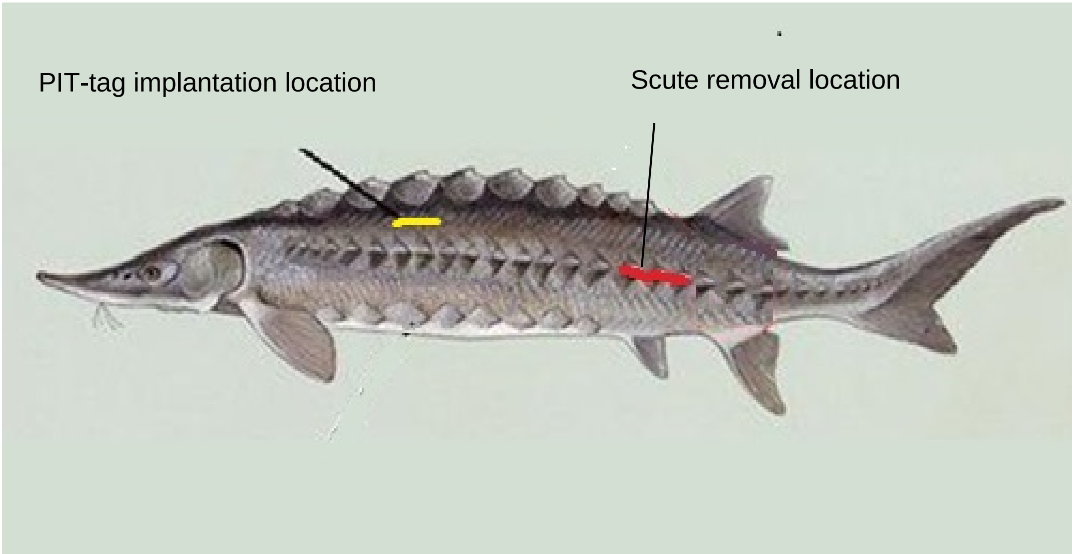

Figure 2 Juvenile White Sturgeon tag implantation and mark locations.

Tagging logistics and data collection were coordinated by BLE staff, 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 a Biomark P4 data processing program. BLE staff were responsible for implementing appropriate quality control/quality assurance protocols (e.g., fish handling and processing methods, daily data verification, and data backups) during fish processing and data recording. The data fields recorded were selected to document the genetic origin, holding water temperature, disposition, fin abnormalities, and the identifying tags and marks applied to each fish (Table 1).

Table 1 Data recorded in Biomark P4 for the 2021BY White Sturgeon tagged and released in the Priest Rapids Project Area in 2022.

Data Field	Description
Session	Project Code – Year – Session ID
Project Code	GCS
Session Message	Record Release Pool (Wanapum or Priest Rapids) and Parental Family (1-6)
Rec #	Sequential record number
PIT-Tag Code	HEX format
SRR code	Three-character code that identifies the species (White Sturgeon), run, and rear type of fish (B0W)
Event Type	Mark
Length (mm)	Measured for all fish; tip of snout to tail fork (nearest 1 mm)
Weight (g)	Measured for all fish (nearest 1 g)
Event Site	Yakama Nation Sturgeon Hatchery (YNSH)
Text Comments	Recorded fin deformities
Event Date	Date and time when each fish was tagged
Event Site	YNSH
Life Stage	Juvenile
Brood Year	2021
Spawn Year	2021
Release Site	COLR7
RKm Mask	0
Organization	GPUD
Capture Method	None
Mark Method	Hand
Mark and Holding Temperature	In Celsius
Hatchery	MSDH (YNSH)

2021BY Releases

In 2022, juvenile White Sturgeon were held in the hatchery post-tagging for a prescribed duration by the hatchery manager to allow recovery from the tagging process prior to release. The release of 2021BY fish into the PRPA was coordinated by Grant PUD biologists and technicians, who worked with staff from the YNSH. In 2022, fish destined for Wanapum reservoir were released at the Vantage boat launch (RM420.6), while fish destined for Priest Rapids reservoir were released at the Desert Aire boat launch (RM400.3). Fish releases to each reservoir were conducted on the same day.

Transport and release of the 2021BY fish was conducted using a Grant PUD hatchery fish transport truck and a Grant PUD pick-up truck pulling a custom sturgeon transport trailer. Both transport vehicles were equipped with onboard oxygen regulation systems to maintain oxygen levels during transport. During the transfer, staff monitored water temperature and dissolved oxygen levels as follows:

- within the holding and transport vehicle tanks during fish transfer from holding tanks to the transport vehicle at YNSH;
- within the transport vehicle tank during transport at two scheduled check stops 40 minutes apart; and,
- within the transport vehicle tank and the receiving waters 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 area 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 shed PIT tags, and if found, the PIT tag numbers were recorded for later removal from the record set.

2.3 Broodstock Capture

Since 2015, broodstock capture efforts 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. In 2022, Grant PUD and BLE biologists angled below McNary Dam to capture adult White Sturgeon as broodstock. Captured White Sturgeon were surgically examined by a BLE biologist to determine sex and maturity. Mature fish identified as candidate broodstock were transported to the YNSH by BLE staff in the Grant PUD sturgeon transport trailer for further examination and gamete extraction.

2.4 Juvenile White Sturgeon Population Indexing

The methods used during the 2022 juvenile White Sturgeon population indexing program were consistent with standardized methodologies applied during indexing studies conducted since 2016 (Golder 2015–2022). In addition, in 2022, fish processing included removing pectoral fin ray sections from captured wild juvenile White Sturgeon under 100 cm FL. These fin ray samples were sent to sturgeon biologists of the Confederated Tribes of the Colville Reservation for age analysis to examine the relationship between successful natural recruitment and flow year. In 2022, a pressure triggered fish descender was used during fish processing to return fish with over-inflated abdominal cavities to depth.

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. Set lines were left to sample overnight (i.e., defined as "overnight set" or approximately 24-hours) and were retrieved and reset the following day.

Consistent with previous study years, Generalized Random-Tessellation Stratified (GRTS) probability sampling was used to select sample sites, with set line locations in 2022 selected using a single pass, unstratified, unequal probability GRTS sampling design (Stevens and Olsen 2004). The GRTS sample locations were pre-selected using the spsurvey package (Kincaid 2007) developed for the R statistical program (R version 4..2.1; R Core Team 2022). The 2022 survey used the same sample multi-density reservoir categories (lower, middle, and upper sections), the boundaries for which were established in previous study years (e.g., Golder 2015).
The Wanapum reservoir GRTS sample sites were constrained within each section of the reservoir to locations were water depth was 15 m or greater, based on bathymetric data. In Priest Rapids reservoir, site selection within each section 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 section were selected to exclude shallow water areas within the lower, middle, and upper reservoir sections that exhibit dense aquatic macrophyte growth.

In Wanapum reservoir, 270 sites (with a 50% overdraw) were drawn, with sites allocated equally among the three reservoir sections (i.e., 90 sites per section). In Priest Rapids reservoir, 90 sites (with 50% overdraw) were drawn, with sites allocated equally among reservoir sections (i.e., 30 sites per section). In both reservoirs, sampling intensity increased from downstream to upstream sections because the areal extent of each section progressively decreased moving upstream. In 2022, set line deployment and retrieval, catch processing, and data recording were conducted in a manner consistent with previous indexing studies (Golder 2022).

The relationship between White Sturgeon fork length and weight (log10 transformed) data was estimated via linear regression for each reservoir separately. Condition was estimated by calculating relative weight based on the standard weight (Ws) equation for White Sturgeon: $Ws = 2.735\ E\text{-}6 * FL^{3.232}$ (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 relative abundance between the two reservoirs and reservoir sections within each reservoir.

2.5 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 compare growth rate among brood years within and between reservoirs and to assess whether growth rates slowed as sturgeon density in the reservoirs increased. All analyses were performed using the package FSA (Ogle et al. 2020) in the statistical environment R v. 4.2.1 (R Core Team 2022).

For each reservoir, a separate von Bertalanffy model was constructed for all brood years releases in Wanapum and Priest Rapids reservoirs. Change in fork length (growth) at age was modeled for brood years with sufficient data to allow the model to converge. These growth curves were overlaid to visually assess differences in growth between the different brood years within and between the two reservoirs.

Since 2014, a Cormack-Jolly-Seber model has been used to estimate the survival of hatchery juvenile White Sturgeon in Wanapum and Priest Rapids reservoirs using mark-recapture data collected during the juvenile White Sturgeon sampling programs. In 2022, the analysis was conducted using the statistical environment R v. 4.2.1 (R Core Team 2022), interfaced with Program MARK (White and Burnham 1999) through the package 'RMark' (Laake 2013). Recapture data for fish that moved to a different reservoir were removed from the dataset – that is, any recaptures that took place after the immigration, were removed from the analysis. A total of 247 fish moved between reservoirs, of which, 246 moved from Wanapum reservoir into Priest Rapids reservoir; only one fish moved from Priest Rapids reservoir upstream to Wanapum reservoir. Since the two reservoirs were analyzed together, this approach meant that fish that were entrained from Wanapum reservoir were correctly modeled as being lost from the population in Wanapum reservoir, but these same fish were not added to the population in Priest Rapids reservoir. Since only a small proportion of all recaptured fish were shown to have migrated (247 fish out of a total of 3,656 fish that were recaptured at least once; 6.8%), a large bias in the population estimates of Priest Rapids reservoir is unlikely. Due to the size selectivity of the small-hook set line sampling gear, model estimated abundances were only applicable for the proportion of the hatchery White Sturgeon population within the size range susceptible to capture by the small-hook juvenile sampling gear (i.e., approximately between 30 cm FL and 140 cm FL). Differences in annual stocking rates, size at release, and growth rates among brood year releases were other variables identified that likely affect model abundance estimates.

Only hatchery fish released in the PRPA between 2011 and 2021 were included in the analysis. Wild fish and fish that were released elsewhere and entrained into the PRPA (i.e., fish originating from Rocky Reach reservoir) were removed from the analysis.

Brood year was included as a predictor in the estimates of survival. The 2010BY was allowed to have two separate estimates of survival – one estimate encompassed the cull/fishery period in 2015/2016, and another estimated covered the time outside of this cull/fishery period. Models were constructed using all combinations of the following survival and recapture specifications:

a) Survival:
    a. as an additive function of brood year and first year post-release and all subsequent years – i.e., survival differed between brood years, and the survival for first year post-recapture survival was allowed to be different than survival in all subsequent years.

   b. as a multiplicative function of 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.
   c. as a multiplicative function of reservoir and brood year, with an additive effect of 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 a multiplicative function of reservoir and age (as a categorical variable) – i.e., recapture by age was allowed to vary independently by release reservoir.
   b. as a multiplicative function of reservoir and age (as a categorical variable), with an additive effect of brood year

The candidate models were evaluated using quasi-likelihood-adjusted Akaike's Information Criterion corrected for small sample size (QAICc), where a lower value indicated 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 2022. 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 2021BY released in 2022. To account for the 2021BY abundance, the total number of 2021BY fish released in 2022 was used as the abundance of that brood year.

2.6 General Data Recording and Analysis

In 2022, copies of the juvenile White Sturgeon indexing databases, 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. When White Sturgeon were captured during PRPA White Sturgeon population indexing assessments, their scute patterns were assessed, and they were assigned a "H-123LAD" designation if they were of YNSH origin (2010BY-2019BY), assigned a 'H-CRITFC" designation if they were of CRITFC origin (2002BY), or they were considered a wild fish ("W") if identifying scute marks were not found or if they were previously marked as a wild fish (i.e., if the second left or second right scute was removed). Field databases were proofed for errors and then merged into a final database for each study component. 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 histories of hatchery juvenile White Sturgeon. Additional post-collection error screening and data proofing was conducted using the statistical environment R, v. 4.2.1 (R Core Team 2022). Summary tables and data checks were conducted in Excel®. All 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 2022, peak mean daily flows in the PRPA, as measured in Wanapum reservoir downstream of Rock Island Dam, were recorded on June 27 (8,212 m³/s; DART 2022). Lowest mean daily discharge was recorded on October 23 (1,049 m^3/s). Peak mean daily water temperature in the PRPA, as measured in Wanapum reservoir downstream of Rock Island Dam, was recorded on September 2 (20.1°C). The lowest mean daily water temperature was recorded on February 9 (2.0°C; Figure 3). A peak discharge volume in the PRPA of 27,292 kilo-acre feet (KAF) was recorded in June; total discharge volume in 2022 was 89,628 KAF (NOAA 2022).

2021BY Hatchery Juvenile White Sturgeon Release

Hatchery juveniles are typically released into the PRPA in late spring after the fish recuperate from tagging and to time the release with the rising hydrograph and when the receiving water temperatures range from 8°C to 12°C. The release of the 2021BY was conducted on April 27, immediately prior to the ascending limb of the seasonal hydrograph (Figure 3). At release, the mean daily discharge was 2,598 m^3/s and the mean daily water temperature was 7.8°C.

Juvenile White Sturgeon Population Indexing

Juvenile White Sturgeon indexing was conducted from September 13 to October 20, 2022, when flows approached seasonal lows and water temperatures gradually decreased from seasonal highs (Figure 3). During sampling, average mean daily discharge was 1,787 m^3/s (SD = ±297 m^3/s), with substantial fluctuations between a low of 1,238 m^3/s on October 15 and a high of 2,494 m^3/s on September 27. 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 18.4°C (SD = ±0.7°C) and ranged between 17.3°C and 19.3°C.

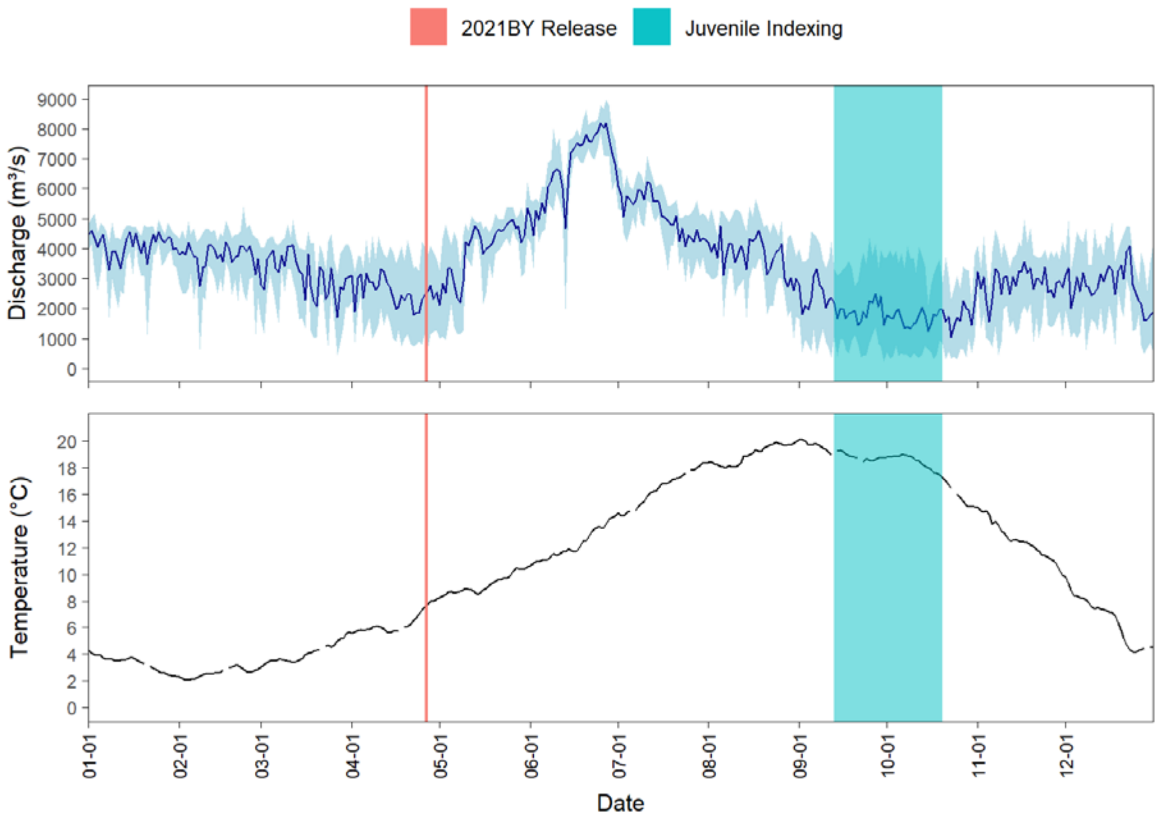

Figure 3 Mean daily discharge (dark blue line), mean hourly discharge (light blue ribbon), and mean hourly water temperature (black line) of the Columbia River in the Priest Rapids Project Area, as measured below Rock Island Dam in 2022. The timing of the 2021BY juvenile White Sturgeon release is highlighted by the red column and the timing of the juvenile White Sturgeon indexing program is highlighted by the blue column.

3.2 2021BY Hatchery Juvenile White Sturgeon Marking and Release

All 2021BY were tested for spontaneous autopolyploidy, processed, and tagged from March 28 to April 1, 2022. The 2021 Grant PUD juvenile White Sturgeon release was limited to individuals that tested negative for spontaneous autopolyploidy. In total, 6 autopolyploidy fish were identified out of the fish tested (Chris Mott, Grant PUD, personal communication, April 28, 2022).

All fish were released on April 27, which was 26-30 days after tagging. A total of 3,269 fish were released in the Project area. In accordance with the SOA, 2,010 fish (62%) were released in Wanapum reservoir at the Vantage boat launch (RM420.6) and 1,259 fish (38%) were released in Priest Rapids reservoir at the Desert Aire boat launch (RM400.3; Table 2). Mean fork length of the 2021BY when tagged was 289 mm (SD = ± 41 mm) and mean weight was 153 g

(SD = ±62 g). Fish released into Wanapum and Priest Rapids reservoirs were of similar size (Table 2).

During transport, oxygen levels in the transport tanks were maintained between 11.2 and 12.2 mg/L and the variation in the transport tank water temperature over the course of the transport was less than 1.5°C. At release, the difference in temperature between the transport water and the receiving water was less than 1°C. Shed PIT tags were not found in the hatchery rearing tanks or in the holding tanks of the transport vehicles. Mortalities were not recorded during transport. All fish were successfully released alive and immediate post-release mortalities were not observed by the crew.

Table 2 Number of 2021BY juvenile White Sturgeon released into Wanapum and Priest Rapids reservoirs, and the mean fork length (FL) and mean weight of fish in each release, April 27, 2022.

	2022 White Sturgeon 2021BY Release		
Release Location Reservoir (River Mile)	**No. of Fish**	**Mean FL (± SD) mm**	**Mean Weight (± SD) g**
Wanapum (420.6)[1]	2,010	290 (±40)	157 (±61)
Priest Rapids (400.3)[2]	1,259	287 (±43)	150 (±63)
Total	3,269	289 (±41)	153 (±62)

[1] Vantage boat launch

[2] Desert Aire boat launch

During tagging of the 2021BY, one or more fin deformities were recorded in 46% of the fish processed (i.e., 1,507 of the 3,269 fish tagged). Of fins deformities noted, deformity of the pectoral fin was most common (n = 1,335 of 1,507 fish with fin deformities).

3.3 2022 Broodstock Capture and 2022BY Production

During the 2022 broodstock capture efforts, over 10 days from May 16 to 20 and May 23 to 27, a total of 101 individual White Sturgeon were captured, with 2 of those fish captured twice (i.e., 103 encounters). Of these, 66 individual White Sturgeon considered adults by size (i.e., greater than 150 cm fork length) were captured. In total, 6 ripe females and 6 ripe males were transported to YNSH for further examination and gamete extraction. On June 15, a 6Fx6M spawning matrix was conducted and sufficient gametes were obtained to produced 36 genetic families for the 2022BY.

3.4 Juvenile White Sturgeon Population Indexing

Juvenile White Sturgeon population indexing in Priest Rapids and Wanapum reservoirs was conducted from September 13 to October 20, 2022. 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 Priest Rapids and Wanapum reservoirs (Table 3).

The mean water depth and the range of depths sampled was greater in Wanapum reservoir (mean = 20.3 m; range = 11.0 to 38.0 m) than in Priest Rapids reservoir (mean = 11.0 m; range = 3.1 to 25.0 m). Mean water depth in the upper section of Wanapum reservoir was slightly lower compared to mean depth in the lower and middle sections, whereas in Priest Rapids reservoir, the mean water depth in the lower section of the reservoir was notably deeper (14.8 m) than in the middle (9.5 m) and upper (8.6 m) sections. At some sample sites, minimum water depths were less than the bathymetric minimum depth criteria for each reservoir (i.e., less than 15 m in Wanapum reservoir and less than 6 m in Priest Rapids reservoir) were recorded due to variation in bathymetry over the length of the deployed set line.

All set lines were intended to be deployed overnight for approximately 24 hours, but actual deployment duration varied between 17.4 and 24.8 hours. Sample durations less than 24 hours were typically due to variations in deployment and retrieval order.

Table 3 **Details of GRTS sample site distributions 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, September 13 to October 20, 2022.**

	Reservoir							
	Priest Rapids (6 m Bathymetric Contour)				Wanapum (15 m Bathymetric Contour)			
	Lower	Middle	Upper	All	Lower	Middle	Upper	All
Number of GRTS sites sampled per section	30	30	30	90	90	90	90	270
Sampling area (ha)	1,369	346	213	1,928	1,664	727	308	2,699
Samples/100 ha	2.2	8.7	14.1	4.7	5.4	12.4	29.2	10.0
Sample depths (m)								
mean	14.8	9.5	8.6	11.0	21.1	20.5	19.5	20.3
min	6.0	3.2	4.0	4.4	11.7	11.5	11.0	11.4
max	25.0	14.2	14.0	17.7	36.5	36.0	38.0	36.8
Sample duration (h)								
mean	20.8	20.6	21.7	21.0	20.8	21.6	21.6	21.3
min	19.3	18.2	20.8	19.4	17.6	17.9	16.8	17.4
max	22.2	22.3	22.9	22.4	23.0	24.9	26.5	24.8

3.4.1 2022 Juvenile White Sturgeon Indexing Catch

In total, 687 White Sturgeon were captured and processed during the juvenile White Sturgeon indexing program in Priest Rapids (n = 189) and Wanapum (n = 498) reservoirs (Figure 4; Table 4). These captures represented 671 individual fish, as 16 fish were captured twice in Wanapum reservoir; no fish were captured more than once in Priest Rapids reservoir. Four wild juvenile White Sturgeon were captured in the PRPA in 2022; a pectoral fin ray section was obtained from these fish and were later provided to biologists with Confederated Tribes of the Colville Reservationfor ageing. Incidental captures were primarily Northern Pikeminnow (*Ptychocheilus oregonensis*; n = 52 in Priest Rapids reservoir; n = 64 in Wanapum reservoir). Within Priest Rapids reservoir, incidental catch of Largescale Sucker (*Catostomus macrocheilus*; n = 2) and Channel Catfish (*Ictalurus punctatus;* n = 14) were also recorded. Within Wanapum reservoir, a single sculpin (*Cottus sp.*) was also captured.

In Priest Rapids reservoir, the 2014BY (42 of 189 fish; 22%) and the 2013BY (42 of 189 fish; 21%) contributed the largest proportions to the total catch. Fewer fish from the 2012BY (25 of 189 fish; 13%), 2015BY (18 of 189 fish; 10%), 2018BY (13 of 189; 7%), 2017BY (11 of 189 fish; 6%) and 2016BY (9 of 189 fish; 5%) brood years were captured. Other brood years (i.e., 2010BY, 2019BYa, 2019BYb, and 2021BY), were captured in low numbers and contributed less than 7% to the total catch combined. The oldest hatchery fish, the 2002BY, were not captured in Priest Rapids reservoir in 2022.

Three wild juvenile White Sturgeon were captured in Priest Rapid reservoir in 2022. Unknown hatchery fish, which are fish that were identified as hatchery fish based on scute markings but could not be assigned to a specific brood year, contributed 6% (11 of 189 fish) to the total catch.

In Wanapum reservoir, the 2017BY (91 of 498 fish; 18%), 2018BY (89 of 498 fish; 18%), and 2014BY (80 of 498 fish; 16%) contributed the largest proportion to the total catch. Fewer numbers of 2013BY (56 of 498 fish; 11%), 2015BY (44 of 498 fish; 9%), 2012BY (40 of 498 fish; 8%), and 2021BY (24 of 498 fish; 5%) fish were captured. Other brood years (i.e., 2010BY, 2016BY, 2019BYa, 2019BYb, and 2021BY) were captured in low numbers and contributed less than 12% of the total catch combined. The oldest hatchery fish, the 2002BY, were not captured in Wanapum reservoir in 2022.

One wild juvenile White Sturgeon was captured in Wanapum reservoir in 2022. Unknown hatchery fish, which are fish that were identified as hatchery fish based on scute markings but could not be assigned to a specific brood year, contributed 2% (11 of 498 fish) to the total catch.

A proportion of the hatchery fish originally released in Wanapum reservoir, that subsequently were entrained and captured in Priest Rapids reservoir, contributed a substantial proportion to the total Priest Rapids reservoir catch (n = 65 of 189 fish; 34%; Table 4). For specific brood years, entrained fish contributed 50% to the 2014BY catch (21 of 42 fish) and 60% to the 2013BY catch (24 of 40 fish) within Priest Rapids reservoir. Low numbers of fish from 2010BY to 2016BY that were originally released in either Rocky Reach reservoir (n = 3 fish) or Wells reservoir (n = 4 fish) were captured in Priest Rapids (n = 1) and Wanapum (n = 6) reservoirs.

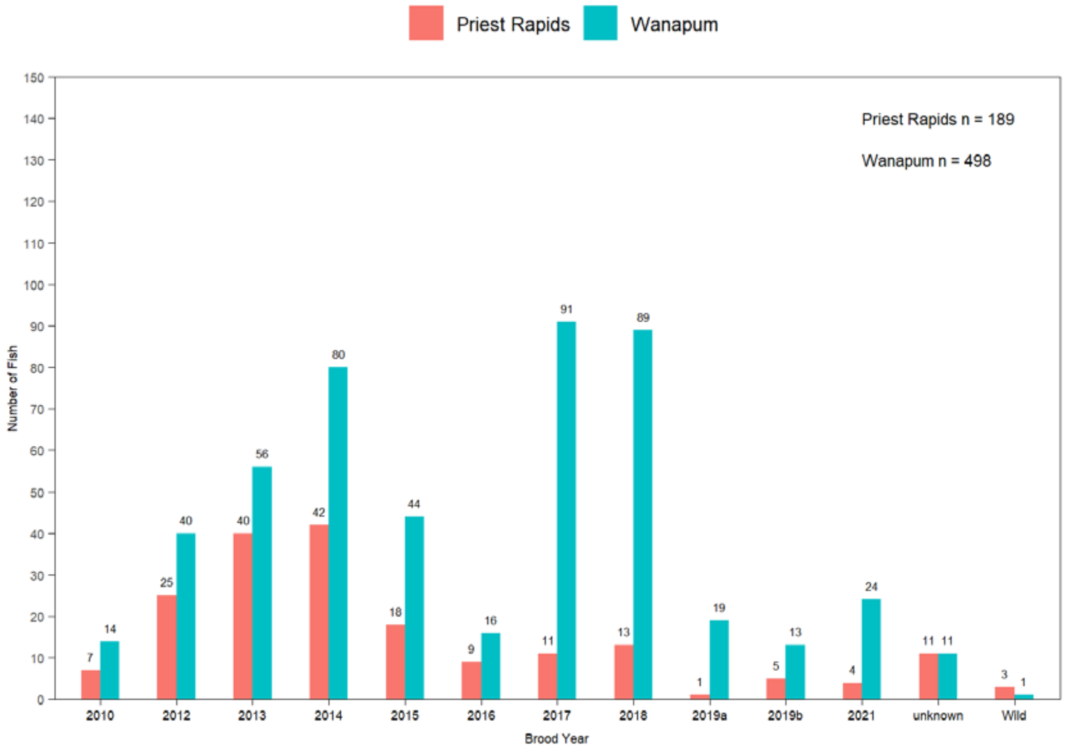

Figure 4 **Summary of hatchery and wild White Sturgeon captured in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022. The Unknown category represents fish suspected to be of hatchery origin but without a PIT tag to allow identification of origin or brood year.**

Table 4 Summary of hatchery and wild White Sturgeon captured in the Priest Rapids Project Area during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.

		Capture Reservoir		
Brood Year	Release Reservoir	Priest Rapids	Wanapum	Total
Upstream Releases				
2002	Rock Island	0	0	0
2012	Rocky Reach	-	1	1
2013	Rocky Reach	-	1	1
2016	Rocky Reach	-	1	1
2010	Wells	1	1	2
2013	Wells	-	1	1
2015	Wells	-	1	1
PRPA Releases				
2010	Priest Rapids	3	-	3
	Wanapum	3	13	16
2012	Priest Rapids	21	-	21
	Wanapum	4	39	43
2013	Priest Rapids	16	-	16
	Wanapum	24	54	78
2014	Priest Rapids	21	-	21
	Wanapum	21	80	101
2015	Priest Rapids	13	-	13
	Wanapum	5	43	48
2016	Priest Rapids	7	-	7
	Wanapum	2	15	17
2017	Priest Rapids	7	-	7
	Wanapum	4	91	95
2018	Priest Rapids	12	-	12
	Wanapum	1	89	90
2019a	Priest Rapids	1	-	1
	Wanapum	-	19	19
2019b	Priest Rapids	5	-	5
	Wanapum	-	13	13
2021	Priest Rapids	3	-	3
	Wanapum	1	24	25
Unknown[1]	NA	11	11	22
Wild	NA	3	1	4
Total		189	498	687

[1]Considered to be of hatchery origin based either on the presence of a PIT tag, marks, or substantial fin deformity, but brood year, source, or stocking location data are unknown.

3.4.2 Catch Rates and Distribution

In total, 306,342 hook-hours of set line sample effort were expended during the 2022 juvenile White Sturgeon indexing program (Table 5). Overall, CPUE in the PRPA was 0.22 fish/100 hook-hours, with higher CPUE recorded in Priest Rapids reservoir (0.25 fish/100 hook-hours) than in Wanapum reservoir (0.22 fish/100 hook-hours). In Priest Rapids reservoir, the highest CPUE was recorded in the upper section of the reservoir (0.36 fish/100 hook-hours), followed by the lower section (0.25 fish/100 hook-hours), with the lowest CPUE recorded in the middle section (0.15 fish/100 hook-hours). In Wanapum reservoir, the highest CPUE was recorded in the upper section of the reservoir (0.30 fish/100 hook-hours), followed by the middle section (0.23 fish/100 hook-hours), with the lowest CPUE recorded in the lower section (0.11 fish/100 hook-hours).

The proportion of set lines that captured one or more fish (Ep) was slightly higher in Wanapum reservoir (Ep = 0.66) than in Priest Rapids reservoir (Ep = 0.62; Figure 5). The difference in Ep between the two reservoirs did not correspond to CPUE due to substantially higher catch on select set lines in Priest Rapids reservoir compared to Wanapum reservoir, As an example, the highest catch on a single setline in Priest Rapid reservoir was 23 fish, while the highest catch on a single setline in Wanapum reservoir was 11 fish. In Priest Rapids reservoir, a slightly higher Ep was recorded in the lower section (Ep = 0.73) compared to the upper section (Ep = 0.67); the lowest Ep was recorded in the middle section (Ep = 0.47), where only 14 of 30 set lines captured fish. In Wanapum reservoir, Ep in each section aligned with corresponding CPUE estimates for these sections, with the highest Ep recorded in the upper section (Ep = 0.77), followed by the middle section (Ep = 0.71), and the lower section (Ep = 0.50).

Table 5 Total set line sample effort, catch, and CPUE in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.

Reservoir	Reservoir Section	Sample Effort (hook-hours)	Catch (Number of fish)				CPUE (Fish/100 hook-hours)			
			Wild	H-123LAD	2002BY	Total	Wild	H-123LAD	2002BY	Wild & Hatchery
Wanapum	Lower	74,830	0	82	0	82	0.000	0.11	0.000	0.11
	Middle	77,678	0	178	0	178	0.000	0.23	0.000	0.23
	Upper	78,333	1	237	0	238	0.001	0.30	0.000	0.30
	All	230,841	1	497	0	498	0.000	0.22	0.000	0.22
Priest Rapids	Lower	24,894	1	60	0	61	0.004	0.24	0.000	0.25
	Middle	24,700	0	36	0	36	0.000	0.15	0.000	0.15
	Upper	25,907	2	90	0	92	0.008	0.35	0.000	0.36
	All	75,501	3	186	0	189	0.004	0.25	0.000	0.25
PRPA	Total	306,342	4	683	0	687	0.001	0.22	0.000	0.22

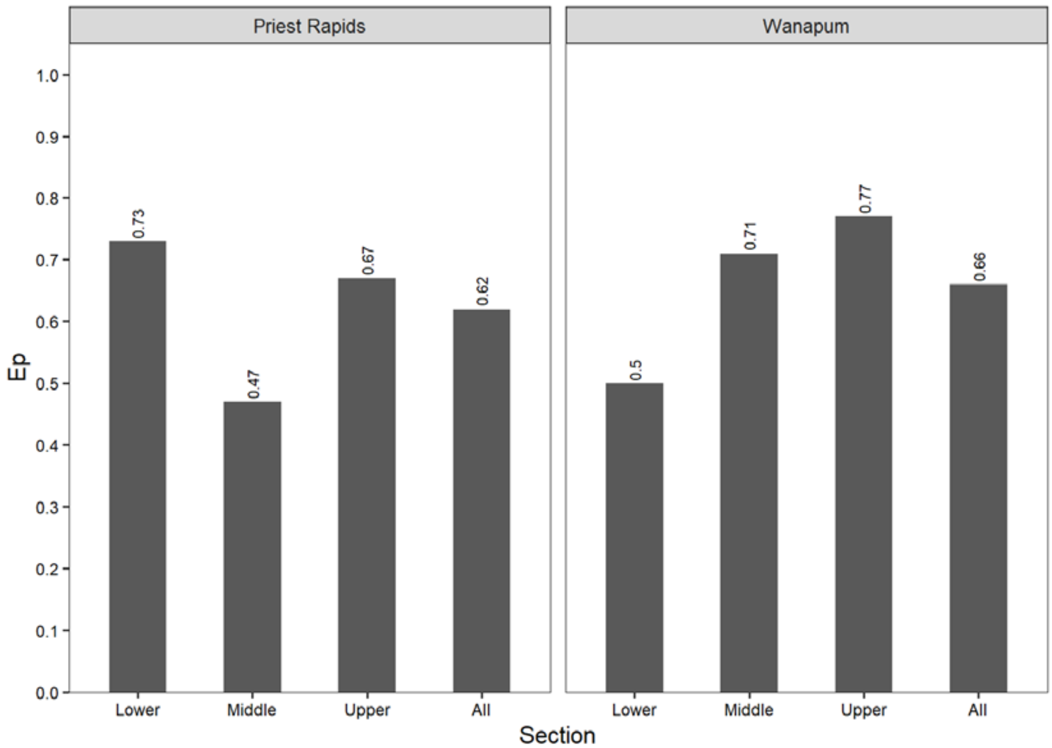

Figure 5 **The proportion of positive catches (Ep) recorded in the Priest Rapids Project area within the lower, middle, and upper section of each reservoir during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.**

In Priest Rapids reservoir, 34 of the 90 set lines deployed (38%) did not catch fish, with a higher proportion of zero-catch effort recorded in the middle section (57%) than in the upper (33%) and lower (27%) sections. In Wanapum reservoir, 92 of the 270 set lines deployed (34%) did not catch fish, with a higher proportion of zero-catch efforts recorded in the lower section of Wanapum reservoir (50%) than in the middle (29%) and upper (23%) sections of the reservoir (Figure 6). 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 in both reservoirs in 2022. In Priest Rapids reservoir, approximately 3% of the set lines deployed (i.e., 3 of 90 set lines), captured between 14 and 23 fish each, which equated to 31% of the total catch (58 of 189 fish). The three high-catch sites in Priest Rapids reservoir were in the upper section of the reservoir. The fourth highest catch in a single site (20 fish captured) was in the middle section and accounted for 50% of the catch in that section. In Wanapum reservoir, fish were less aggregated, in that 3% of the set lines deployed (8 of 270 set lines) captured between 7 and 11 fish each, which contributed only 13% to the total catch (66 of 498 fish).

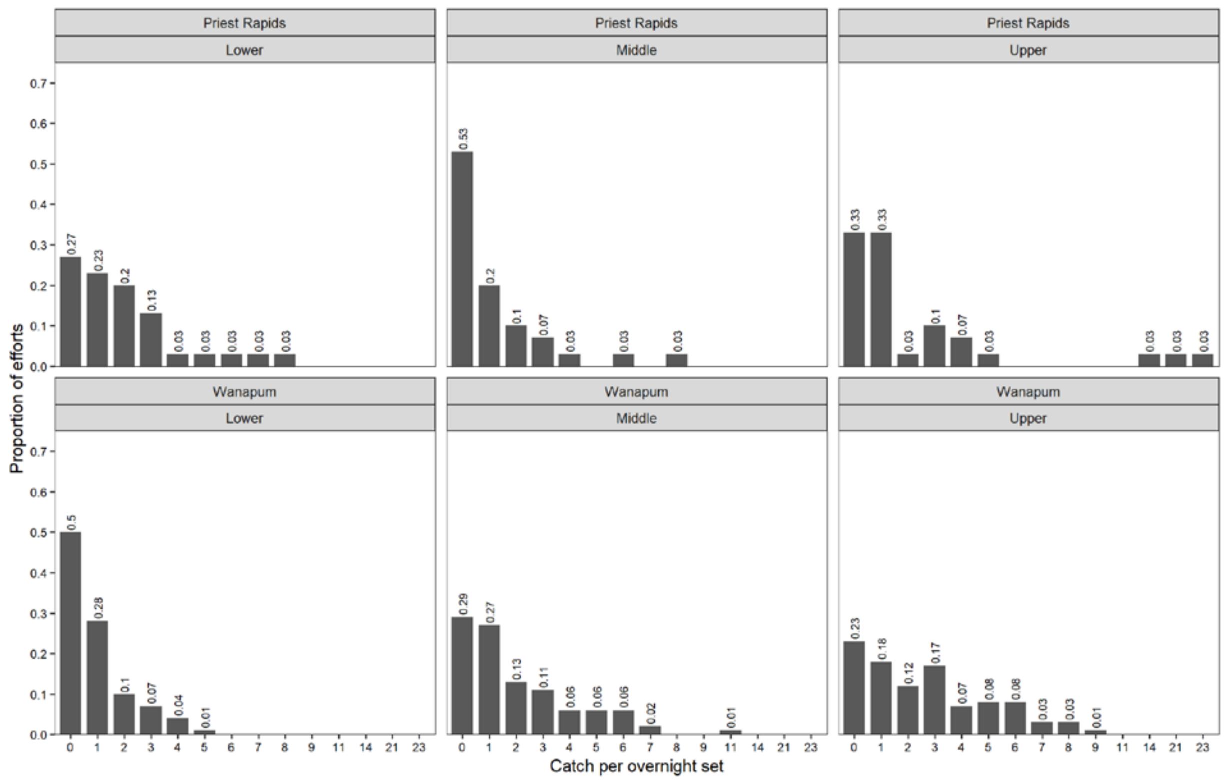

Figure 6 **Frequency histograms of White Sturgeon catch-per-overnight-set in the Priest Rapids Project Area during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.**

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 7).

In Priest Rapid reservoir, similar CPUEs were recorded at most River Miles within the lower section of the reservoir, with the highest CPUE recorded near the upstream boundary of the lower section near RM403. CPUE was very low for a large portion of the middle section, with the highest CPUE in this section recorded at a localized area near RM408. In the upper section, the highest CPUE was in the Wanapum Dam tailrace area near RM415, which had the highest CPUE values within the entire reservoir.

In Wanapum reservoir, CPUE was low throughout most of the lower section but increased near RM425. In the middle section, CPUE was uniformly low from RM428 to RM438, but increased slightly from RM439 to RM440. In the upper section, CPUEs were lower from RM441 to RM449, but increased from RM450 to RM452. The high CPUE at RM452 was due, in part, to a moderately high catch (i.e., 8 fish) on a single line deploy at the location.

Figure 7 **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 September 13 to October 20, 2022.**

In Priest Rapids reservoir, based on the distribution of fish by brood year as measured by Ep, the 2014BY were the most abundant brood year in all sections of the reservoir, followed by the 2013BY in the lower and upper sections, the 2012BY in the upper section, and a uniform prevalence of the 2015BY in all three reservoir sections. The 2013BY and 2014BY were the dominant catch in the lower section of the reservoir. All brood years, with the exceptions of the 2019BYa cohort, were captured in the lower section, which included modest numbers of the 2016BY, 2017BY, and 2018BY. Older fish (i.e., 2015BY or older) were more prevalent in the 2022 catch than younger fish in all reservoir sections, but particularly within the lower and upper section of Priest Rapids reservoir (Figure 8). Wild fish were captured in the upper and lower sections, but not in the middle section. The 2019BYa were not captured in the lower or middle sections and were captured only in low numbers in the upper section of Priest Rapids reservoir. 2021BY fish were captured in all sections of the reservoirs, indicating that these fish dispersed upstream from their release location in the lower section of the reservoir.

In Wanapum reservoir, fish from each brood year, wild fish, and unknown hatchery fish were recorded in the upper section. The highest Eps were associated with the 2018BY, the 2017BY, and the 2014BY in the middle and upper sections of the reservoir. Excluding the 2017BY and the 2018BY, the distribution Eps were similar in the middle and upper sections for the 2016BY and older fish captured in these sections. Low numbers of the 2019BYa, the 2019BYb, and the 2021BY were captured in all reservoir sections, with high Eps recorded for 2021BY fish in the middle and upper sections of the reservoir, upstream of their release location in the lower section of the reservoir. A single wild fish was captured in the upper section of the reservoir.

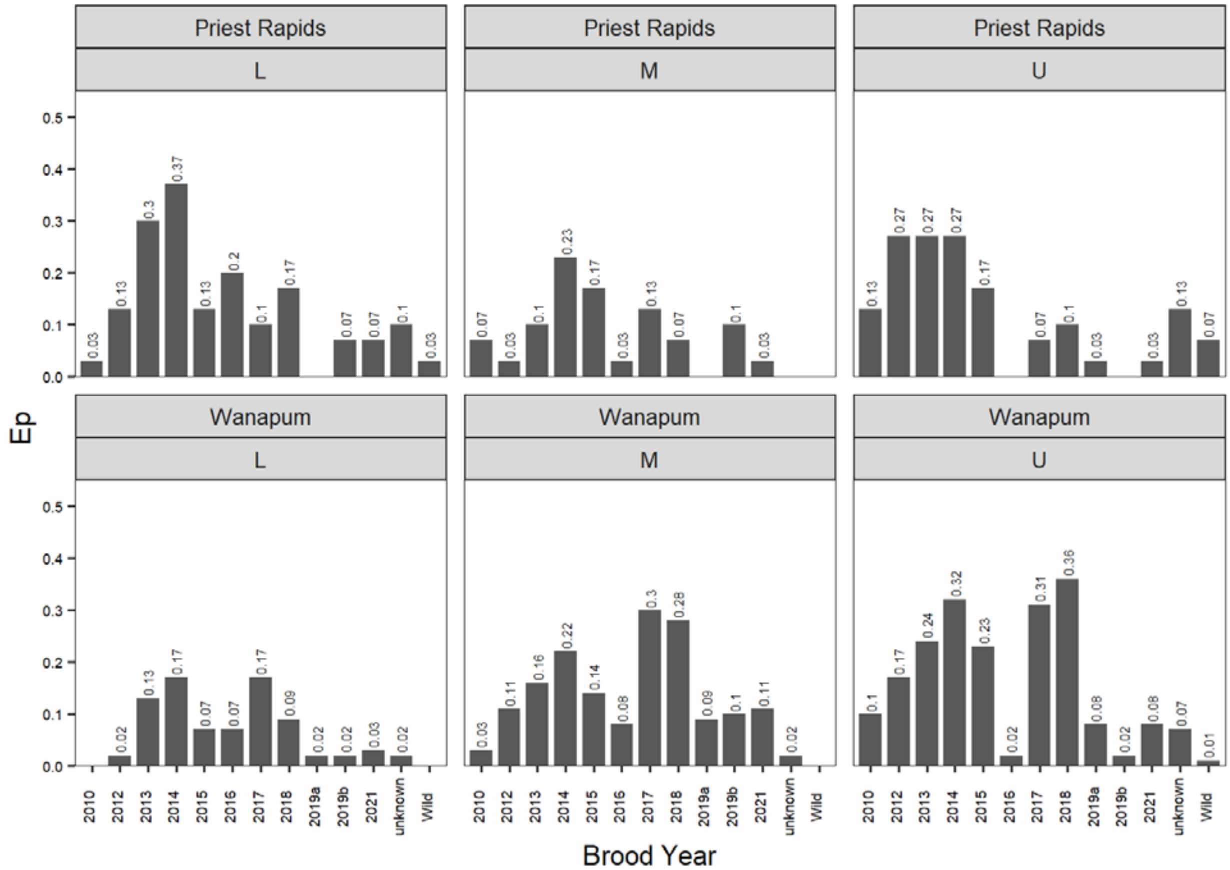

Figure 8 **The proportion of positive catch (Ep) of wild and hatchery White Sturgeon in the lower, middle, and upper sections of Priest Rapids and Wanapum reservoirs recorded during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.**

3.4.3 White Sturgeon Size Distribution

In total, 671 individual White Sturgeon were captured and measured for fork length (FL) during the 2022 juvenile White Sturgeon indexing program in the PRPA. In Priest Rapids reservoir, these fish ranged from 37.5 to 127.0 cm FL (mean = 75.6 cm FL; n = 189; Table 6). In Wanapum reservoir, these fish ranged from 33.0 to 136.5 cm FL (mean = 70.9 cm FL; n = 482).

The length-frequency distributions of brood years 2010BY through 2021BY captured in Priest Rapids and Wanapum reservoirs exhibited a substantial overlap among brood years, with overlap among all brood years, with the exception of the oldest (2010BY) and youngest (2021BY) brood years. In both reservoirs, the spread of the length frequency distribution was low for younger fish and increased as fish aged. In Priest Rapids reservoir, length frequencies generally overlapped and frequency of any single 10 cm fork length bin did not exceed 6% within any brood year; distinct modes were not evident in any brood year (Figure 9). In Wanapum reservoir, the distribution of lengths was similar to the distribution of lengths for each corresponding brood year in Priest Rapids reservoir. The 2018BY distribution exhibited a stronger mode (percent frequency 10%) that suggested a predominant size class of between 50.0 and 59.9 cm FL for this brood year (Figure 10). In both reservoirs, mean length of the 2012BY was lower (mean = 75.9 cm FL, SD±19.6; n = 63) than the younger 2013BY (mean = 85.9 cm FL, SD±18.3; n = 92) and the 2014BY (mean = 81.7 cm FL, SD±16.6; n = 121), which indicate the 2012BY are growing slower than other brood years.

Wild fish captured either in Priest Rapids or Wanapum reservoirs, ranged from 73.5 to 86.5 cm FL (mean = 80.1 cm FL; n = 4). Based on their fork lengths, these wild fish were considered juveniles.

Weights recorded for fish in each brood year exhibited a similar trend in both reservoirs and provided additional insight on growth differences among brood years (Table 7). The mean weight of the 2012BY (mean = 3,609 g; SD±3,163 g; n = 63) was lower than the younger 2013BY (mean = 4,305 g; SD±3,299 g; n = 92) and the 2014BY (mean = 4,305 g; SD±2,590 g; n = 121) and suggests that the reduced growth of the 2012BY is likely a real attribute of that brood year population.

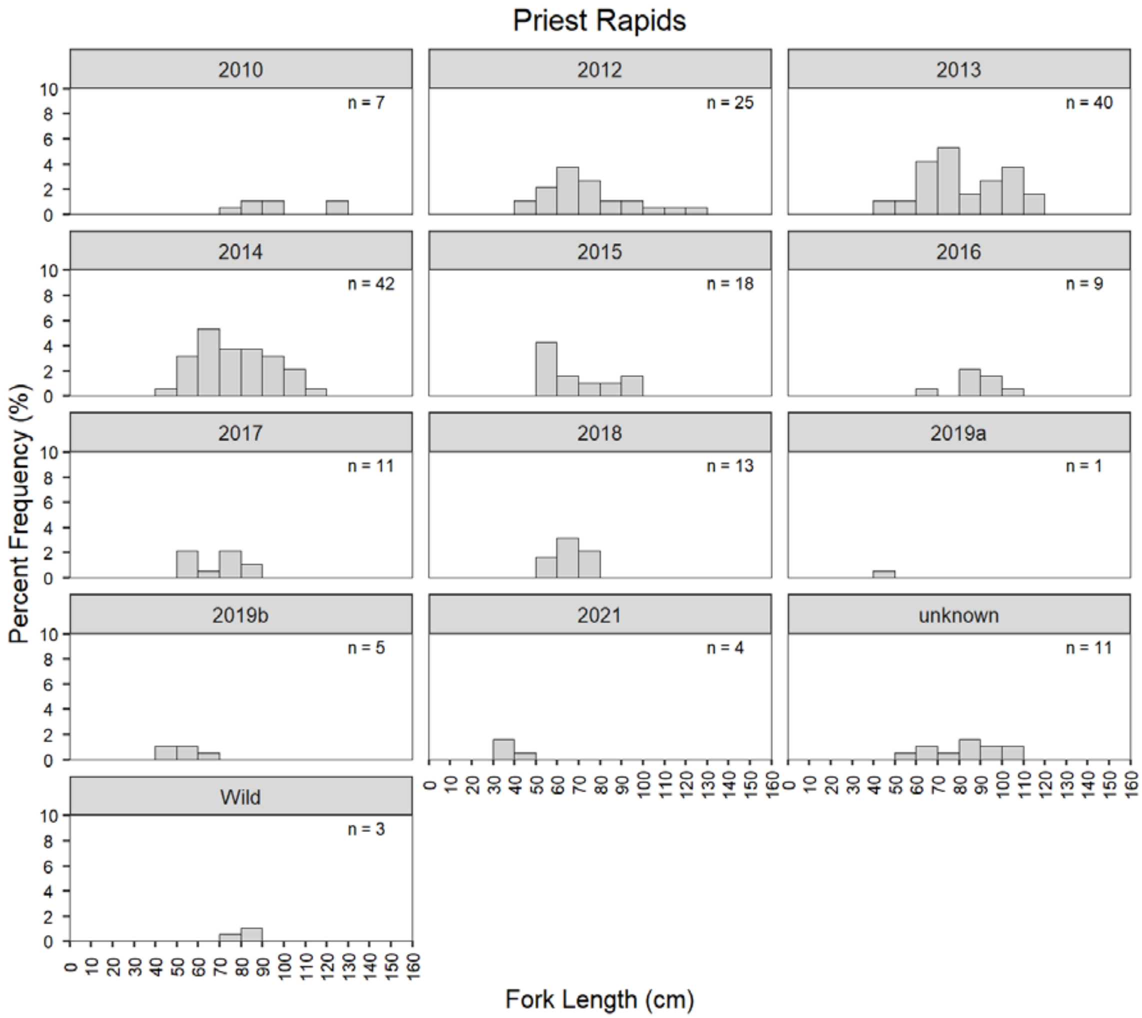

Figure 9 **Length-frequency distribution by brood year for hatchery and wild White Sturgeon captured in Priest Rapids reservoir during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.**

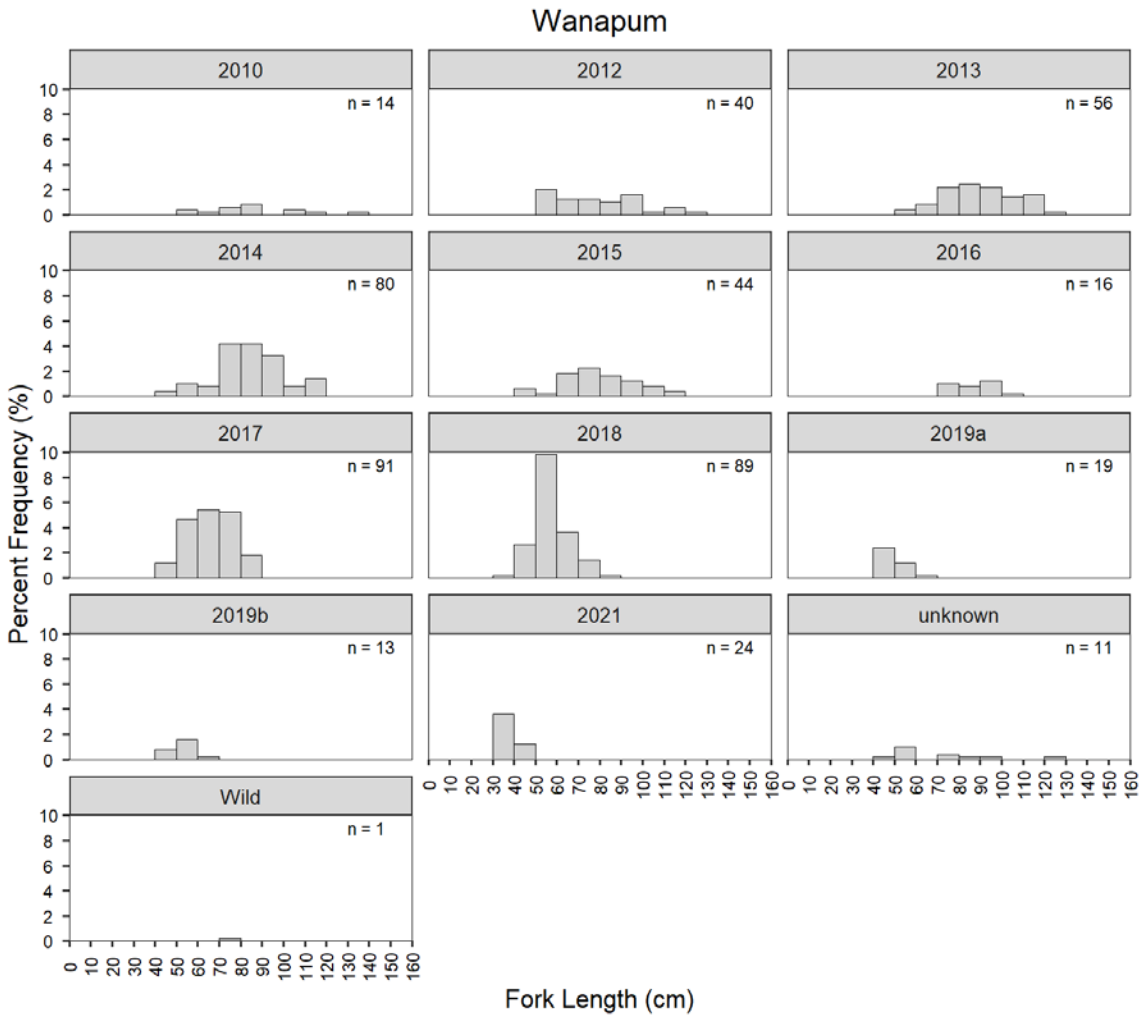

Figure 10 **Length-frequency distribution by brood year for hatchery and wild White Sturgeon captured in Wanapum reservoir during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.**

Table 6 **Summary of fork lengths of White Sturgeon captured in Priest Rapids and Wanapum reservoirs during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022. For individuals captured more than once during the survey, the fork length recorded during first capture was used.**

Program	Brood Year	Priest Rapid Fork Length (cm)					Wanapum Fork Length (cm)					Combined Fork Length (cm)				
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Chelan PUD	**2012**	-	-	-	-	-	1	127.5	-	127.5	127.5	1	127.5	-	127.5	127.5
	2013	-	-	-	-	-	1	114.0	-	114.0	114.0	1	114.0	-	114.0	114.0
	2016	-	-	-	-	-	1	70.0	-	70.0	70.0	1	70.0	-	70.0	70.0
Douglas PUD	**2010**	1	93.0	-	93.0	93.0	1	78.0	-	78	78	2	85.5	10.6	78	93
	2013	-	-	-	-	-	1	123.0	-	123	123	1	123.0	-	123	123
	2015	-	-	-	-	-	1	83.5	-	83.5	83.5	1	83.5	-	83.5	83.5
Grant PUD	**2010**	6	97.7	21.5	77.0	127.0	13	88.3	24.2	51.5	136.5	19	91.3	23.2	51.5	136.5
	2012	25	73.8	19.4	43.5	123.0	38	77.3	19.8	52.0	118.5	63	75.9	19.6	43.5	123.0
	2013	40	81.8	19.8	46.5	115.0	52	89.0	16.5	50.5	118.0	92	85.9	18.3	46.5	118.0
	2014	42	77.3	17.4	49.5	118.0	79	84.0	15.8	49.0	118.0	121	81.7	16.6	49.0	118.0
	2015	18	69.4	15.3	50.5	97.0	39	78.6	17.4	44.5	114.0	57	75.7	17.1	44.5	114.0
	2016	9	87.0	12.1	61.0	100.5	15	85.7	9.2	73.0	106.0	24	86.2	10.2	61.0	106.0
	2017	11	68.5	11.2	52.0	84.5	89	65.6	10.8	42.2	86.5	100	65.9	10.9	42.2	86.5
	2018	13	65.2	7.3	52.0	74.5	83	56.3	8.1	39.5	84.0	96	57.5	8.5	39.5	84.0
	2019a	1	43.0	-	43.0	43.0	19	48.9	4.8	44.0	62.0	20	48.6	4.8	43.0	62.0
	2019b	5	52.7	5.9	46.5	61.0	13	51.2	4.9	44.0	63.0	18	51.6	5.1	44.0	63.0
	2021	4	40.1	3.9	37.5	46.0	24	38.2	3.9	33.0	49.0	28	38.5	3.9	33.0	49.0
Unknown[1]	**Unknown**	11	81.6	16.3	52.0	103.5	11	69.4	23.1	45.0	124.0	22	75.5	20.5	45.0	124.0
Wild	**Wild**	3	82.3	4.3	78.0	86.5	1	73.5	-	73.5	73.5	4	80.1	5.6	73.5	86.5
All sturgeon	**All**	189	75.6	18.9	37.5	127.0	482	70.9	20.4	33.0	136.5	671	72.2	20.1	33.0	136.5

[1]Considered to be of hatchery origin based either on the presence of a PIT tag, marks, or substantial fin deformity, but brood year, source, or stocking location data are unknown.

Table 7 Summary of weight (g) of White Sturgeon captured in Priest Rapids and Wanapum reservoirs during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.

Program	Brood Year	Priest Rapids Weight (g)					Wanapum Weight (g)					All Weight (g)				
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
Chelan PUD	2012	-	-	-	-	-	1	11,080	-	11,080	11,080	1	11,080	-	11,080	11,080
	2013	-	-	-	-	-	1	10,470	-	10,470	10,470	1	10,470	-	10,470	10,470
	2016	-	-	-	-	-	1	2,165	-	2,165	2,165	1	2,165	-	2,165	2,165
Douglas PUD	2010	1	6,260	-	6,260	6,260	1	3,885	-	3,885	3,885	2	5,072	1,679	3,885	6,260
	2013	-	-	-	-	-	1	14,420	-	14,420	14,420	1	14,420	-	14,420	14,420
	2015	-	-	-	-	-	1	4,035	-	4,035	4,035	1	4,035	-	4,035	4,035
Grant PUD	2010	6	7,821	5,458	3,075	15,430	11	4,354	2,734	895	9,315	17	5,577	4,110	895	15,430
	2012	25	3,193	3,050	515	12,750	38	3,882	3,245	860	13,210	63	3,609	3,163	515	13,210
	2013	40	4,478	3,123	680	11,150	52	5,892	3,327	710	12,865	92	5,277	3,299	680	12,865
	2014	42	3,580	2,534	675	10,350	79	4,691	2,552	760	11,420	121	4,305	2,590	675	11,420
	2015	18	2,705	2,049	885	7,600	39	3,901	2,565	425	9,950	57	3,523	2,460	425	9,950
	2016	9	5,124	2,041	1,470	7,580	15	4,910	1,684	2,460	8,185	24	4,990	1,785	1,470	8,185
	2017	11	2,270	1,225	890	4,485	89	2,074	1,091	435	5,250	100	2,096	1,101	435	5,250
	2018	13	1,970	684	895	3,050	83	1,285	647	85	4,200	96	1,378	690	85	4,200
	2019a	1	400	-	400	400	19	761	292	465	1,575	20	743	295	400	1,575
	2019b	5	969	396	635	1,615	13	938	519	480	2,585	18	947	477	480	2,585
	2021	4	372	113	290	540	24	331	94	210	545	28	337	95	210	545
Unknown[1]	Unknown	11	4,142	2,274	1,025	7,710	10	2,177	1,920	460	6,515	21	3,206	2,292	460	7,710
Wild	Wild	3	3,772	853	2,810	4,435	1	2,470	-	2,470	2,470	4	3,446	953	2,470	4,435
All sturgeon	All	189	3,553	2,846	290	15,430	479	3,120	2,781	85	14,420	668	3,242	2,804	85	15,430

[1]Considered to be of hatchery origin based either on the presence of a PIT tag, marks, or substantial fin deformity, but brood year, source, or stocking location data are unknown.

3.4.4 Fin Deformity in Juvenile White Sturgeon Indexing Catch

In 2022, fin deformities were identified in 67% (441 of 654 fish) of the total catch of hatchery fish for which brood year and release location were known (Table 8). The highest occurrence of fin deformities was evident in the 2019BYa and 2019BYb combined (89%), the 2021BY (89%), and the 2014BY (84%). The 2013BY had the lowest prevalence of fin deformity of the hatchery fish captured in 2022 (39%).

Table 8 Occurrence of fin deformities in hatchery juvenile White Sturgeon captured in 2022.

Brood Year	Total Catch	Fish with Fin Deformity	Deformity (%)
2010	19	9	47
2012	64	36	56
2013	94	37	39
2014	122	102	84
2015	61	38	62
2016	24	14	58
2017	102	72	71
2018	102	74	73
2019a&b[1]	38	34	89
2021	28	25	89
Total	654	441	67

[1] The 2019BYa and 2019BYb catch were combined

3.4.5 Juvenile White Sturgeon Indexing Gear Performance

As noted in previous juvenile indexing studies, a portion of the small-hook gangions used each year are damaged by large fish that either straighten hook or break the leader when they take the hook (Golder 2017). In 2022, the hooks on 172 gangions (21.5% of the gear inventory) were damaged or lost in Wanapum reservoir, with approximately equal numbers of the 2/0 and 4/0 gangions damaged (Table 9). Lost hooks, where the leader broke or the gangion detached from the set line, represented less than 1% of the inventory (2 of 800 hooks). Damaged and lost hooks in relation to the number of hooks deployed in Wanapum reservoir over the study (10,798 gangions fished) was 1.6%.

Gear was damaged or lost in Priest Rapids reservoir at a slightly higher rate than in Wanapum reservoir, with 90 of the 400 hooks (22.5%) damaged or lost. Approximately equal numbers of 2/0 and 4/0 hooks were damaged. Lost hooks represented 2.5% of the gear allotment for Priest Rapids reservoir (10 of 400 hooks). Damaged and lost hooks in relation to the number of hooks deployed in Priest Rapids reservoir over the study (3,600 gangions fished) was 2.5%.

Of the total damaged hooks in each reservoir, 51% (n = 88 of 172 hooks) were damaged in the upper section of Wanapum reservoir. Conversely, in Priest Rapids reservoir, 51% (n = 46 of 90 hooks), were damaged in the lower section of the reservoir.

The 4/0 hook size caught 60% of the catch (299 of 498 fish) in Wanapum reservoir and 55% of the catch (103 of 189 fish) in Priest Rapids reservoir. The smallest fish caught by each hook size was similar. The largest fish caught by the 4/0 hooks was greater than the largest fish caught by 2/0 hooks. Mean catch of the 4/0 hooks was higher in each reservoir and they were marginally more effective at capturing larger fish (Table 10).

Table 9 Hook rate and overall gangion damage and loss in the Priest Rapids Project area during the juvenile White Sturgeon indexing program in 2022.

Reservoir	Hook Size	Gangions: No. Set	Gangions: Gear Inventory	Hook/Gangion Fate: Bent	Lost	Total	Proportion of Set Gangions with Damage or Lost Hooks	Proportion of Gangion Inventory with Damaged or Lost Hooks
		n	n	n	n	n	%	%
Wanapum	**2/0**	5,399	400	86	1	87	1.6	21.8
	4/0	5,399	400	84	1	85	1.6	21.3
Total		10,798	800	170	2	172	1.6	21.5
Priest Rapids	**2/0**	1,800	200	42	5	47	2.6	23.5
	4/0	1,800	200	38	5	43	2.4	21.5
Total		3,600	400	80	10	90	2.5	22.5
PRPA		14,398	1200	250	12	262	1.8	21.8

Table 10 White Sturgeon catch by hook size in the Priest Rapids Project Area during the juvenile White Sturgeon indexing program in 2022.

Reservoir	Hook Size	Catch	Fork Length (cm)			
		n	Mean	SD	Min	Max
Wanapum	2/0	199	68.1	17.5	33.5	111.0
	4/0	299	72.8	21.7	33.0	136.5
Priest Rapids	2/0	86	71.2	16.5	43.5	122.5
	4/0	103	79.3	20.0	37.5	127.0

3.4.6 Hatchery Juvenile White Sturgeon Abundance Estimates

Capture success during the 2022 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 in Priest Rapids and Wanapum reservoirs. Of the 6 models constructed, 5 converged and were used to calculate model-averaged values of recapture and survival estimates. Of these 5 models, the model with the lowest QAICc had survival as a multiplicative function between brood year and reservoir, with an additive effect of 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 that spent more than a year at large, mean survival estimates were lower in the first year post-release than in subsequent years at large (Figure 11). In Priest Rapids reservoir, survival in the first year post-release was highest for the 2010BY (mean of 0.586, 95% CI = 0.472–0.691). The remaining brood years had similar survival in the first year post-release, with mean estimates ranging between 0.049 (2019BYa) to 0.244 (2018BY). In Wanapum reservoir, the 2010BY had similar survival to most other brood years, while the 2016BY had the lowest survival, similar to the 2016BY in Priest Rapids reservoir, with a mean of 0.085

(95% CI = 0.053–0.133). The survival in first year post-release for the remaining brood years ranged from 0.187 (2019BYb) to 0.474 (2019BYa).

The 2019BY, which was released in both 2019 (BY2019a) and 2020 (BY2019b) had opposite survivals between Wanapum and Priest Rapids reservoirs. In Priest Rapids reservoir, survival in the first year post-release was low for 2019BYa (0.049) and high for 2019BYb (0.207). In comparison, the trend was opposite in Wanapum reservoir, with high survival in the first year post-release for 2019BYa (0.474), with a subsequent decrease for 2019BYb (0.187).

In subsequent years post-release, survival was generally high for both reservoirs, ranging between 0.873 (2019BYa) and 0.995 (2010BY) in Priest Rapids reservoir, and between 0.926 (2016BY) and 0.992 (2019BYa) in Wanapum reservoir. During the 2015/2016 period, when some of the 2010BY fish may have been culled or harvested during the Tribal and sport fisheries, survival was estimated to be particularly low in Priest Rapids reservoir, with a mean of 0.401 (95% CI = 0.294–0.519). In Wanapum reservoir, the 2010BY survival associated with the cull / fishery period was higher, with a mean of 0.822 (95% CI = 0.687–0.907).

In Wanapum reservoir, recapture probabilities generally decreased with fish age for the oldest brood years, and generally increased with age for the younger brood years (Figure 12). For younger brood years, recapture probabilities in Wanapum reservoir were two to three times higher compared to fish of the same age in Priest Rapids reservoir. In Priest Rapid reservoir, recapture probabilities remained relatively constant or slightly increased for all brood years, with the exception of the 2010BY, whose recapture probability decreased.

The model-averaged survival estimates were used to calculate total 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 2022 (Figure 13; Table 11). Estimated total abundance of the hatchery juvenile White Sturgeon (2010BY to 2019BYb) releases in the Priest Rapids Project Area by calendar year and in relation to annual and cumulative hatchery releases, 2011 to 2022.Table 11). After the initial release of hatchery fish in 2011, the 2012 population abundance value estimated for both reservoirs decreased, as hatchery fish were not released in 2012 (i.e., a 2011BY was not released). From 2012 to 2014, each successive annual release of hatchery fish was reflected in step increases in total annual population abundance estimates (Figure 13). Between 2015 and 2019 for Priest Rapids reservoir, and between 2016 and 2021 for Wanapum reservoir, the estimated population abundance of hatchery White Sturgeon in each reservoir remained steady. In Priest Rapids, this was followed by a decline between 2019 and 2020, when only 261 fish were released into Priest Rapids, which was not sufficient to compensate for the mortality of previously released fish. With the release of the 2021BY, the 2022 hatchery fish abundance estimate in Wanapum reservoir was 10,809 fish (95% CI = 9,041–12,576) or 35.5% of total hatchery releases to date (n = 30,489). In Priest Rapids reservoir, the 2022 hatchery fish abundance estimate was 3,909 fish (95% CI = 3,211–4,606) or 28.9% of total hatchery releases to date (n = 13,515).

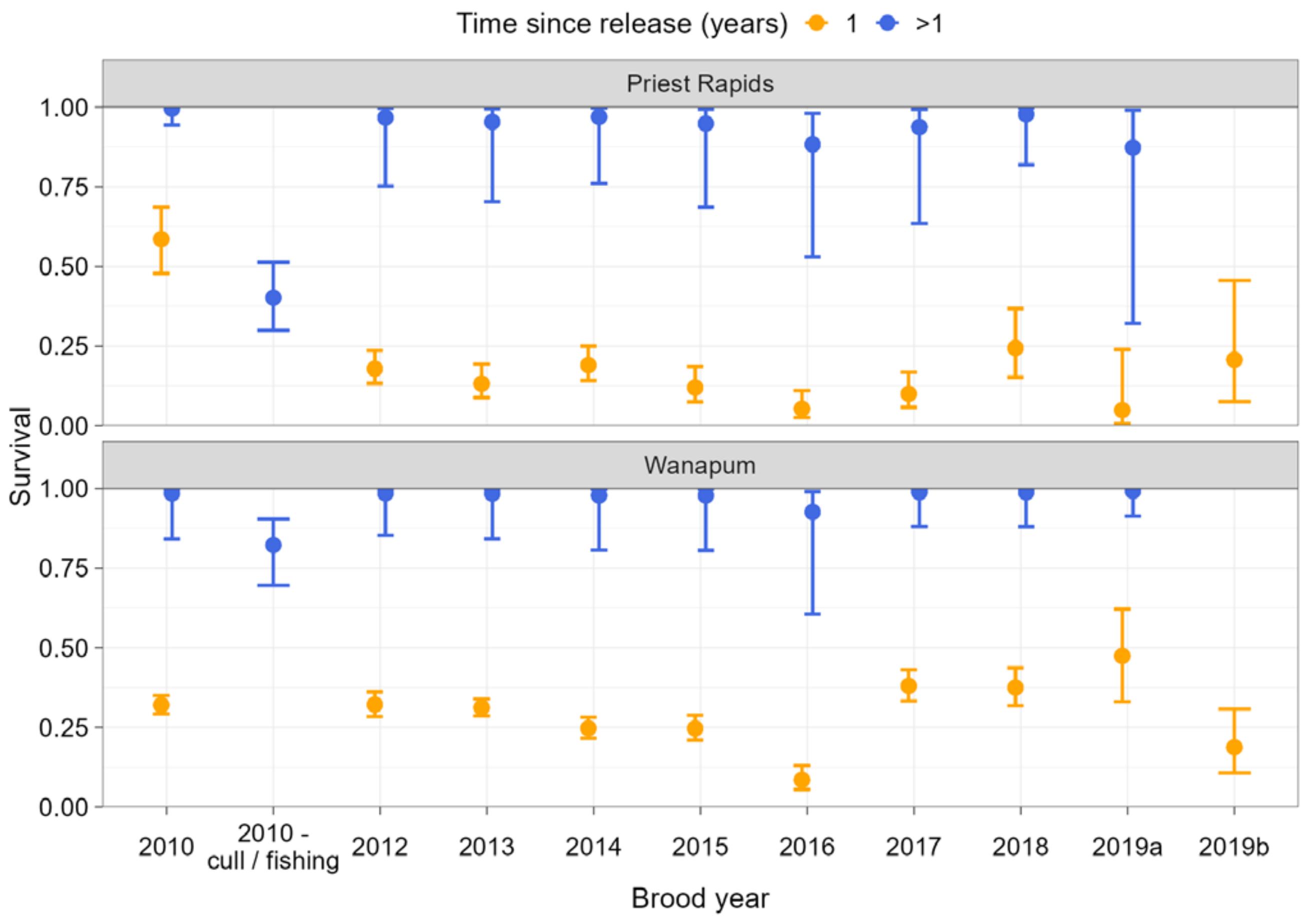

Figure 11 **Estimated survival of hatchery juvenile White Sturgeon by brood year, reservoir, and age class (i.e., first year post-release or in any subsequent year combined).**

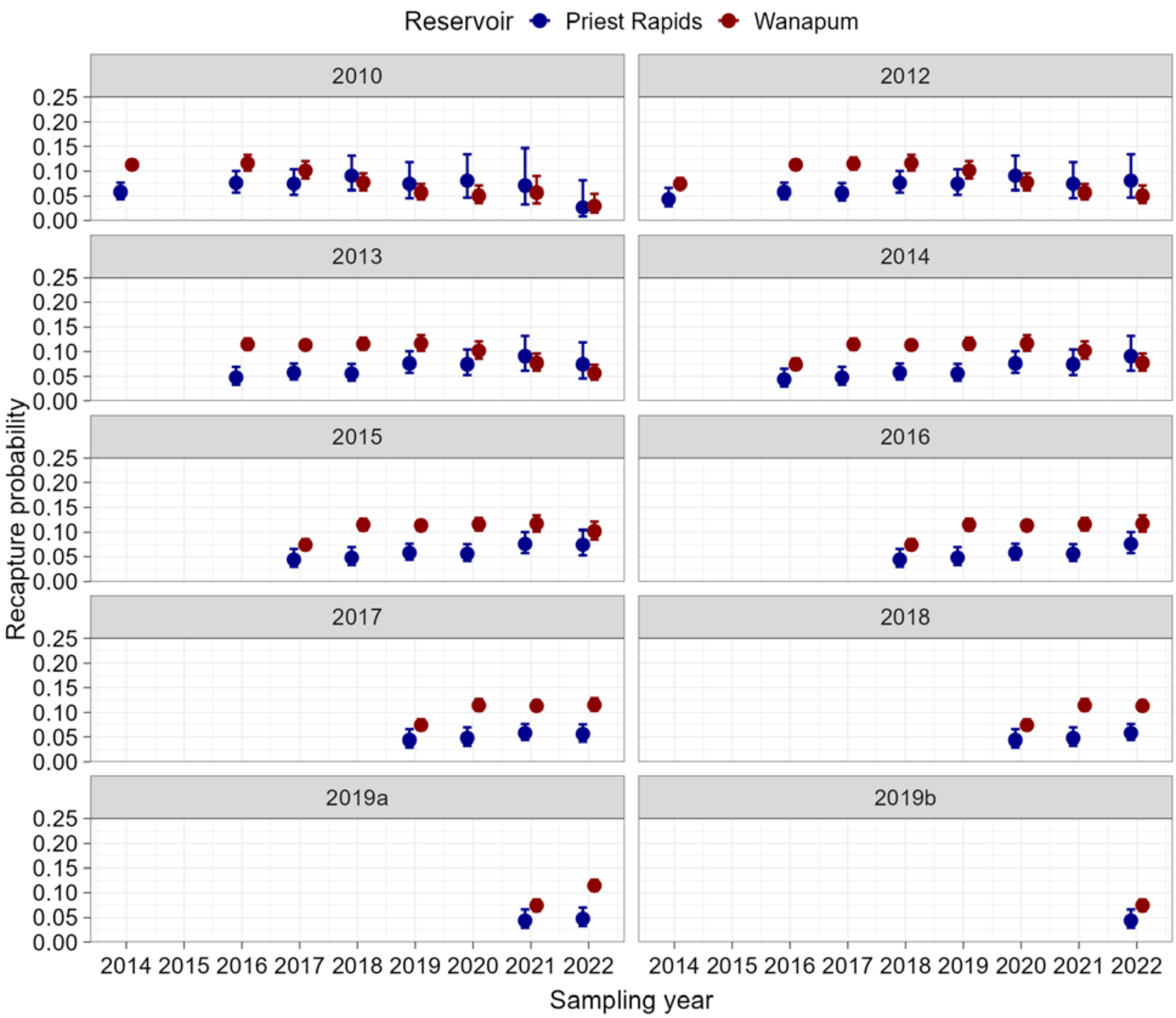

Figure 12 **Estimated probability of recapture of hatchery juvenile White Sturgeon by sampling year (age), brood year, and reservoir.**

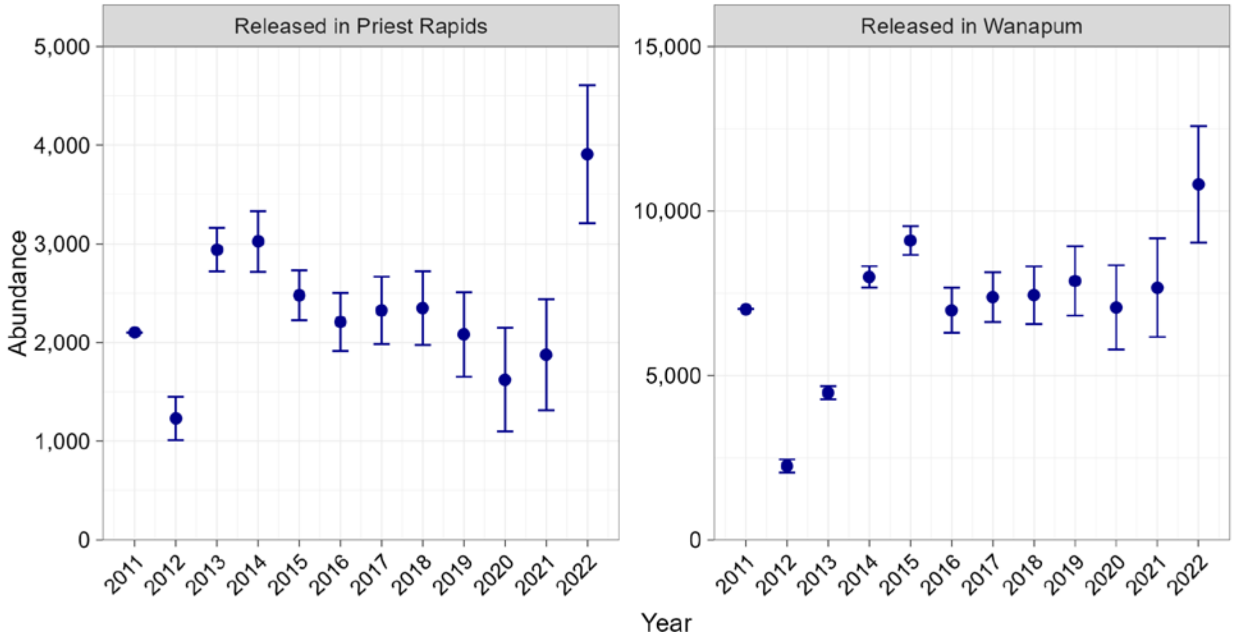

Figure 13 **Estimated abundance of hatchery juvenile White Sturgeon (based on survival of 2010BY to 2019BYb releases) by calendar year for Wanapum and Priest Rapids reservoirs, 2011 to 2022.**

Table 11 Estimated total abundance of the hatchery juvenile White Sturgeon (2010BY to 2019BYb) releases in the Priest Rapids Project Area by calendar year and in relation to annual and cumulative hatchery releases, 2011 to 2022.

Pool	Year	Abundance Estimate (95% CI)	Annual Hatchery Release Number	Cumulative Release Number
Wanapum	2011	7,015 (7,015–7,015)	7,015	7,015
	2012	2,244 (2,041–2,446)	0	7,015
	2013	4,473 (4,268–4,678)	2,264	9,279
	2014	7,994 (7,666–8,322)	5,092	14,371
	2015	9,099 (8,665–9,533)	5,007	19,378
	2016	6,980 (6,298–7,662)	2,005	21,383
	2017	7,382 (6,624–8,140)	1,999	23,382
	2018	7,440 (6,565–8,315)	1,983	25,365
	2019	7,872 (6,818–8,925)	1,767	27,132
	2020	7,065 (5,782–8,348)	411	27,543
	2021	7,667 (6,169–9,164)	936	28,489
	2022	10,809 (9,041–12,576)	2,010	30,489
Priest Rapids	2011	2,101 (2,101–2,101)	2,101	2,101
	2012	1,231 (1,009–1,452)	0	2,101
	2013	2,941 (2,721–3,161)	1,717	3,818
	2014	3,024 (2,717–3,332)	1,500	5,319
	2015	2,478 (2,225–2,731)	1,495	6,814
	2016	2,208 (1,913–2,503)	1,253	8,067
	2017	2,326 (1,986–2,667)	1,249	9,316
	2018	2,350 (1,977–2,722)	1,241	10,566
	2019	2,082 (1,653–2,510)	890	11,446
	2020	1,623 (1,098–2,148)	261	11,707
	2021	1,874 (1,311–2,437)	549	12,256
	2022	3,909 (3,211–4,606)	1,259	13,515

3.5 Assessment 2010-2019BY Growth

Annual growth rate was calculated for each brood year released in the PRPA, based on the difference in fork length between release and capture, divided by the time at large for fish more than one year at large (Table 12). Based on the 2022 catch results, growth rates were calculated for each brood year in each reservoir and each reservoir section. When comparing brood years that were captured in moderate numbers within a reservoir section (i.e., more than 20 fish), growth rates of young fish were marginally higher than older fish and growth rate gradually decreased with age. For brood years where similar numbers of fish were captured in each section, mean growth rates were generally highest in the lower sections of each reservoir, decreased in the middle sections, and were lowest in the upper sections of each reservoir (Figure 14). This declined in growth rate was most pronounced in the 2017BY and 2018BY and was evident in older brood years (i.e., 2013BY and 2014BY) if captured in moderate numbers (i.e., more than 10 fish) in each of the three reservoir sections.

Table 12 Growth of the 2010BY to 2019BYb by reservoir section in PRPA during juvenile White Sturgeon indexing, 2022.

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	1	**8.5**	-	8.5	8.5	1	**5.6**	-	5.6	5.6	4	**5.7**	2.0	4.4	8.7
2012	4	**7.9**	1.7	5.5	9.2	1	**4.8**	-	4.8	4.8	10	**3.6**	0.9	1.8	4.9
2013	11	**9.2**	1.2	5.9	10.4	6	**6.0**	0.7	4.9	6.8	23	**5.5**	2.3	1.9	11.0
2014	12	**8.7**	1.8	5.0	11.9	8	**4.8**	1.7	1.9	6.7	21	**5.4**	2.0	1.7	9.0
2015	4	**8.0**	2.1	5.7	10.1	6	**6.0**	2.4	3.7	9.5	8	**5.2**	2.3	2.7	10.2
2016	8	**11.7**	1.4	9.4	13.2	1	**5.6**	-	5.6	5.6	-	-	-	-	-
2017	5	**11.3**	0.7	10.7	12.1	4	**6.9**	1.9	5.9	9.8	2	**7.2**	2.4	5.5	8.9
2018	8	**11.9**	1.4	9.4	13.6	2	**8.9**	3.9	6.1	11.6	3	**10.1**	1.7	8.4	11.8
2019a	-	-	-	-	-	-	-	-	-	-	1	**1.3**	-	1.3	1.3
2019b	2	**9.4**	0.4	9.1	9.6	3	**1.7**	1.0	0.7	2.6	-	-	-	-	-
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	**7.4**	-	7.4	7.4	11	**4.5**	1.3	2.5	7.3
2012	2	**8.3**	1.2	7.4	9.2	11	**7.1**	1.4	5.2	9.6	25	**4.0**	1.4	1.7	7.4
2013	11	**8.9**	2.1	5.3	11.0	13	**7.6**	1.7	5.3	11.0	24	**6.7**	2.2	2.8	10.5
2014	19	**8.7**	1.9	5.6	11.7	21	**7.4**	1.3	5.0	11.1	38	**6.2**	2.2	2.3	11.2
2015	7	**10.7**	1.2	8.8	12.4	13	**8.6**	1.8	6.3	13.1	19	**5.3**	1.7	1.0	7.8
2016	7	**11.8**	1.6	10.0	14.5	7	**10.1**	1.4	8.8	12.5	2	**10.3**	2.7	8.4	12.2
2017	16	**10.8**	1.5	8.0	12.4	36	**9.3**	1.8	5.4	12.1	37	**6.7**	2.0	2.8	11.3
2018	8	**10.9**	1.3	9.1	13.5	35	**9.3**	2.0	5.5	13.9	38	**7.1**	1.9	4.1	13.9
2019a	2	**9.8**	0.4	9.5	10.1	9	**6.3**	1.8	4.3	10.3	8	**4.2**	1.5	2.0	6.3
2019b	2	**6.6**	2.3	4.9	8.2	9	**4.5**	4.2	0.2	12.9	1	**0.1**	-	0.1	0.1

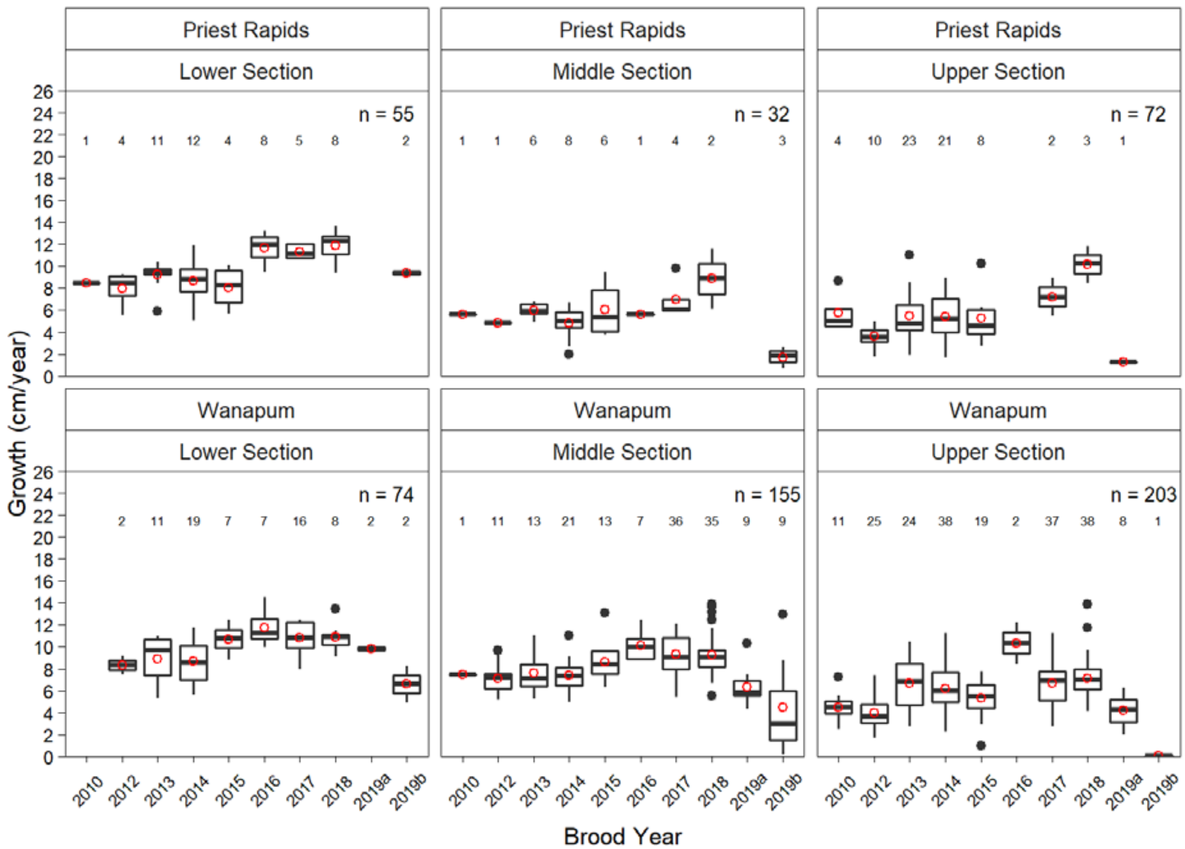

Figure 14 **Growth rates in fork length of the 2010BY through 2019BYb (fish one year or more at large) captured during juvenile White Sturgeon indexing in the lower, middle, and upper sections of Priest Rapids and Wanapum reservoirs, 2022. Red circles represent the mean, the box represents 25 and 75 percentiles, the whiskers represent 10 and 90 percentiles, the solid horizontal line represents the median, and the black circle represents outliers.**

In the juvenile indexing catch, difference in brood year growth rates by reservoir and reservoir section were reflected in the relative weight calculations for each brood year and in relation to reservoir section where most of the fish were captured (Figure 15). In both Priest Rapids and Wanapum reservoirs, based on the condition factor calculated for each fish, a greater proportion of the 2012BY had lower relative weights in relation to the mean predicted relative weight expected for a fish of that length. In Priest Rapids reservoir, a greater proportion of the 2014BY also had lower relative weights than the predicted relative weight. Conversely, both the 2013BY and 2018BY in Wanapum reservoir had a greater proportion of fish with higher relative weights than the predicted mean relative weight. For other brood years, the distributions of relative weights were generally distributed uniformly or slightly above the mean predicted relative weight. Based on the juvenile White Sturgeon indexing catch, relationships between $\log^{10}$ FL and $\log^{10}$ weight were highly significant and the regression parameter estimates for Priest Rapids and Wanapum reservoirs were nearly identical. This indicated that fish were of similar condition in both reservoirs, and that among the brood years captured in Priest Rapids and Wanapum reservoirs in 2022, fish of similar length also had similar weights (Figure 16).

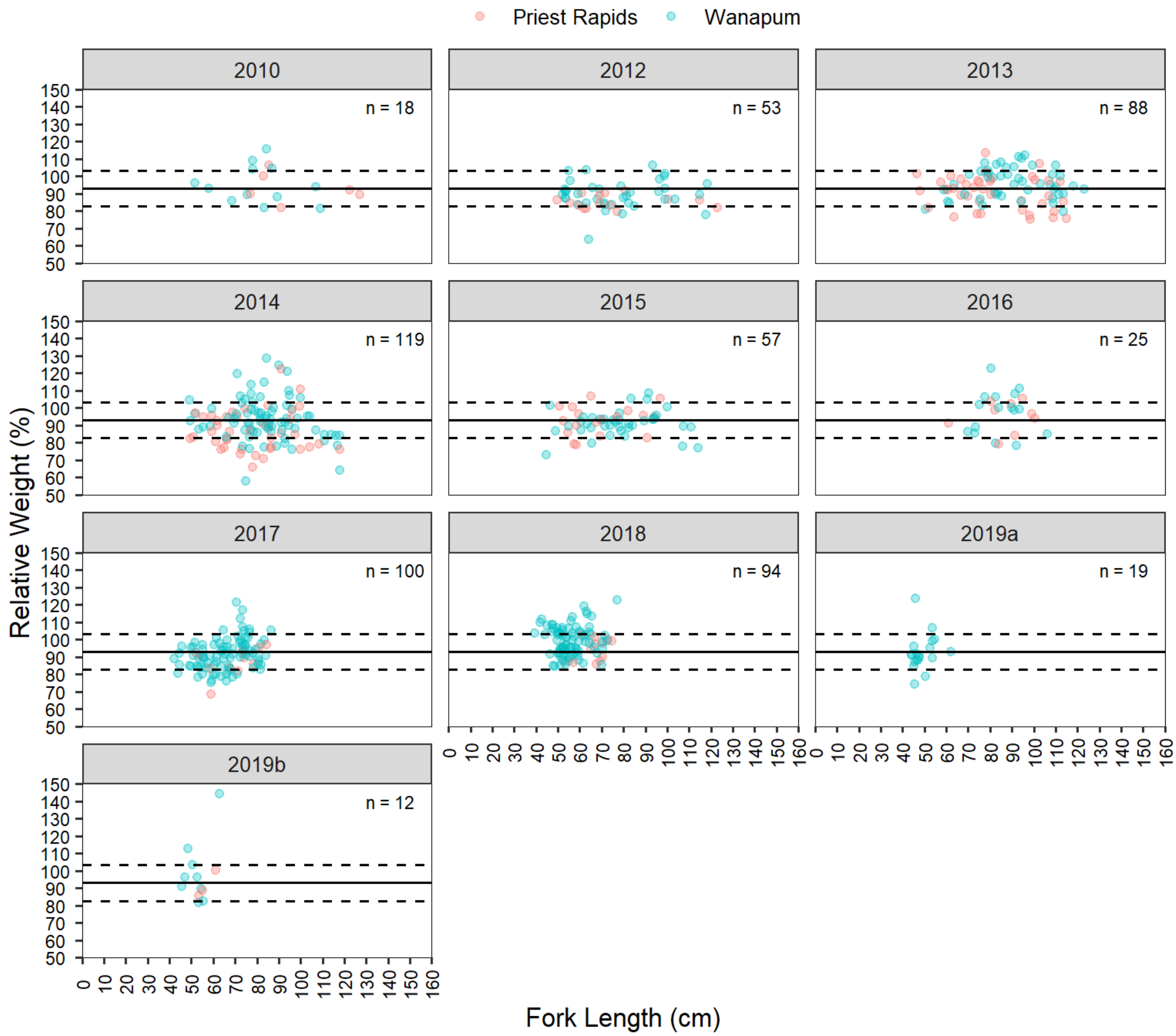

Figure 15 **Relative weight in relation to fork length for each brood year of hatchery juvenile White Sturgeon, one year or more at large, captured in Priest Rapids and Wanapum reservoirs during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022. The solid line is the mean relative weight condition factor of all fish combined, ±1 SD (dashed lines).**

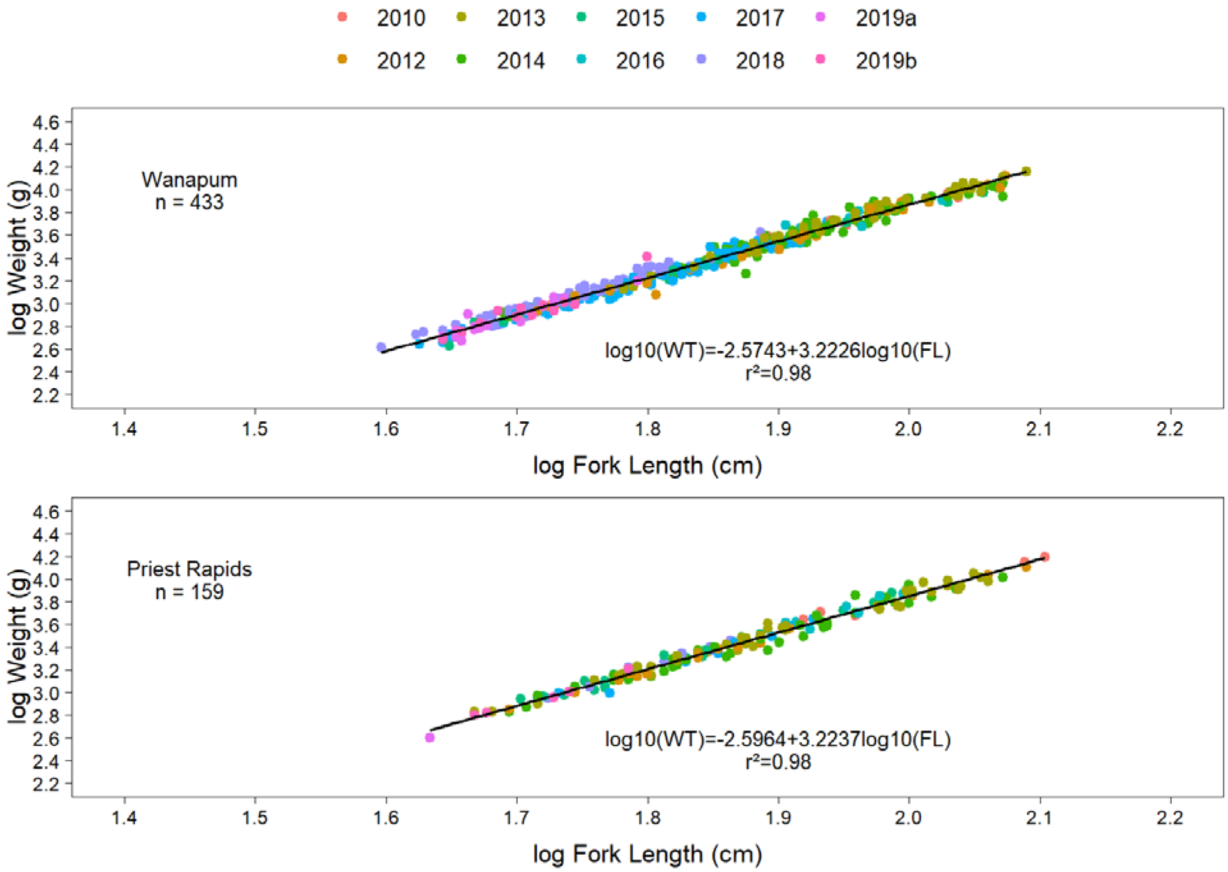

Figure 16 Linear regression of log10 fork length and log10 weight for hatchery juvenile White Sturgeon of each brood year, one year or more at large, captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.

3.5.1 Assessment of Density Dependent Growth

Fish growth varied with both brood year and reservoir (Figure 17). In Wanapum reservoir, most brood years exhibited similar high growth rates, with the exception of the 2012BY, which had depressed growth in comparison to other brood years. Growth rate of the 2019BYa, at large since 2020, exhibited a decreasing trend in growth in 2022 after their first year after release. The 2013BY, 2014BY and 2015BY have growth rates that appear to be on a trajectory to exceed the long-term growth rate of the 2010BY. The substantial overlap of growth curves in Wanapum reservoir indicates that, with the exception of the 2012BY, most brood year releases have similar growth rates and suggests that density dependent growth in Wanapum reservoir is not evident.

Growth differed for fish in Priest Rapids reservoir when compared to fish in Wanapum reservoir. In Priest Rapids reservoir, the 2010BY had the highest growth rate and the growth rates of other brood years were notably lower, with the exception of the 2016BY. Although the 2016BY appear to be growing fast than other brood years, catch of the 2016BY was low and more recaptures are required to better evaluate the growth rate of this brood year. In general, growth tends to slow and plateau by age-6 in Priest Rapids reservoir relative to brood years of the same age in Wanapum reservoir. This difference was most evident in the 2010BY, whose growth slowed down in Priest Rapids reservoir (i.e., estimated fork length of 64 cm by age-6) but did not slowdown in Wanapum reservoir (i.e., estimated fork length of 76 cm by age-6). Growth models of the 2012BY, 2014BY and 2015BY indicate that these brood years had similarly low growth rates in Priest Rapids reservoir; however, unlike the 2012BY and 2015BY, the growth rate trajectory of the 2014BY does not appear to be plateauing. Even though brood year growth rates in Priest Rapids reservoir were lower than in Wanapum reservoir, younger brood years (i.e., 2017BY) in Priest Rapids reservoir still exhibited higher growth than older brood years for the same age. At present, with the inclusion of the 2022 data, the effect of density dependency on juvenile White Sturgeon growth in Priest Rapids reservoir remains uncertain.

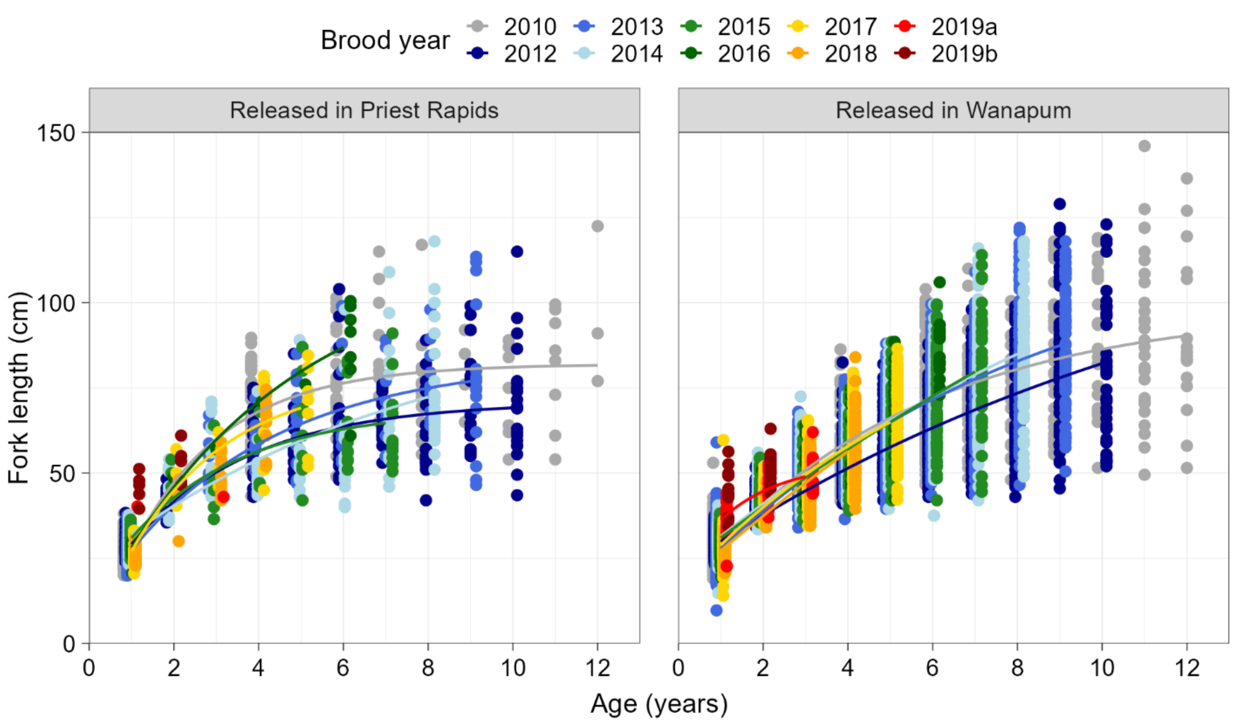

Figure 17 Estimated growth of hatchery juvenile White Sturgeon by brood year in Wanapum and Priest Rapids reservoirs for fish captured during the juvenile White Sturgeon indexing program, September 13 to October 20, 2022.

4.0 Discussion

The following sections provide a discussion of the 2022 (FERC License Year 15) M&E program results for the PRPA in context with previous study results. In 2022, activities included the tagging and release of the full annual allotment of 2021BY juvenile White Sturgeon, as outlined in the 2016 SOA, and completion of juvenile White Sturgeon population indexing.

4.1 Discharge and Temperature

A peak discharge volume of 27,292 KAF in June 2022 substantially exceeded the annual average peak discharge volume of 19,886 KAF in the Project area from 2010 to 2021 for that month (Figure 18). The 2022 peak flows occurred notably later than the peak of the historical average discharge and high flows persisted into July before declining sharply in August and into September. Flows in September 2022 were below the 2010-2021 average and the historic minimum due to below average precipitation and drought conditions throughout the Pacific Northwest in September and October; however, the total annual 2022 discharge volume (89,628 KAF) was approximately equal to the 2010-2021 average (88,436 KAF). Low flows during sampling of the upper section of each reservoir allowed sampling gear to be deployed at locations not normally sampled during study years where sampling was conducted during periods of higher flows. The combination of low flow and very warm weather in summer 2022 resulted in above average water temperatures in September and October during juvenile White Sturgeon population indexing compared to other study years (Figure 19). The higher water temperatures did not have a notable effect on fish health during sampling, as all fish recovered after processing.

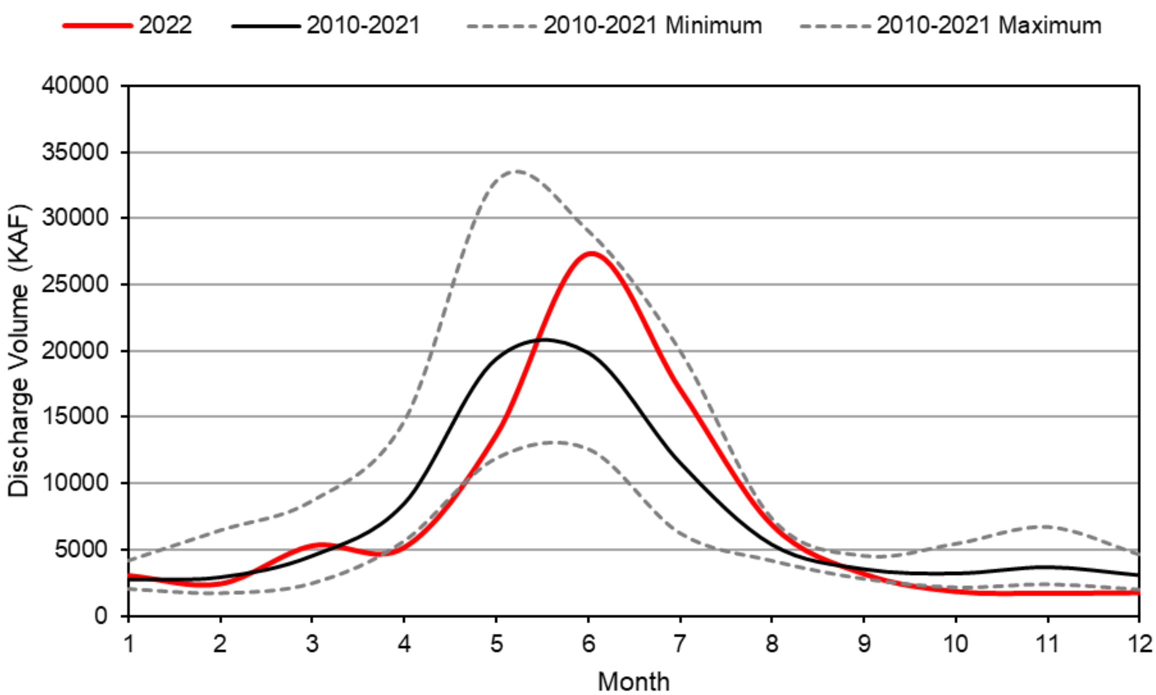

Figure 18 The 2022 mean monthly discharge volume in comparison with the mean monthly discharge volume in the Project area from 2015 to 2021 and the mean discharge range recorded (highest and low flow years) from 2015 to 2021. Data recorded at Rock Island Dam.

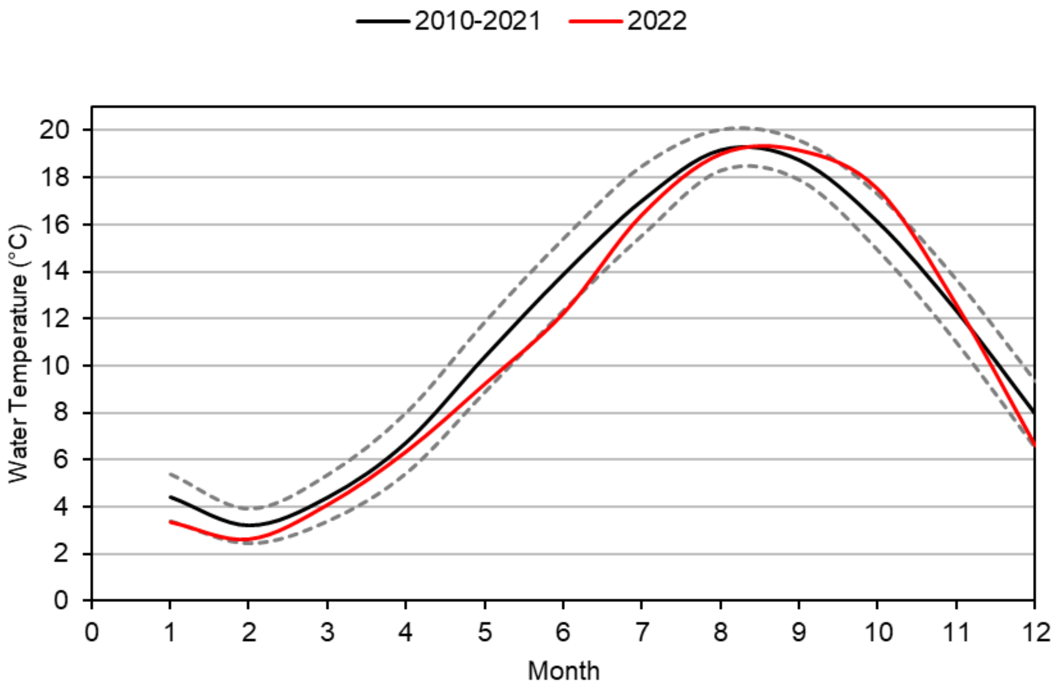

Figure 19 **The 2022 mean monthly water temperature (red line) in comparison with the 2010 to 2021 mean monthly water temperature (black line) and standard deviation (dashed line) in the Project area as recorded at Rock Island Dam.**

4.2 Juvenile White Sturgeon Processing and Release (2021BY)

In 2022, Grant PUD, YNSH, and BLE staff conducted the tagging and testing of the 2021BY for the presence of SA, processing 3,269 fish in approximately 4.5 days. Over this period, the staff tagged and tested between 421 and 853 fish each day. The tagging rate in 2022 was higher than the expected rate (i.e., only 500 and 600 fish/day due to the additional time associated with testing for SA) and approached the historical tagging rate of approximately 1,000 fish per day in previous tagging years when SA testing was not required. Personnel participating in the 2022 tagging and testing activities had previous experience with both tagging and blood testing procedures, and this experience likely improved efficiency and contributed to the high fish processing rate in 2022.

Six fish tested positive for spontaneous autopolyploidy (0.2% of the fish tested). In 2021, testing identified 16 fish with spontaneous autopolyploidy or 1.1% of the approximately 1,500 2019BYb fish processed (Golder 2022). With the 2021BY release in 2022, a total of 44,004 hatchery juvenile White Sturgeon have been released in the PRPA to date (Table 13).

The 2021BY were the first age-1 hatchery fish to be released at the new release locations in Priest Rapids reservoir, at the Desert Aire boat launch (RM400.3), and in Wanapum reservoir, at the Vantage boat launch (RM420.6). The capture of fish from the 2021BY in the upper sections of both Priest Rapids and Wanapum reservoirs during the juvenile White Sturgeon indexing study confirmed the dispersal of these age-1 fish to all portions of the study area.

During tagging of the 2021BY fish, fin deformities were observed and recorded in 46% of the fish tagged (1,507 of 3,269 fish). The 2021BY fin deformity rate was substantially lower than fin deformity rates recorded for the 2019BYa and the 2019BYb (97% and 100%, respectively) and similar to the fin deformity rates recorded for the 2018BY (31%). As discussed in previous reports, the long-term biological implications of fin deformities on White Sturgeon survival, growth, and future reproductive success are not known (Golder 2018). During previous 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). However, in the 2022 catch, the proportion of 2021BY captured with and without fin deformities (i.e., 89% fin deformity rate in the 2021BY) differed notably from fin deformity rates recorded during the tagging and processing of 2021BY at the hatchery (i.e., 46% fin deformity rate). The difference in reported fin deformity rates in the hatchery release and indexing capture data was attributed to inherent variability in the metric due to the relatively small number of fish captured from each brood year (compared to the release size) and likely a bias by field crews in assessing the extent of fin deformity when present, both at the hatchery prior to release and during subsequent encounters in the field. Overall, the large proportion of fish with fin deformities in the 2022 catch (i.e., 67%; see Table 8) suggests that fin deformities do not appear to have a substantial effect on the survival of juvenile hatchery White Sturgeon.

Table 13 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	3.0	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**
2019a	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 2019a		**672 (0)**	**35.5**	**5.2**	**288**	**106**
2019b	Wanapum	Vantage	420.6	MCW	20-Apr-21	936 (0)	48.3	5.1	776	257
	Priest Rapids	Desert Aire	400.3	MCW	20-Apr-21	549 (0)	48.2	5.3	795	277
				Total 2019b		**1,485 (0)**	**48.3**	**5.2**	**783**	**265**
2021	Wanapum	Vantage	420.6	MCW	27-Apr-22	2,010 (0)	29.1	4.0	157	61
	Priest Rapids	Desert Aire	400.3	MCW	27-Apr-22	1,259 (0)	28.7	4.3	150	63
				Total 2021		**3,269 (0)**	**28.9**	**4.1**	**153**	**62**
				Total 2010-2021		**44,004 (346)**	**30.3**	**3.7**	**202**	**73**

[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
[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 Juvenile Indexing Sampling Effort and Catch

The 2022 juvenile White Sturgeon population indexing study was consistent with the study design established in 2014 and sample effort was consistent with 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 and catch within each reservoir. Since the start of systematic indexing in 2014, a total of 5,214 White Sturgeon have been captured in the PRPA (Table 14). Total catch in 2022 was 687 fish, which was lower than in 2021 (i.e., 924 fish) due to lower catch in Wanapum reservoir, from 754 fish in 2021 to 498 fish in 2022. The capture of wild juvenile White Sturgeon in both Wanapum reservoir (n =1) and Priest Rapids reservoir (n =3) indicates that natural recruitment still occurs in the PRPA. Given the aggregate nature of White Sturgeon, some variation in total catch within each reservoir would be expected. In Priest Rapids reservoir, and to a lesser extent in Wanapum reservoir, substantial numbers of fish are captured within specific high-use areas; however, these areas are not necessarily sampled each year. In Priest Rapids reservoir, these sites can contribute up to 40% of the total catch for the reservoir. Consequently, if these areas are not sampled in a given study year, either not selected during a random draw of sample sites or volitionally excluded if the locations are not safe to sample (i.e., downstream of spillways in a high flow year), total catch in that study year potentially will be reduced.

In Wanapum reservoir, higher catch was associated with lower water years when peak annual flows in summer did not exceed 20,000 KAF (Figure 20). Why catch may be higher in a lower flow year than a higher flow year in Wanapum reservoir is unknown, but may relate to change in White Sturgeon distribution and higher use of the upper section of the reservoir for feeding in high flow years where the fish are less likely to be captured. Additional data will be required to determine whether this trend (i.e., higher catch in Wanapum reservoir in low flow years) persists.

Table 14 White Sturgeon catch by reservoir in the Priest Rapids Project area during juvenile White Sturgeon indexing conducted from 2014 to 2022.

Study Year	Wanapum Reservoir Catch	Priest Rapid Reservoir Catch	Total Catch
	n	n	n
2014[1]	233	86	319
2016	746	141	887
2017	490	78	568
2018	454	109	563
2019	566	73	639
2020	484	143	627
2021	754	170	924
2022	498	189	687
All Years	**4,225**	**989**	**5,214**

[1] Sample effort was lower in 2014 compared to subsequent years.

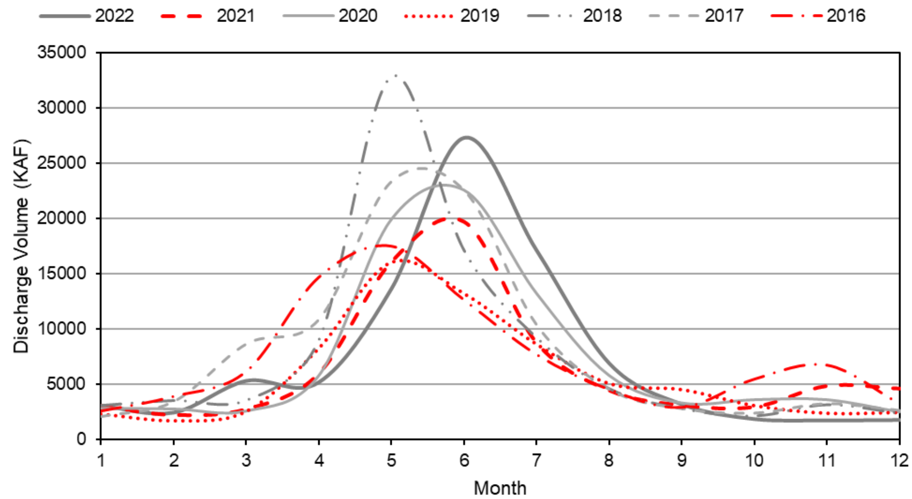

Figure 20 **Discharge for the Colombia River by year, 2016 to 2022. Catch in Wanpum reservoir was higher in years with low flow (red line) than in years with higher flow (grey lines) from 2016 to 2022.**

In 2022, use of a fish descender reduced handling time and eliminated the need for invasive deflation procedures to return fish with over pressurized abdominal cavities to depth (i.e., insertion of a large gauge needle through the abdominal wall to equalize pressure). Use of the fish descender will be included as part of the sturgeon indexing work procedures in future study years.

4.3.1 Catch Distribution by Brood Year and Reservoir

Wanapum reservoir

In 2022, the 2017BY (18% or 91 of 498 fish) and the 2018BY (18% or 89 of 398 fish), contributed the largest portion of the catch in Wanapum reservoir, followed by the 2014BY (16%; 80 of 498 fish) and the 2013BY (11%; 56 of 498 fish). The 2022 catch proportion by brood year differed substantially from 2020 and 2021 when the 2014BY contributed the largest portion of the catch in Wanapum reservoir (24% or n = 116 of 484 in 2020; 25% or n = 189 of 754 in 2021), followed by the 2013BY (19% in 2020; 90 of 484 fish and 15% in 2021; 116 of 754 fish). The lower catch proportion of the 2013BY and 2014BY was attributed to a gradual reduction in catchability of these brood years by the juvenile sampling gear, opposed to a change in population abundance of these brood years. Both the 2017BY (n = 91) and 2018BY (n = 89), which were released in similar numbers (2017BY n = 1,983; 2018BY n = 1,767), were captured in similar numbers in 2021 (2017BY n = 95; 2018BY n = 90) and 2022 (2017BY n = 91; 2018BY n = 89) and have similar survival rates in Wanapum Reservoir (see Figure 11).

The 2015BY, 2016BY, and 2017BY, which were released in nearly identical numbers, contributed similar proportions to the total catch in 2021 (2015BY n = 79; 2016BY n = 31; 2017BY n = 95), 2020 (2015BY n = 62; 2016BY n = 10; 2017BY n = 72), and 2019 (2015BY n = 42; 2016BY n = 10; 2017BY n = 60). In 2022, the catch proportion of 2015BY decreased in relation to the 2017BY (2015BY n = 44; 2016BY n = 16; 2017BY n = 91). The catch proportions of these brood years historically were assumed to reflect their relative abundance in

Wanapum reservoir; however, the change in catch proportion recorded in 2022 suggests that the 2015BY may have reduced catchability with the juvenile sampling gear. The 2016BY were captured in lower numbers (16 fish) in 2022 compared to 2021 (31 fish). Based on the current and historic low catch numbers, abundance of the 2016BY in Wanapum reservoir is likely low and potentially indicates low post-release survival or high emigration out of the Project area (Golder 2020). The low survival rate of the 2016BY was attributed to the low size at release (weight) compared to other brood years released in the PRPA (see Table 13). White Sturgeon investigations in the Upper Columbia have identified a positive relationship between size at release and survival (personal communication, J. McLellan, Confederate Tribes of the Colville Reservation).

In 2022, Ep for Wanapum reservoir was 0.66 and was lower than in both 2020 (Ep = 0.70) and 2021 (Ep = 0.74). However, the general trend in Ep among reservoir sections in 2022 was consistent with the two preceding years, with the highest Ep in the upper section (2020 Ep = 0.73; 2021 Ep = 0.83; 2022 Ep = 0.77), slightly lower Ep in the middle section (2020 Ep = 0.62; 2021 Ep = 0.77; 2022 Ep = 0.71), and the lowest Ep in the lower section (2020 Ep = 0.43; 2021 Ep = 0.63; 2022 Ep = 0.50). Prior to 2020, the highest Eps by reservoir section were generally recorded in the middle section of Wanapum reservoir, with slightly lower Eps in the upper section, and the lowest Eps in the lower section. The change in Ep was mirrored by similar changes in CPUE in each reservoir section (see Table 5). The shift in Ep and catch distribution to the upper section of Wanapum reservoir appears to be due to an increase in fish use of the upper section and a corresponding decrease in fish use of deep-water habitat in the lower and middle sections compared to previous samples years (Golder 2017).

The Eps of most brood years were marginally higher in the upper section of Wanapum reservoir than in the middle section in 2022 (see Figure 8). Although Eps were lower in the middle section, the relative differences in Eps among the brood years in both the upper and middle sections were similar. In the lower section, Eps were uniformly lower and the relative differences in Ep among the brood years differed from corresponding brood years in the middle and upper sections. In 2021, the highest Eps were recorded for the 2014BY (0.39), the 2013BY (0.37), and the 2018BY (0.36), in the upper section of Wanapum reservoir. In 2022, this order changed, with the highest Eps recorded for the 2018BY (0.36), the 2014BY (0.32), and the 2017BY (0.31). This general trend was evident to a lesser extent in the middle and lower reservoir sections. Additional catch data in future indexing studies will confirm whether the changes recorded in 2022 are indicative of a long-term shift in brood year catch composition of juvenile White Sturgeon in Wanapum reservoir.

Priest Rapids reservoir

A substantial difference between the Priest Rapids and Wanapum reservoir, in relation to sampling design, is that sampling in Priest Rapids reservoir includes the Wanapum Dam tailrace, whereas in Wanapum reservoir, the tailwater area below Rock Island Dam is shallow and generally inaccessible. Sampling effort conducted in the Wanapum Dam tailrace area can contribute up to 41% of the total catch in Priest Rapids reservoir (Golder 2021). Even though both reservoirs have inherent hydrological differences (e.g., size, gradient, residence time), conditions within each reservoir were assumed equally suitable for sturgeon growth and development based on the presence of an existing wild sturgeon population in both reservoirs. If this assumption was valid, trends in relative abundance among brood years within Priest Rapids reservoir would be expected to align with trends observed in Wanapum reservoir. As such, any substantial deviation in trends may relate to different environmental conditions between the two reservoirs 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 2022, as well as in previous indexing studies, over 50% of the 2013BY captured in Priest Rapids reservoir were fish that were entrained from Wanapum reservoir.

In Priest Rapids reservoir, the 2022 catch (n = 189) exceeded catches from all previous indexing studies: 170 fish in 2021, 143 fish in 2020, 73 fish in 2019, 109 fish in 2018, 78 fish in 2017, and 141 fish in 2016. Total catch has varied considerably among study years, with the catch from one or two high use areas contributing a high proportion to the total catch. In indexing years with low catch, the reduced catch was due in part to random chance, in that sample sites were not selected in high use areas, which is an inherent problem when sampling a highly aggregated population using a study design based on random probability sampling. Overall, 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 harvest fishery in 2015 and 2016, during which some 2010BY fish were also likely harvested, the 2013BY were the predominant brood year in the catch composition in 2017 (25%; 20 of 78 fish), 2018 (29%; 32 of 109 fish), 2019 (26%; 19 of 78 fish) and 2020 (24%; 34 of 143 fish), with all other brood years individually contributing 21% or less to the catch. In 2021, the catch proportion between the 2013BY (22%; 37 of 170 fish) and the 2014BY (20%; 34 of 170 fish) were nearly equal and suggests the 2013BY are recruiting away from the juvenile indexing gear. In 2022, the 2014BY (22%; 42 of 189 fish) had a slightly higher catch proportion than the 2013BY (21%; 40 of 189 fish).

Catch proportion of the 2017BY (6%; 11 of 189 fish) and the 2018BY (7%; 13 of 189 fish) in Priest Rapids reservoir did not mirror the high catch proportion of these brood years in Wanapum reservoir where they were the dominant catch. Given that the 2015BY to the 2018BY should have grown enough to recruit to the sampling gear, the low catch of these brood years suggests low survival or downstream emigration out of the reservoir.

The overall Ep for Priest Rapids reservoir in 2022 was 0.62, which is the highest annual Ep recorded in Priest Rapids reservoir, exceeding the previous high Ep that was recorded in 2016 (Ep = 0.53). Lower Ep values were recorded in 2021 (Ep = 0.51), 2020 (Ep = 0.44), 2018 (Ep = 0.41), and 2017 (Ep = 0.39), while the lowest Ep was recorded in 2019 (Ep = 0.33). The Ep among reservoir sections can vary substantially. In 2022, the highest Ep was recorded in the lower section (Ep = 0.73) and exceeded the Ep recorded in the upper section for the first time since the start of population indexing. The high Ep in 2022 suggests high fish use and that the fish distributed relatively evenly throughout the lower section of Priest Rapids reservoir. The high Ep in the lower section of Priest Rapids reservoir also contrasted substantially with the lower section of Wanapum reservoir, which had the lowest Ep in Wanapum reservoir. Consistent with other study years, the middle section of Priest Rapids reservoir had the lowest EP in 2022 (Ep = 0.47).

In 2022, CPUE in Priest Rapids reservoir (CPUE = 0.25 fish/100 hook-hours) exceeded that of Wanapum reservoir (CPUE = 0.22 fish/100 hook-hours) for the first time since the start of standardized small-hook juvenile indexing in 2016 (Table 15). Overall higher CPUE in Priest Rapids reservoir was due to higher catch in the lower section of Priest Rapids reservoir than in previous study year, whereas catch in both the lower and middle sections of Wanapum reservoir in 2022 were the lowest on recorded (Golder 2017–2022). Consistent with previous study years, lower CPUE was recorded in the middle section of Priest Rapids reservoir (CPUE= 0.15 fish/100 hook-hours) than in the lower section (CPUE= 0.25 fish/100 hook-hours) and upper section (CPUE= 0.36 fish/100 hook-hours). Lower use of the middle section of Priest Rapids reservoir by sturgeon was attributed to hydraulic and habitat attributes within the middle section that may be less favorable for sturgeon (e.g., high water velocity, limit holding and feeding habitat) compared to the upstream and downstream sections.

Table 15 Catch-per-unit-effort (CPUE) by reservoir in the Priest Rapids Project area during juvenile White Sturgeon indexing conducted from 2016 to 2022.

Study Year	Wanapum Reservoir CPUE	Priest Rapid Reservoir CPUE
	fish/100 hook-hour	fish/100 hook-hour
2016	0.31	0.17
2017	0.21	0.10
2018	0.19	0.14
2019	0.24	0.09
2020	0.20	0.17
2021	0.36	0.22
2022	0.22	0.25

4.3.2 Juvenile White Sturgeon Population Estimates

With the inclusion of the 2022 data, a high proportion of the CJS models constructed to estimate survival and recapture probabilities converged (i.e., 5 of 6 models), which was an improvement compared to 2021 (4 of 6 models converged). Consistent with the 2021 model, the 2022 model was selected based on the lowest QAICc value and modeled survival as a multiplicative function between brood year and recapture reservoir, with an additive effect of age class (i.e., first year after release or any subsequent year). Prior to 2021 and 2022, the amount of recapture data was not sufficient for previous models to include both brood year and recapture reservoir as model variables. As with previous modeling efforts, model-averaged estimates were calculated for each reservoir to estimate brood year survival in the 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). All models since 2020 have modeled recapture probability as a multiplicative function of age (as a categorical variable) and release reservoir. From 2021 onward, recapture data was sufficient to allow convergence of models to estimate recapture probability by reservoir and age (sample year) for each brood year.

First year survival was lower in Priest Rapids reservoir than in Wanapum reservoir for all brood years, with the exception of the 2010BY in Priest Rapids reservoir, which had the highest first year survival of all brood years in the PRPA. Consistent with previous model estimates, the low first year survival of the 2016BY was supported by the empirical catch data of this brood year in both reservoirs, with slightly higher first year survival in Wanapum reservoir than in Priest Rapids reservoir. Possible reasons for low first year survival of the 2016BY (i.e., high mortality due to small size at release, emigration, etc.) were summarized in previous reports (Golder 2018, 2022). The brood year with the highest first year survival in Wanapum reservoir was the 2019BYa (0.474), followed by the 2017BY (0.360) and 2018BY (0.360). In Priest Rapids reservoir, the 2019BYa and 2017BY had much lower first year survival. Difference in size at release of the 2017BY (i.e., fish released in Priest Rapids reservoir were smaller than fish released in Wanapum reservoir) was identified as a possible variable responsible for the difference in survival between the two reservoirs (Golder 2022). The low first year survival of the 2019BYa in Priest Rapids reservoir compared to Wanapum reservoir did not correspond to size at release (i.e., size was similar between reservoirs) and was likely due to some other variable. First year survival of the 2019BYb was similar in both reservoirs. These fish were held in the hatchery and released at age-2 at a much larger size (see Table 13) and had similar first year survival rates. Given their size at release, higher first year survival would be expected, similar to the post-first year survival rates for older cohorts. Additional recapture data will be required to further refine the survival rate of the 2019BYb.

Survival rates increased for all brood years after one year at large in both reservoirs, with most brood years with mean survival rates in excess of 0.90. Lower post-first year survival rates were evident for the 2016BY in both reservoirs; however, post-first year survival of the 2016BY was slightly higher in Priest Rapids reservoir than in Wanapum reservoir. Post-first year survival was notably higher for the 2019BYa in Wanapum reservoir than in Priest Rapids reservoir; additional data will be required to confirm whether this observed difference is accurate .

In 2022, the change in recapture probabilities of older brood years over sampling years was notably different between the two reservoirs (see Figure 12). In Wanapum reservoir, with inclusion of the 2022 capture data, a clear trend of decreasing recapture probabilities was evident in the 2010BY, the 2012BY, the 2013BY, and the 2014BY, as well as in the 2015BY for the first time since their release. Recapture probability of younger brood years in Wanapum reservoir either remained constant or increased. In Priest Rapids reservoir, the trend of decreasing recapture probabilities was evident for the 2010BY, but the recapture probabilities of other brood years either remained unchanged or increased compared to previous sampling years (i.e., 2012BY to 2016BY). A decrease in recapture probability would be expected for the older brood years, as the catchability of these fish by small-hook set line sampling gear also decreases as the fish grow in size. The difference in recapture probabilities of older brood years in the two reservoirs was attributed to reduced growth rate of fish in Priest Rapids reservoir that has resulted in a higher proportion of fish within these older brood years remaining small and susceptible to capture with small-hook set line gear (see Figure 17). In Wanapum reservoir, higher growth rate of these older brood years resulted in larger fish and reduced recapture probabilities as catchability with small-hook set line sampling decreased. The difference in recapture probabilities of older brood years between the two reservoir was also supported by the change recorded in the 2022 catch composition and the relative abundance of each brood year caught within each reservoir (see Figure 4).

With the inclusion of the 2022 catch data and updating of the model, population estimates of the proportion of the hatchery population susceptible to capture with small-hook set line gear were generated for the 2011–2022 study years (see Table 11). In the previous 2020 and 2021 models, the population estimates either decreased (2020) or increased slightly (2021) due to the smaller release numbers of the 2019BYa in 2020 (n = 672) and the 2019BYb in 2021 (n = 1,495). These release numbers were either not sufficient to compensate for the mortality of previously released fish or just sufficient to result in a small increase in the overall population. In 2022, the number of 2021BY fish released equaled the full annual hatchery release quantity prescribed for the PRPA under the 2016 SOA (n = 3,269). As the survival probabilities of the newly released fish are not calculated until the fish are one year at large, the 2022 population estimate increased an amount approximately equal to the 2022 hatchery release size. For White Sturgeon between 33.0 cm FL and 136.5 cm FL, the population in Wanapum reservoir increased from the previous 2021 estimate of 8,292 (95% CI = 6,748–9,836) to 10,809 (95% CI = 9,041 – 12,576) in 2022, which equates to 35% of the total hatchery releases to date (30,489 fish). In Priest Rapids reservoir, the 2022 hatchery fish abundance of fish in the same size range was 3,909 (95% CI = 3,211–4,606) compared to the previous 2021 hatchery fish abundance estimate of 2,408 (95% CI = 1,744–3,073), which equates to 29% of total hatchery releases to date (13,515 fish).

4.4 Growth

Difference in growth and substantial variations in length and weight among individual fish within the same brood year were evident in the 2022 data and during previous indexing studies (Golder 2017–2022). Similar to previous indexing studies, the 2022 length-frequency histograms of most brood years substantially overlapped, with the exception of the oldest (i.e., 2010BY) and youngest fish (i.e., 2021BY). Previous studies noted a decrease in catch frequency of fish over 90 cm FL; however, weight and the overall condition of the fish were also identified as variables that affect catchability and the maximum size of White Sturgeon likely to be caught by the juvenile indexing set line gear (Golder 2021).

In 2022, lower relative weights were recorded for the 2012BY in both Priest Rapids and Wanapum reservoirs and this has been a consistent attribute of the 2012BY since the first juvenile White Sturgeon assessment was conducted in 2014 (Golder 2015). In both 2021 and 2022, higher relative weights were recorded for the 2013BY and the 2018BY in Wanapum reservoir (see Figure 15). With the inclusion of the 2022 capture data, growth data for each brood year, based on change in fork length in relation to brood year age, supported previous findings that the 2012BY grow slower than other brood years (see Figure 17). The lower relative weight and slower growth rate of the 2012BY in Wanapum reservoir was possibly related to higher energetic expenditure by these fish as most were captured in the upper section of the Wanapum reservoir where flows were higher. However, given that the 2012BY in Priest Rapids also have lower relative weights and grow slower than other brood years, the growth rate of the 2012BY maybe related more to genetic attributes of the brood year rather than to environmental variables.

In general, growth rate data (i.e., change in fork length) for each brood year within each reservoir indicate that fish in Priest Rapids reservoir grow faster than fish in Wanapum reservoir up to approximately age-4. After age-4, growth rate in Priest Rapids slows and eventually plateaus after age-6 for most brood years, whereas fish older than age-4 in Wanapum reservoir continued to grow at a similar rate until age-8 to age-9, after which growth slows (see Figure 17). Growth rate estimates of brood years in both reservoirs in 2022 supported previous findings from the 2020 and 2021 studies that indicated that mean growth rates of all brood years were highest in the lower section and lowest in the upper section of each reservoir (Golder 2021–2022). The difference in growth among reservoir sections was assumed to be due to one of the following: 1) greater energetic expense by fish in the upper and middle sections compared to fish in the lower section of the reservoir; or, 2) possible density dependent growth in the upper section of Priest Rapids reservoir as a result of higher use of this section by larger numbers of sturgeon compared to the middle and lower sections.

A detailed examination of these growth data was first conducted in 2020 (i.e., length-at-age curves; Golder 2021). In 2022, inclusion of an additional year of growth data was not sufficient to expand on or refute the 2020 findings, which concluded that 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. 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 remains unclear. If density does affect growth, reduced growth may be limited to fish occupying the upper reservoir section and to fish occupying the Wanapum Dam tailrace area. If a substantial change in the condition of juvenile White Sturgeon in Priest Rapids reservoir is detected in future indexing studies, this evidence, combined with evidence of reduced growth, would be considered strong supportive evidence of density dependent growth.

4.5 Alternative Stocking Strategy for Priest Rapids reservoir

An alternate stocking strategy was developed and implemented in 2021 in Priest Rapids reservoir to address potential issues related to possible density dependent growth of hatchery fish released into the Wanapum Dam tailrace area. Sturgeon densities are known to be high in the upper section of Priest Rapids reservoir (see Table 5 and Figure 7) and juvenile fish in the Wanapum Dam tailrace area may potentially compete with older and larger juveniles from previous brood year releases that did not disperse downstream. Based on access and logistic considerations, the Desert Aire boat launch (RM400.3) and the Vantage boat launch (RM420.6) were selected as the new release sites in Priest Rapids and Wanapum reservoirs, respectively. All 2021BY fish were released at these locations on April 27 and upstream dispersal of these fish was confirmed through the capture of 2021BY fish in the upper section of each reservoir. Difference in growth and survival among brood years based on the change in release locations may be evaluated in future indexing studies.

4.6 Summary

In 2022, 2021BY fish were released into the Project area at Desert Aire boat launch in Priest Rapids reservoir and the Vantage boat launch in Wanapum reservoir. The total number of 2021BY fish were released (n = 3,269 fish) in each reservoir in the 2016 SOA (38% in Priest Rapid reservoir; 62% in Wanapum reservoir).

Broodstock collection was successfully completed to produce a 2022BY based on a 6Fx6M spawning matrix using fish captured in John Day reservoir.

Juvenile White Sturgeon indexing conducted in 2022 in the PRPA captured 687 fish total, which consisted of a record high catch of 189 fish in Priest Rapids reservoir and 498 fish in Wanapum reservoir. The juvenile White Sturgeon CJS population model was revised to calculate survival probability estimates and recapture probabilities by brood year to estimate total White Sturgeon population susceptible to the sampling gear in each reservoir by calendar year. Other metrics, like catch proportion, length-frequency, CPUE, and Ep estimates, were calculated for each brood year to infer differences in survival and abundance among groups and to inform the CJS population model results. Two separate survival estimates were generated for the 2010BY to account for loss of individuals taken as bycatch during the 2002BY removal effort. To account for the reduction in captures of larger fish, as fish grew and recruited away from the juvenile gear, the recapture rate was allowed to vary with age. This specification of the model accounted for 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 the gear. Future juvenile indexing studies will continue to address sample gear bias by assessing the size selectivity of the juvenile sampling gear. The estimated population of hatchery White Sturgeon between 33.0 cm FL and 136.5 cm FL was 10,809 fish in Wanapum reservoir and 3,909 fish in Priest Rapids reservoir.

Mean annual growth rates recorded in 2022 for each hatchery brood year were similar to rates recorded in previous study years. Higher growth rates of older brood years were recorded in Wanapum reservoir than in Priest Rapids reservoir. Lower growth rates were evident for individuals of brood years that resided in the upper sections of each reservoir and were assumed to relate to higher energetic cost. Density dependent growth of fish was not evident in Wanapum reservoir in 2022. In Priest Rapids reservoir, growth was slower for fish older than age-6; however, it was unclear if the reduced growth rate was due to localized density dependent growth of fish in the upper section of Priest Rapids reservoir. A change in the dominant brood years in the catch and the recapture probabilities of these brood years in each reservoir was evident in 2022 data. In Wanapum reservoir, the previous dominant brood years, 2013BY and 2014BY, were caught in lower numbers than the 2017BY and 2018BY. In Priest Rapids reservoir, where growth was slower, the 2013BY and 2014BY continued to comprise the greatest proportion of the total catch.

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Appendix A
2022 White Sturgeon Broodstock Collection Grant County PUD and Blue Leaf Environmental

MEMORANDUM

TO: Mike Clement, Grant County PUD

FROM: Corey Wright, *Blue Leaf Environmental*

DATE: January 13th, 2023

SUBJECT: Broodstock Collection Below McNary Dam in 2022

During the 2022 broodstock collection effort fishing took place in the spawning sanctuary below McNary dam on the Columbia River over ten days, May 16th to May 20th and from May 23rd to May 27th. Flows during this time were between 232 kcfs and 287 kcfs, which is below the 10 year mean by ~56 kcfs. River temperatures ranged from 11.4°C to 12.7°C, the mean temperature was 11.8°C which is 1.4°C below the 10 year mean.

There were 101 individual white sturgeon captured and 2 fish were captured twice for a total of 103 sturgeon landings. The mean number of fish captured per day was 10 while the mean per day per boat was 5.2 up slightly from the 2012-2021 mean per day per boat of 4.7. There were 66 individual white sturgeon over 150 cm or mature spawning size were captured and 2 fish were captured twice for a total of 68 >150cm sturgeon landings. A total of 6 ripe females and 6 ripe males were transported to Marion Drain Hatchery. On the 15th of June a 6x6 spawning matrix was attempted, all fish were successfully spawned resulting in 36 families.

This year six sturgeon previously transported to the hatchery were recaptured. This brings the total number of sturgeon since 2012 captured in years following their participation in a spawning event to 19, some of them recaptured multiple times pre and/or post spawn.

ACKNOWLEDMENTS

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

Table 1 . Catch data from white sturgeon broodstock collection efforts below McNary Dam in 2021.

No.	Date	Sex Code	Length (mm)	Girth (mm)	Fate	Event Type	Mark @ Cap	PIT Tag
1	5/16/2022 8:40	M1-4	1680	660	R2R	Recapture	L3,L13	3D9.1BF233B5AB
2	5/16/2022 8:54	M5	2280	920	Hatchery	Mark	L1-3	3DD.0077916486
3	5/16/2022 9:08	M1-4	1620	640	R2R	Mark		3DD.0077910A1A
4	5/16/2022 9:36	M5	1820	740	Hatchery	Recapture	L2	3D9.1BF1CB957F
5	5/16/2022 10:20	M1-4	2380	940	R2R	Recapture	L2	3D9.1C2DF1ACF9
6	5/16/2022 10:38		2180	870	R2R	Recapture	L2	3D9.1BF10E240B
7	5/16/2022 10:41	F5	2600	1010	Hatchery	Recapture	L2,R2	3DD.007790BD62
8	5/16/2022 11:56	F5	2090	920	Hatchery	Mark		3DD.00779159B3
9	5/16/2022 13:03		1260	530	R2R	Recapture		3D9.1C2D2F8482
10	5/16/2022 14:00		2900	1210	R2R	Recapture	L2	3D9.1C2DC96D01
11	5/16/2022 14:03	M1-4	1750	710	R2R	Recapture	L2,R2	3D9.1BF1B84207
12	5/16/2022 14:29	M5	2410	940	Hatchery	Mark		3D9.1C2DF1306D
13	5/17/2022 0:00		1420	580	R2R	Mark	R23, R25	3D9.1C2DF193DB
14	5/17/2022 0:00		1250	460	R2R	Mark	L15, L16	3D9.1C2DECF020
15	5/17/2022 7:34		1340	560	R2R	Mark		3D9.1C2DF17834
16	5/17/2022 8:11		1320	520	R2R	Mark		3D9.1C2DECA19D
17	5/17/2022 8:33		2600	990	R2R	Recapture		3DD.0077536116
18	5/17/2022 8:40	F4	2770	1070	R2R	Mark		3D9.1C2DE48DA9
19	5/17/2022 9:11	F3	2450	990	R2R	Mark		3D9.1C2DEC9FFC
20	5/17/2022 9:38		1300	550	R2R	Mark		3D9.1C2DECE81C
21	5/17/2022 9:56	F3	2520	1020	R2R	Mark		3D9.1C2DF18C18
22	5/17/2022 11:03	M1-4	2380	1000	R2R	Recapture	L2	3D9.1C2DECC830
23	5/17/2022 12:28	M5	2450	780	Hatchery	Mark		3D9.1C2DF17960
24	5/17/2022 12:59	M1-4	1600	640	R2R	Recapture	L2	3D9.1C2CDADF32
25	5/17/2022 13:49	F3	1710	720	R2R	Mark		3D9.1C2DF1633E
26	5/17/2022 14:00	M5	1740	720	Hatchery	Recapture	L2	3DD.00776396B9
27	5/17/2022 14:36	M5	2050	800	Hatchery	Mark	L2,R2,R5,R7,R8	3D9.1C2DF1A95A
28	5/17/2022 14:47		960	430	R2R	Mark		3D9.1C2DEC0C3B
29	5/17/2022 15:09		1140	410	R2R	Mark		3D9.1C2DF178DC
30	5/18/2022 8:15		1360	540	R2R	Recapture		3D9.1BF1C51C4B
31	5/18/2022 8:38		780	340	R2R	Mark		3D9.1C2DF12C17
32	5/18/2022 9:09	M5	2680	1040	R2R	Recapture	L2	3DD.007791149D
33	5/18/2022 9:17		2390	940	R2R	Recapture		3D9.1C2DF1ACF9
34	5/18/2022 9:44		2180	810	R2R	Recapture	L2, R11	3D9.1BF1CFF1F7
35	5/18/2022 9:53		1180	460	R2R	Mark		3D9.1C2DEC7718
36	5/18/2022 10:27		950	360	R2R	Mark	L18-20	3DD.00779E936C
37	5/18/2022 10:49		770	300	R2R	Mark	R26-30	3D9.1C2DF1366C
38	5/18/2022 12:55		1920	780	R2R	Mark		3D9.1C2DF164D2
39	5/18/2022 13:13		1420	570	R2R	Recapture	L10,R9	3DD.003D560354

No.	Date	Sex Code	Length (mm)	Girth (mm)	Fate	Event Type	Mark @ Cap	PIT Tag
40	5/18/2022 13:16		2340	860	R2R	Mark		3D9.1C2DEC6293
41	5/19/2022 0:00		1150	450	R2R	Recapture		3D9.1C2DA8E855
42	5/19/2022 0:00		1010	400	R2R	Mark		3D9.1C2DE49C01
43	5/19/2022 8:36		2300	820	R2R	Recapture	L2	3D9.1C2DC87728
44	5/19/2022 8:38		2290	930	R2R	Mark		3D9.1C2DF1B194
45	5/19/2022 9:27		1260	630	R2R	Mark		3D9.1C2DCBD7A6
46	5/19/2022 13:00	F3	2500	1030	R2R	Mark		3D9.1C2DF16883
47	5/19/2022 11:33		1950	550	R2R	Mark		3D9.1C2DE4ABFB
48	5/20/2022 10:13		1490	580	R2R	Recapture		3D9.1BF10E7297
49	5/20/2022 11:08	F4	2290	950	R2R	Mark		3D9.1C2DF129FD
50	5/20/2022 11:18		2620	1060	R2R	Recapture	L3	3D9.1C2DF15A41
51	5/20/2022 12:39	M5	1990	940	R2R	Mark		3D9.1C2DF16A7A
52	5/20/2022 14:06	F5	2380	1000	R2R	Recapture	L2	3D9.1C2DF1A610
53	5/20/2022 14:14		2140	810	R2R	Mark	L3	3D9.1C2DE44E76
54	5/23/2022 0:00		1160	490	R2R	Mark		3D9.1C2DF1B92D
55	5/23/2022 8:30		790	330	R2R	Mark	L17-19	3DD.00779FA2AA
56	5/23/2022 8:49		1680	640	R2R	Mark		3D9.1C2DF17072
57	5/23/2022 8:52	F5	1690	740	R2R	Recapture	L2	3D9.1BF10E22FD
58	5/23/2022 10:01		2350	880	R2R	Recapture		3D9.1C2DF5DEEA
59	5/23/2022 11:46		2290	930	R2R	Recapture	L2	3D9.1BF2649B7A
60	5/23/2022 14:01		1200	520	R2R	Mark		3D9.1C2DECDCCA
61	5/23/2022 15:01		1080	440	R2R	Mark		3D9.1C2DF17C6B
62	5/23/2022 15:41		1720	720	R2R	Mark		3D9.1C2DE5055B
63	5/23/2022 15:45		1100	470	R2R	Mark		3D9.1C2DF13728
64	5/24/2022 0:00		1210	500	R2R	Recapture		3D9.1BF2648515
65	5/24/2022 0:00		1280	530	R2R	Recapture		3D9.1C2CDADD2B
66	5/24/2022 0:00		1190	510	R2R	Mark		3D9.1C2DF13F72
67	5/24/2022 0:00		1610	660	R2R	Mark		3D9.1C2DE4985E
68	5/24/2022 0:00		1310	500	R2R	Recapture		3DD.007763BF69
69	5/24/2022 0:00		1110	460	R2R	Recapture		3D9.1C2DC8F6C4
70	5/24/2022 0:00		1340	580	R2R	Recapture		3D9.1BF1661483
71	5/24/2022 9:08		2560	1170	R2R	Recapture	L2	3D9.1C2DF795E7
72	5/24/2022 9:17		2770	1070	R2R	Recapture		3D9.1C2DE48DA9
73	5/24/2022 10:53		2260	930	R2R	Recapture	L2,L14,R9,R14-16	3DD.0077917EAD
74	5/24/2022 10:58	M5	2180	950	R2R	Mark	L14, L15, L18	3D9.1C2DE4EB65
75	5/24/2022 11:54	M5	2120	990	R2R	Recapture	L2,L9	3D9.1BF10D5DEE
76	5/24/2022 12:38	F5	2500	940	Hatchery	Mark		3D9.1C2DF147F0
77	5/24/2022 13:07		1860	770	R2R	Recapture		3D9.1C2CDACDE3
78	5/24/2022 13:22		2180	880	R2R	Recapture	L2,5,6,9,10,13	3D9.1BF10EF3C6
79	5/24/2022 14:06	F5	2300	900	Hatchery	Mark		3D9.1C2DF1BA10

No.	Date	Sex Code	Length (mm)	Girth (mm)	Fate	Event Type	Mark @ Cap	PIT Tag
80	5/24/2022 15:03		1920	760	R2R	Recapture	L2	3D9.1BF264CACB
81	5/25/2022 8:38	F5	2570	1140	R2R	Mark	L17	3D9.1C2DEC62B8
82	5/25/2022 9:48		1930	730	R2R	Mark		3D9.1C2DF1B728
83	5/25/2022 9:51		2250	890	R2R	Mark	R17	3D9.1C2DEC9778
84	5/25/2022 10:34	F5	2450	960	R2R	Recapture	L2	3D9.1C2DC9459B
85	5/25/2022 10:54		1950	820	R2R	Recapture	L2	3D9.1C2D6726D6
86	5/25/2022 11:24		2330	840	R2R	Mark		3D9.1C2DF18C34
87	5/25/2022 12:25	F5	2580	1130	Hatchery	Mark	L3	3D9.1C2DE3F804
88	5/25/2022 12:46		2060	760	R2R	Mark		3D9.1C2DF1938F
89	5/26/2022 9:37		1740	690	R2R	Mark		3D9.1C2DECE1E1
90	5/26/2022 0:00		1390	550	R2R	Recapture	L2, L22-27, R17-18	3D9.1C2DF1865C
91	5/26/2022 0:00		910	350	R2R	Recapture	L2, L19-22	3DD.0077A06390
92	5/26/2022 0:00		1400	570	R2R	Mark		3DD.0077913FB8
93	5/26/2022 10:16	F5	2840	1200	Hatchery	Mark		3D9.1C2DF137A9
94	5/26/2022 10:27		2040	830	R2R	Mark	L2	3D9.1C2DEC5A4D
95	5/26/2022 10:31		2030	820	R2R	Mark		3D9.1C2DF17F4D
96	5/26/2022 12:57		2770	1120	R2R	Recapture	2L	3D9.1C2DC90D83
97	5/26/2022 15:10		2070	870	R2R	Recapture	L22	3D9.1C2DEC7E24
98	5/27/2022 7:54		2370	850	R2R	Mark		3D9.1C2DF16061
99	5/27/2022 9:04		1890	810	R2R	Mark		3D9.1C2DF16152
100	5/27/2022 9:10		2230	880	R2R	Recapture	L2	3DD.007753466E
101	5/27/2022 10:25		2540	1030	R2R	Mark		3D9.1C2DEC96B0
102	5/27/2022 13:02		1830	720	R2R	Mark		3D9.1C2DEC623B
103	5/16/2022		1100	4600	R2R			No scan

Appendix B
2018 - 2022 Biological Objectives Status Report

BIOLOGICAL OBJECTIVES STATUS REPORT 2018 to 2022

A component of the Priest Rapids Project Area (PRPA or "the Project") Water Quality Certification required that Public Utility District No. 2 of Grant County, Washington (Grant PUD), in consultation with members of the Priest Rapids Fish Forum (PRFF), develop and implement a White Sturgeon Management Plan (WSMP) within one year after the issuance of the Federal Energy Regulatory Committee (FERC) license for the Project on April 17, 2008. The WSMP was developed in 2009 (Grant PUD 2009)[1]; Specific Biological Objectives of the WSMP are as follows:

1) Spawning and rearing in the Project area: Natural reproduction potential reached via natural recruitment.
2) Spawning, rearing, and harvest in Project reservoirs: Increase the White Sturgeon population in the Project's reservoirs to a level commensurate with available habitat.
3) Adult and juvenile upstream and downstream migration: Provide safe, effective, and timely volitional passage, if reasonable and feasible passage means are developed.
4) Until reasonable and feasible means for re-establishing natural production and providing support for migration are available, and recognizing that those means appear unlikely in the foreseeable future, the Biological Objective is to sustain a population at a level commensurate with available habitat through implementation of a White Sturgeon supplementation program in the Project's reservoirs. The supplementation program will provide an initial foundation for the Monitoring and Evaluation (M&E) Program, which is designed to a) identify existing impediments to achieving the Biological Objectives, b) sustain the populations until the existing impediments can be corrected, and c) mitigate for population losses due to Project impacts.
5) The goals of the WSMP are to: (1) identify and address Project effects on White Sturgeon and, (2) develop and implement "Implementation Measures" designed to avoid and mitigate for Project effects on White Sturgeon. Adaptive management shall be applied to resolve critical uncertainties. In addition, the following tasks, consistent with achieving the Biological Objectives, are incorporated into the WSMP:

    Task 1: Determine the effectiveness of the supplementation program in creating a sustainable White Sturgeon population in the Project reservoirs based on natural production potential and adjust the supplementation program accordingly.

    Task 2: Determine the carrying capacity of available White Sturgeon habitat in each reservoir.

    Task 3: Determine juvenile downstream passage rates and survival.

[1] Grant PUD (Public Utility District No. 2 of Grant County). 2009. Priest Rapids Project – FERC P-2114. White sturgeon Management Plan. License Article 401(a)(11), April 2009.

The FERC license stipulates that progress achieved in attaining the Specific Biological Objectives identified in the WSMP is to be reviewed and reported every 5 years after issuance of the Project FERC license in 2008. The first Biological Objectives Status Report was completed in 2012 (Golder 2013)[2] and summarized the successes, short-comings, and lessons learned since the initial implementation of the WSMP in 2010 when field data collection and supplementation efforts commenced. The second Biological Objectives Status Report was completed in 2018 (Golder 2019)[3] and summarized the progress made from License Year 6 (2014) to License Year 10 (2017). The purpose of the present report is to summarize the progress made from License Year 11 (2018) to License Year 15 (2022) towards meeting the specific Biological Objectives in the WSMP.

The WSMP identified six Protection, Mitigation, and Enhancement measures (PMEs) to be implemented by Grant PUD to achieve the Biological Objectives of the WSMP. The following section lists these PMEs, describes progress-to-date in their implementation, and identifies where modifications from the proposed WSMP study program and schedule have occurred. These modifications were made in consultation with the PRFF as part of the adaptive management approach described in the WSMP.

1) **Prepare a brood stock collection and breeding plan within year one of the effective date of the New License and, if feasible, begin brood stock collection in year two of the New License.**

Broodstock capture by guide-assisted angling was conducted in the tailwater of McNary Dam in 2018 and 2019 and in 2021 and 2022. In 2018 and 2019, Grant PUD and Chelan PUD collaboratively funded the broodstock capture program. The objective of this joint program was to catch and transport a sufficient number of broodstock for the Yakama Nation Sturgeon Hatchery (YNSH) aquaculture supplementation program to meet the genetic diversity requirements of the WSMP and to achieve stocking requirements in both the PRPA and in Rocky Reach Reservoir. This capture effort was conducted by Blue Leaf Environmental Inc. (BLE) biologists, Chelan and Grant PUD personnel, and volunteers, who were support by commercial fishing guides. The BLE biologists surgically inspected mature fish for gonad development and were responsible for transport of potential candidate broodstock from McNary Dam to YNSH with the Grant PUD White Sturgeon transport trailer. Due to the COVID-19 pandemic and mandatory social distancing requirements, broodstock collection was not conducted in 2020. In discussions between Grant PUD and Chelan PUD on how the broodstock collection program should proceed after 2020, Chelan PUD opted to use wild-spawned larvae, collected and reared by the Colville Confederated Tribes (CCT), as the primary source of juvenile White Sturgeon for the supplementation program in their county from 2021 onward. In 2021 and 2022, broodstock capture efforts resumed downstream of McNary Dam, solely funded by Grant PUD. In 2020 during natural spawning assessments, Grant PUD re-examined the feasibility of collection and *in situ* incubation of wild spawned White Sturgeon eggs captured below Rock Island Dam as an

[2] Golder Associates Ltd. 2013. White sturgeon monitoring and evaluation program annual report 2012. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 10-3930-0302: 67pp. + 6 app.

[3] Golder Associates Ltd. 2013. White sturgeon monitoring and evaluation program annual report 2012. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 10-3930-0302: 67pp. + 6 app.

alternate source of larval sturgeon (Golder 2021)[4]. To date, a suitable alternative source of brood has not been identified to either replace or significantly supplement the current approach, based on the annual capture and spawning of broodstock. Broodstock capture efforts from 2018 to 2021 were not successful in achieving a full spawning matrix (i.e., spawning of six females and six males to produce36 genetic crosses), and the progeny in those brood years consisted of between 24 to 32 genetic crosses (Table 1). In 2022, a full spawning matrix was successfully achieved.

Table 1 **The capture locations of White Sturgeon broodstock spawned at YNSH, and the resulting factorial breeding matrices and genetic crosses produced for each juvenile brood year, 2018 to 2022.**

Brood Year	Capture Location and Number of Fish Spawned at YNSH	Sex Ratio Ripe Fish Spawned		Resulting Factorial Breeding Matrice(s)	Number of Genetic Crosses[1]		
	McNary Dam Tailwater	Female	Males		Unique	Half-sib	Total
2018	12	5	5	5Fx5M	5	20	25
2019	10	5	5	4Fx5M, 1Fx3M	5	19	24
2020	-	-	-	-	-	-	-
2021	12	6	6	5Fx6M, 1Fx2M	6	26	32
2022	12	6	6	6Fx6M	6	30	36

[1] Unique crosses are classified a single mating between one female and one male. Half-sib crosses are produced when an egg taken from a single female is crossed with another male above the single unique pairing. The number of half-sib crosses produced depends on the amount of eggs and milt obtained from the fish.

2) **Implement a White Sturgeon supplementation program by releasing up to 5,000 yearling White Sturgeon into the Wanapum Reservoir each year and 1,500 yearling White Sturgeon into the Priest Rapids Reservoir annually for Years 3 through 7 of the M&E program, with subsequent annual release levels to be determined by the PRFF, based on monitoring results.**

In 2016, members of the PRFF negotiated a revised stocking strategy that would be logistically sustainable over a long term scenario and result in an adult population within the PRPA that is similar in density to downstream reservoirs and able to sustain a limited harvest fishery. The release strategy selected by the PRFF allocated a maximum of 3,250 fish released annually in the PRPA, with 2,000 fish (i.e., 62%) released in Wanapum reservoir and 1,250 fish (i.e., 38%) released in Priest Rapids reservoir. This new release strategy was endorsed by all PRFF members and implemented under a Statement of Agreement issued on March 11, 2016 (SOA). The original end date of the SOA was anticipated to be 2020; however, due to the COVID-19 pandemic, the PRFF members agreed to extend the end date of the SOA until sufficient data are obtained to amend and update the existing release strategy outlined in the SOA. The genetic

[4] Golder Associates Inc. 2021. White Sturgeon Management Plan Annual Report (2020. Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 189924702: 74 pp. + 1 app.

diversity objectives outlined in the SOA required each annual release consist of progeny from 18 unique crosses (i.e., annual broodstock captures of 18 females and 18 males). In practice, broodstock capture efforts were unable to obtain the large number of fish required to meet the SOA genetic diversity objectives. Furthermore, regulators in both Washington and Oregon raised concerns about how the removal of large numbers of spawners would affect the existing wild population of White Sturgeon in John Day reservoir. As such, the PRFF members revised the SOA genetic diversity requirements for each annual release to the maximum genetic crosses possible based on a fixed amount of capture effort per year (i.e., 10-days of sampling).

Due to the cancellation of brood stock collection in 2020, the members of the PRFF agreed on an alternate release strategy to divide the 2019BY release between 2020 and 2021 by holding and rearing half of the 2019BY for an additional year. This revised strategy ensured a minimum release of fish in each year and kept the hatchery operating at a sustainable level without requiring a complete shutdown of the facility. A secondary benefit of the 2020-2021 release strategy was that it allowed a comparison of first-year and post-first year survival of age-1 fish (2020 release) and age-2 fish (2021 release) from the same brood year.

In total, 11,307 juvenile hatchery White Sturgeon have been released in the PRPA from 2018 to 2022 (Table 2). Releases from 2018 to 2020 were at locations within Wanapum (i.e., Frenchman Coulee Launch, RM424.5) and Priest Rapids reservoirs (i.e., Wanapum Dam Tailrace launch, RM415.6) that had been used consistently for fish releases to the PRPA since 2015. Fish releases in 2018 and 2019 were in early spring and consistent with previous releases. Due to the pandemic, the tagging and release of the age-1 2019BY fish in 2020 was delayed until mid-summer (July 23, 2020).

Prior to 2018, PRFF members were aware of spontaneous autopolyploidy syndrome in sturgeon, a genetic defect known to occur in hatchery spawned juvenile White Sturgeon that results in a certain proportion of the spawned progeny having a chromosome count of 10N or 12N, instead of 8N, the normal number of chromosomes in White Sturgeon. The exact cause of the syndrome is not well understood; however, the biological risk of the syndrome is that 10N and 12N fish are either sterile or will produce sterile progeny. In context with the Grant PUD hatchery juvenile White Sturgeon release program in the PRPA, a risk was identified by the PRFF that hatchery operations could amplify the presence of the syndrome in the existing PRPA population of White Sturgeon through the inadvertent release of large numbers of 10N or 12N fish. In response, a screening program was initiated in 2020 with the purchase of a Coulter Counter that uses a blood sample to determine if a fish has the syndrome. Due to the pandemic, the Coulter Counter was not available until 2021. In 2021 and 2022, all adult broodstock candidates were tested for the syndrome and any positive fish identified were not used as broodstock. All progeny in each brood year release were also tested individually prior to processing. In 2021, 16 of 1,501 2019BYb (age-2 fish) fish tested were identified as positive and were euthanized (Golder 2022)[5]. In 2022, only 6 of 3,275 2021BY fish tested were identified as positive and were euthanized (Golder 2023)[6].

In 2021, new release sites were established in Wanapum reservoir (Vantage boat launch, RM420.6) and Priest Rapids reservoir (Desert Aire boat launch, RM400.3). The change in

[5] Golder Associates Inc. 2022. White Sturgeon Management Plan Annual Report (2021). Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 20413113: 82 pp. + 2 app.

[6] Golder Associates Inc. 2023. White Sturgeon Management Plan Annual Report (2022). Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 20413113: in preparation.

release locations was based on preliminary evidence from the juvenile White Sturgeon population indexing study that suggested that brood year releases in Priest Rapids reservoir from 2017 onward had low survival and slower growth compared to the same releases in Wanapum reservoir. A possible hypothesis for the lower abundance and growth was that the fish released at the Wanapum Dam tailrace launch did not disperse readily downstream and were exposed to increased competition due to high densities of older brood years that resided in the tailrace area. A comparison of telemetry and catch data of hatchery releases in both Wanapum and Priest Rapids reservoirs indicated that fish released in the lower section of Wanapum reservoir tended to disperse upstream, whereas fish released in the upper section of Priest Rapids reservoir tended to remain in the upper section of the reservoir. The solution proposed was to standardize the release strategy so that fish were released in the lower section of both reservoirs into similar habitat and have a similar opportunity to disperse upstream. The new release locations were used during releases in 2021 and 2022 and are the planned release locations for all future releases.

Table 2 Numbers of juvenile hatchery White Sturgeon released from 2018 to 2022 (2017BY to 2021BY) in the PRPA.

Brood Year	Reservoir	Release Location	River Mile	Brood Source	Release Date	Number Released (Acoustic-tagged fish)
2017	Wanapum	Frenchman Coulee	424.5	MCW	1-May-18	1,983 (20)
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	1-May-18	1,241 (12)
				Total 2017		3,224 (32)
2018	Wanapum	Frenchman Coulee	424.5	MCW	7-May-19	1,767(0)
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	7-May-19	890 (0)
				Total 2018		2,657 (0)
2019a	Wanapum	Frenchman Coulee	424.5	MCW	23-Jul-20	411 (0)
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	23-Jul-20	261 (0)
				Total 2019a		672 (0)
2019b	Wanapum	Vantage	420.6	MCW	20-Apr-21	936 (0)
	Priest Rapids	Desert Aire	400.3	MCW	20-Apr-21	549 (0)
				Total 2019b		1,485 (0)
2021	Wanapum	Vantage	420.6	MCW	27-Apr-22	2,010 (0)
	Priest Rapids	Desert Aire	400.3	MCW	27-Apr-22	1,259 (0)
				Total 2021		3,269 (0)
				Total 2017BY-2021BY released		11,307 (32)

3) **Design and implement a long-term juvenile index monitoring program over the term of the New License to monitor age-class structure, survival rates, growth rates, distribution, and habitat selection of juvenile sturgeon.**

A critical component of the M&E program is to assess the abundance and survival of each juvenile White Sturgeon brood year release. These data are also used to adjust future annual release numbers in response to changes in overall abundance and survival estimates.

From 2018 to 2022, juvenile White Sturgeon population assessments were conducted with baited setlines using the same standardized methodology applied during indexing studies conducted since 2016. Setline sampling was conducted in the PRPA over a three-week period, typically in mid or late summer. Set line sample locations in the “lower”, “middle”, and “upper” sections of each reservoir were selected using a single pass, unstratified, unequal probability general random tessellation stratified (GRTS) sampling design (Stevens and Olsen 2004)[7]. Shallow areas in each reservoir (i.e., <15 m in Wanapum and <6 m in Priest Rapids reservoirs) were excluded from the sample site selection process in order to concentrate sample effort in deeper water habitat where sturgeon typically reside. Set lines were deployed and left overnight for sampling durations ranging between 18 and 24 hours. Total sample effort was consistent among study years and consisted of 270 overnight sets in Wanapum reservoir and 90 overnight sets in Priest Rapids reservoir. Total catch during juvenile White Sturgeon population assessments in Wanapum and Priest Rapids reservoirs from 2018 to 2022 is provided in Table 3.

Table 3 Total catch during juvenile White Sturgeon population assessment conducted from 2018 to 2022 in the PRPA.

Study Year	Wanapum Reservoir Catch	Priest Rapid Reservoir Catch	Total Catch
	n	n	**n**
2018	454	109	**563**
2019	566	73	**639**
2020	484	143	**627**
2021	754	170	**924**
2022	498	189	**687**
All Years	**2,756**	**684**	**3,440**

With the inclusion of the 2022 data in a Cormack-Jolly-Seber (CJS) model, the brood-year-specific survival estimates varied between Priest Rapids reservoir and Wanapum reservoir to support a model that included reservoir of capture as an explanatory variable. This result allowed use of model averaged estimates for each reservoir to estimate brood year survival in the first year after release (i.e., one year at large) and for all subsequent years (i.e., greater than one year at large; Table 4). The 2022 CJS model results indicated that first year survival was lower in Priest Rapids reservoir than in Wanapum reservoir for all brood years, with the exception of the 2010BY population in Priest Rapids, which had the highest first year survival of all brood years in the PRPA. Consistent with previous model estimates, the low first year survival of the 2016BY was supported by the empirical catch data of this brood year in both reservoirs. In 2021 and 2022, greater numbers of 2016BY were captured in both Wanapum and Priest Rapids reservoirs compared to previous indexing years; however, the 2016BY still remain underrepresented in both reservoirs. The low first year survival estimates of the 2016BY may have been the result of higher mortality (vs emigration) due to their small size at release, as this brood year release was below average weight at release (2016BY mean = 126 g; 2010BY–2019BY mean = 205 g), but more likely due to a higher rate of emigration based on an entrainment rate of 25% for acoustic-tagged 2016BY juveniles post-release from Wanapum reservoir, which was the highest rate of entrainment of all brood year releases (Golder 2018)[8].

[7] Stevens Jr., D.L. and Olsen, A.R. 2004. Spatially Balanced Sampling of Natural Resources. Journal of the American Statistical Association, 99, 262-278.Uphoff, J. H., Jr. 1993. "Determining Striped Bass Spawning Stock Status from the Presence or Absence of Eggs in Ichthyoplankton Survey Data." North American Journal of Fisheries Management 13(4): 645-656.

[8] Golder Associates Inc. 2018. White Sturgeon Management Plan Annual Report and Year 10 Biological Objective Status Report (2017). Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 10-3930-0306: 51 pp. + 4 app.

The highest first year survival in Wanapum reservoir was the 2019BYa (0.474) and the 2017BY (0.380). This contrasted with the first year survival of these same brood years in Priest Rapids where their survival was substantially lower (2019BYa survival = 0.049; 2017BY survival = 0.100). This difference in 2017BY first year survival may be due to a lower weight at release of 2017BY in Priest Rapids reservoir (mean = 136 g) compared to the 2017BY released in Wanapum reservoir (mean = 150 g). For the 2019BYa release in 2020, mean release weights of the 2019BYa were nearly identical in both reservoirs and release weight was likely not a factor in first year survival.

Survival rates increased for all brood years in both reservoirs after one year at large. Juvenile and adult White Sturgeon capture data from 2018 indicated that the 2002BY "cull" and removal efforts from 2016 to 2018 also negatively affected both wild sturgeon and the 2010BY that were within the slot-size identified for harvest[9]. As such, subsequent population models included the effect of 2002BY removal efforts on the 2010BY survival as a variable, with the 2022 model using two different post-first year survival estimates for the 2010BY(i.e., "pre and post-cull"). The 2010BY survival in the absence of 2002BY removal was 0.98 or greater for each reservoir (i.e., "pre-cull"). During the removal years, the 2010BY survival estimates decrease substantially in Priest Rapids reservoir (0.401) compared to Wanapum reservoir (0.822; "post-cull"). Parsing out the effect of the 2002BY removal effort on 2010BY survival allowed a more realistic estimate of post-removal 2010BY survival and the contribution of the 2010BY to the current PRPA population.

Table 4 First year and post-first year survival of hatchery juvenile White Sturgeon brood years released in the PRPA in 2022.

	First Year Survival		Post-First Year Survival	
Brood Year	Priest Rapids Reservoir	Wanapum Reservoir	Priest Rapids Reservoir	Wanapum Reservoir
2010	0.586	0.320	0.995	0.903
2010 -post cull	-	-	0.401	0.822
2012	0.179	0.321	0.967	0.985
2013	0.132	0.312	0.953	0.984
2014	0.190	0.247	0.969	0.978
2015	0.120	0.247	0.948	0.978
2016	0.053	0.085	0.883	0.926
2017	0.100	0.380	0.937	0.988
2018	0.244	0.375	0.977	0.988
2019a	0.049	0.474	0.873	0.992
2019b	0.207	0.187	-	-

In each study year from 2018 to 2022, annual growth rate was calculated for each brood year released in the PRPA, based on the difference in fork length between release and capture, divided by the time at large, for fish more than one year at large. In general, growth rate was

[9] Golder Associates Inc. 2019. White Sturgeon Management Plan Annual Report and Year 10 Biological Objective Status Report (2018). Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 1899247: 74 pp. + 1 app.

higher in younger fish than in older fish and gradually decreased as fish aged. Across all brood years, mean growth rates were generally highest in the lower sections of each reservoir, decreased in the middle sections, and were lowest in the upper sections of each reservoir. This declined in growth rate was most pronounced in young brood years (i.e., 2017BY, 2018BY).

Growth models based on change in fork length by age for each brood year indicated that growth differed for fish in Wanapum reservoir compared to fish in Priest Rapids reservoir. Fish in Priest Rapids reservoir exhibited slower growth that plateaued after age-6 (e.g., 2010BY growth slowed down by age-6 in Priest Rapids reservoir). In Wanapum reservoir, growth rates were higher for older fish and slowed only slightly in fish age-10 or older. In Priest Rapids reservoir, the 2012BY and 2014BY were growing slower that other brood years; in Wanapum reservoir, the 2012BY growth rate was notably slower than in other brood years.

Overall, growth rate estimates for each brood year were insufficient to conclude if density dependent growth was evident 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. 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 remains unclear. If density does affect growth, reduced growth may be limited to fish occupying the upper reservoir sections and to fish occupying the Wanapum Dam tailrace area.

The 2022 CJS model provided population estimates for juvenile hatchery White Sturgeon in Wanapum reservoir (n = 10,809; 95% CI = 9,041–12,576) and Priest Rapids reservoir (n = 3,909; 95% CI = 3,211–4,606). These estimates represent the numbers of fish surviving from all hatchery fish released into the PRPA since 2011. A notable divergence in recapture probabilities of older brood years was evident in the 2022 catch data, with decreasing recapture probabilities for the 2015BY and older fish in Wanapum Reservoir. This difference in recapture probabilities between the two reservoirs was attributed to higher growth rates in Wanapum reservoir that reduced the catchability of larger fish in Wanapum reservoir on juvenile set line gear compared to fish of the same age in Priest Rapids reservoir. This trend of reduced recapture probability of older brood years is expected to continue in Wanapum reservoir as fish age and also will become more evident in catch data from Priest Rapids reservoir in subsequent study years.

4) **As part of the supplementation program, conduct tracking surveys of juvenile White Sturgeon released with active tags to determine emigration rates and passage survival from the Priest Rapids Project area.**

Tracking of juvenile White Sturgeon movements and emigration rates of the 2017BY was conducted in 2018 using up to 11 acoustic telemetry receivers (Amirix Vemco model VR2W®) deployed in the PRPA to monitor the movements of acoustic-tagged adult and hatchery juvenile White Sturgeon[10]. With the completion of the last year of juvenile White Sturgeon acoustic tagging and movement monitoring in 2018, as obligated under the FERC license, the acoustic telemetry receivers were removed on May 1 and 2, 2019. The telemetry data recorded were used to assess movements for each brood year of hatchery releases and release groups within the brood year release (e.g., time of release, of different broodstock origin, etc.). Since 2010, a

[10] Golder Associates Inc. 2019. White Sturgeon Management Plan Annual Report and Year 10 Biological Objective Status Report (2018). Report prepared for Public Utility District No. 2 of Grant County, Ephrata, Washington. Golder Associates Ltd. Report No. 1899247: 74 pp. + 1 app

portion of acoustic-tagged fish (31 of 339 detected tags or 9.1%) have emigrated out of the reservoir where they were stocked (either by involuntary entrainment or volitional movements). Over this time, emigration rates of acoustic-tagged fish from Wanapum reservoir have averaged 10.8%/yr (range from 0.0 to 25.0%/yr) compared to 3.8%/yr (range from 0.0 to 9.5%/yr) from Priest Rapids reservoir. The substantially lower emigration rates from Priest Rapids reservoir suggest only a small percentage of fish are emigrating from the PRPA.

Table 16 Entrainment rate of acoustic-tagged juvenile White Sturgeon released into the Priest Rapids Project area between 2011 and 2018, detailed by release pool, year, and dam of entrainment.

Release Details				Entraining Dam (RM)	Number Entrained	Percent Entrainment (%)
Pool	**Year**	**n**	**Release RM**			
Wanapum	2011 (2010BY)	70	450.6	Wanapum (415.6)	9	12.9
Wanapum	2013 (2012BY)	24	450.6/442.0	Wanapum (415.6)	0	0.0
Wanapum	2014 (2013BY)	52	421.5	Wanapum (415.6)	3	5.8
Wanapum	2015 (2014BY)	48	424.5	Wanapum (415.6)	7	14.6
Wanapum	2016 (2015BY)	25	424.5	Wanapum (415.6)	3	12.0
Wanapum	2017 (2016BY)	20	424.5	Wanapum (415.6)	5	25.0
Wanapum	2018 (2017BY)	20	424.5	Wanapum (415.6)	1	5.0
Subtotal		259			28	10.8
Priest Rapids	2011 (2010BY)	21	415.6	Priest Rapids (397.1)	2	9.5
Priest Rapids	2013 (2012BY)	6	415.6	Priest Rapids (397.1)	0	0.0
Priest Rapids	2014 (2013BY)	14	415.6	Priest Rapids (397.1)	0	0.0
Priest Rapids	2015 (2014BY)	15	415.6	Priest Rapids (397.1)	0	0.0
Priest Rapids	2016 (2015BY)	7	415.6	Priest Rapids (397.1)	0	0.0
Priest Rapids	2017 (2016BY)	12	415.6	Priest Rapids (397.1)	1	8.3
Priest Rapids	2018 (2017BY)	12	415.6	Priest Rapids (397.1)	0	0.0
Subtotal		80			3	3.8

5)

6) **Compile information on other White Sturgeon supplementation programs in the region.**

Information regarding White Sturgeon supplementation in the PRPA and in other parts of the Columbia River watershed is typically reviewed and exchanged during monthly meetings of the PRFF. During these meetings, ideas to improve sample methods and aquaculture techniques are shared, as well as new information from the M&E program and potential changes to the monitoring programs. The PRFF consults specialists and experts outside the group when necessary. Since 2010, the annual results and findings of the Grant PUD WSMP M&E program have been summarized in report format and provided to the PRFF. Some PRFF members also attend annual or special conferences to exchange information with researchers and managers of White Sturgeon recovery programs in the upper, middle, and lower Columbia River, the Kootenai River and Nechako River.

7) **Use the information collected above to direct and modify the supplementation program strategy.**

As discussed above, several modifications to the original objectives of the WSMP and the proposed M&E programs have been required based on the results obtained from the recovery program and information learned from other White Sturgeon supplementation programs. The successful negotiation of the SOA in 2016 demonstrates that the PRFF can function effectively as an technical oversight body and find consensus when addressing complicated or contentious issues. From 2018 to 2022, changes and modifications to the WSMP and the M&E program have been approved by the PRFF and reflect the adaptive management approach that is a vital part of the WSMP. Information from the M&E programs and other recovery programs will continue to be incorporated into the overall management framework of the WSMP

Appendix C

2022 WSMP Agency Comment and Grant PUD Response to Comments

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	iv	It isn't clear how it was determined that growth rate influenced recapture probability. Wouldn't slower growing fish be susceptible to the gear for a longer period of time.	Comment noted. This section has been modified to provide further clarity. Lower recapture probability was evident in Wanapum reservoir (WR), not in Priest Rapids reservoir (PR). Recapture probability was decreasing overtime and lower in WR than in PR for 2010BY-2014BY. The 2015BY recapture probability was decreasing in WR but still slightly higher in WR compared to PR.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	4	Were all fish screened for SAP or just a subsample? The two highlighted sentences suggest opposite sampling strategies.	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	5	What criteria were used to assess overall health? Were fish of poor health released?	This section has been modified to address this comment
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	6	Weren't six females spawned, resulting in six maternal families?	Correct. This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation	2023-03-13	6	Were fish re-measured for length/weight before release? If not, how was additional holding accounted for in	Additional information has been added to this section to provide clarity. Fish

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
(J. McLellan)			growth estimates? Was the holding period the same for both releases?	were not re-measured before release. The post-processing holding time in previous years was approximately two weeks and growth during this time was assumed to be minimal.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	7	Would be good to clarify where the measurements were obtained from (i.e., rearing vessel, transport tank, reservoir). Was temp and DO measured in both the rearing vessels and the transport tanks just prior to loading the fish into the transport tanks? Then in the transport tanks just after all fish loaded? Was temp and DO measured in both the transport tanks and the reservoir just prior to releasing the fish into the reservoir?	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	7	Confederated Tribes of the Colville Reservation - CBC has emphasized the use of the official name.	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	8	Also log10 transformed?	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation	2023-03-13	8	If holding times or rearing conditions were different between release groups, then the growth estimates could be biased, particularly if post-	This section has been modified to provide clarity regarding this comment For each brood year release, a

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
(J. McLellan)			measurement holding times were relatively long (weeks or months). How is this accounted for in the analysis?	post-processing holding time of approximately two weeks was targeted. In 2022, the holding time was longer (four weeks) due to scheduling conflicts. Prior to processing, feed was withheld from the fish for a few days prior to processing to reduce handling stress. Growth during the short post-processing holding period prior to release is assumed to be minimal and likely would not affect growth estimates and interpretation of the data.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	9	How did you handle growth modeling for fish with recaptures, and thus length/weight measurements, in multiple surveys (handled in multiple years)?	Growth of recaptured fish were treated as independent measures at each age. A repeated measures model could be developed if sufficient data are available. Will consider for 2023.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	9	Why weren't the 2016 and 2017 broodyears included?	All years of data were included; however, the model did not converge for the brood years identified.
Confederated Tribes of the Colville Reservation	2023-03-13	12	Suggest removing as it is implied from the previous sentence.	This section has been modified to address this comment.

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
(J. McLellan)				
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	17	Mean CPUE? If so, provide measure of precision (i.e., standard deviation).	The measure is not a mean, but single measure (total catch/total effort).
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	29	They were also spatially balanced.	Grant PUD agrees with this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-13	29	I suggest you remove the last two sentences of this paragraph, because the point you are trying to make isn't clear and it may be incorrect. One interpretation is that you are suggesting that the GRTS approach is biased - which it in itself is not. The sample frame and strata (based on depth and width) may not result in complete sampling of the target population or sample sizes may not be large enough, but these would be the result of choices by the study designers and not a problem with the GRTS approach as implied. The survey design resulted in greater effort (sets/ha) in the middle and upper strata, which are narrower and shallower on average, in direct contradiction to the second to last sentence in this paragraph. The second interpretation is that the survey design does not	This section has been modified to address this comment. This section is a presentation of the catch data as a measure of CPUE by River Mile and explain why higher effort was recorded in some river miles and not in others. The presentation of sample effort and catch data by River Mile does provide a broad overview of the spatial differences in the amount of effort applied and relative fish density in each reservoir. As such, continued inclusion of the data as presented in the 2022 report is suggested, however, alternate methods of data presentation will be considered in

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
			result in enough sets per river mile in the narrower reaches; however, river mile isn't one of the sampling strata. Perhaps river mile isn't an appropriate scale at which to be examining the data? Maybe use heat maps or graduated symbols to display the results spatially? Furthermore, more effort can be added to the narrower strata in order to increase the samples/river mile if that is important.	future reports (e.g., spatial density plots).
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	37	Consider explaining the box plots in the caption (e.g., box 25 and 75 percentiles, whiskers 10 and 90 percentiles, solid horizontal line median, outliers black circles).	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	37	Sample sizes by BY?	This section has been modified to address this comment
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	39	Interesting that the apparent outlier in Wr plot 2019BY (Figure 15) is not really standing out in this figure.	Comment noted. This has been reviewed and the outlier filter used to generate each figure and ensured they are the same.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	39	Discussion.	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation	2023-03-14	39	The method by which density dependent effects on growth were evaluated was not described, so it is not clear	This section has been modified to address this comment.

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
(J. McLellan)			how you arrived at this conclusion. Suggest removing - also see next comment.	
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	39	It is probably not safe to assume that younger year classes, as densities increase, are going to see the same level of growth that the first year class exhibited. Also, the BY2010 growth estimate was based on very small sample sizes and was likely biased as only the slowest growing fish would still recruit to the gear. Suggest removing.	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	40	Wouldn't this be indicative of a potential density-related impact on growth?	Grant PUD generally agrees that the difference in growth curves maybe indicative of different growing conditions within each reservoir, but whether this difference is due to density dependence is not clear. The 2017BY and 2018BY, in Priest Rapids reservoir, although data are limited, appear to be growing at a higher rate than older brood years when compared for the same age. This may suggest that age and size may be a factor in Priest Rapids reservoir (i.e., older

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				fish more subject to density dependent growth, younger fish less so).
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	40	See previous comment about the lack of clarity regarding evaluation of factors affecting growth. In addition, this statement does not seem to be supported by the information presented (e.g., slowing growth, plateauing growth). Suggest removing.	Additional information has been added to clarify interpretation of the data to identify that younger brood year releases continue to grow at similar rates or higher rates than older brood year releases for a given age. (curves overlap or are higher).
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-02-23	42	These six fish were not released so they do not comprise a percentage of them. They comprise a percentage of the fish tested.	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	47	BY2016 fish had the smallest size (weight) at release. In the upper Columbia there is a positive relationship between size at release and survival.	Grant PUD agrees. This relationship between weight and survival was identified in previous reports and will be referenced as a personal communication based on the comment provided.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	47	Explain why this is a reasonable assumption.	This section has been modified to address this comment
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	48	This needs more fleshing out. It is not clear how this relates to the previous sentences in this paragraph.	This section has been modified to address this comment.

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	48	Are you suggesting a different survey design would be better? There is a tone in this report that you don't like the spatially balanced random sampling design. As such, it seems that you should provide an evaluation of potential sampling designs with their respective pros and cons relative to the study objectives and then make a recommendation.	This section has been modified to address this comment
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	48	The term cull suggests a selective removal of an individual broodyear, which was not exactly the case. While intended to reduce the numbers of BY2002 fish using length restrictions, the fish actually harvested were not selected by the harvesters based on BY. The monitoring data clearly indicates wild fish and hatchery fish from other broodyears were also harvested.	Grant PUD agrees with this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	48	On a separate note, this probably biased your growth estimates (at least in previous years), as the fastest growing BY2010 fish were the ones that were harvested.	Grant PUD agrees with this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	48	How are they the "new dominant" broodyear if the BY2013 fish simply aren't recruiting to your gear? The gear in this survey is so selective that phrases like this are not very meaningful. Suggest removing.	This section has been modified to address this comment.
Confederated Tribes of the Colville	2023-03-14	49	Were water velocities measured?	Water velocities were not measured. This section has been

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
Reservation (J. McLellan)				modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	50	The fish in this release group were nearly 100 g larger than the next largest fish released (except BY2019b of course). In the upper Columbia, there was a positive relationship between mass at release and first year survival. This seems to support the same for Wanapum.	Grant PUD agrees with this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	50	At release these fish were near the upper end of the range of lengths recruiting to the sampling gear, so many likely grew to the point where they are no longer recruiting relatively quickly. As such, gear related effects on capture probability likely biased the estimate low.	Additional catch data will refine the survival rates. Based on their size at release, the 2019b brood year should have the highest post-release survival.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	50	Possible evidence of density related declines in growth? Increased CPUE, plus increased Ep, plus increased density, and slow growth - starting to make a case for it. Does this trend hold up when larger hook sizes are used?	Possible density dependent growth in Priest Rapids reservoir was identified in previous reports as a localized effect due to the release of hatchery fish directly into the Wanapum tailrace. Subsequent monitoring of future brood years released in the lower section of Priest Rapids reservoir will provide additional data to further investigate whether density dependent growth is evident in Priest Rapids reservoir. The effect of larger hook size was not

Submitting Entity	Date Received	Page #	Agency Comment	Grant PUD Response
				considered during development of the report.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	51	Abundances within which size range? It would be good to make it clear that the estimates are based on gear that is size selective and these estimates only apply to the sizes of fish that are recruiting to the gear. Also should point out that changes in abundance estimates are not unexpected due to different stocking rates, differences in survival that are likely influenced by size at release which has been fairly variable, and differences in growth rates, all of which collectively effect how many fish are within the effective size range of the gear.	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	51	The results are more and more biased toward slower growing fish within BY2012 with each passing year due to gear selectivity.	Grant PUD agrees with this comment. This would be expected for all brood year releases.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	51	Clarify that you are referring to growth in length.	This section has been modified to address this comment
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	52	What did this consist of?	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	52	Agreed. However, there are a few places in this document where you state that there is no evidence of density dependent effects on growth in Priest Rapids reservoir. Those should	This section has been modified to address this comment.

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			be revised to reflect the uncertainty.	
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	52	This contradicts all statements indicating no evidence of density dependent effects on growth in Priest Rapids reservoir, with the exception of the uncertainty indicated in the previous paragraph. Consider revising to insure consistency regarding density dependent effects on growth throughout.	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	52	The abundance estimates did not apply to the total population. It only applied to those fish susceptible to the sampling gear.	This section has been modified to address this comment.
Confederated Tribes of the Colville Reservation (J. McLellan)	2023-03-14	53	The previous sentence contradicts this statement. High density may be influencing growth in the upper reach.	This section has been modified to address this comment

From: Mike Clement
To: Deb Firestone
Subject: FW: GCPUD 2022 WSMP Report Review
Date: Thursday, March 2, 2023 10:44:24 AM
Attachments: 2023_02_06 GCPUD 2022 DRAFT_WSMP Report CTCR.pdf

For your records

From: Jason McLellan <Jason.McLellan@colvilletribes.com>
Sent: Thursday, February 23, 2023 11:12 AM
To: Mike Clement <Mclemen@gcpud.org>
Cc: Tracy Hillman <tracy.hillman@bioanalysts.net>
Subject: GCPUD 2022 WSMP Report Review

Hi Mike,

Attached are our review comments and suggested edits to the GCPUD Draft 2022 WSMP Report. There is a lot of good information in the report and I appreciate having the opportunity to read it and to provide comments. There were a few items that stood out to me.

1. There was inconsistency in the conclusions about the occurrence of density dependent effects on growth in the upper reaches of both Wanapum and Priest Rapids. It would be good if the conclusions, even if it is that they are uncertain, are consistent throughout.
2. There seems to be an underlying tone of dislike for the survey design almost to the point of incorrectly suggesting it is biased. The document, and committee, would be better served if these suggestions were removed,.and instead, a comparative evaluation of the current and alternative sampling designs concluding with a recommendation for future surveys were provided.
3. Gear selectivity, along with variation in stocking numbers, locations, and sizes, is clearly influencing and potentially limiting the usefulness of some of the results. It may be time to consider introducing larger hook sizes into the survey design. This has been done in Wells and Rocky Reach by fishing "large-hook" setlines along with the "small-hook" setlines during the "juvenile indexing" surveys (e.g., 50% of sites fished with small gear and 50% large).

Thanks again for the opportunity to review. Please contact me if you have any questions.

Best Regards,
Jason

Appendix D
Washington Department of Ecology Approval Letter – March 10, 2023

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Central Region Office
1250 West Alder St., Union Gap, WA 98903-0009 • 509-575-2490

March 10, 2023

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

Sent Via Email Only

RE: Request for Ecology Review and Comments – *2022 White Sturgeon Management Plan Annual Report*
Priest Rapids Hydroelectric Project No. 2114

Dear Tom Dresser:

The Washington State Department of Ecology (Ecology) has reviewed the *2022 White Sturgeon Management Plan Annual Report* sent via email to Ecology on February 6, 2023.

Ecology has **no comments** for the *2022 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