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March 22, 2019

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) – 2018 White Sturgeon Management Plan Annual Report

Dear Secretary Bose,

Please find enclosed Public Utility District No. 2 of Grant County, Washington (Grant PUD) 2018 White Sturgeon Management Plan (WSMP) Annual Report consistent with the requirements of Article 401(a)(11) of the Priest Rapids Project License[1] and the Washington State Department of Ecology (Ecology) 401 Water Quality Water Quality Certification Condition of 6.2(5)(b) and 6.2(5)(d) for the Priest Rapids Project (Project).

The study objectives and tasks which were completed under the 2018 Monitoring & Evaluation program were as follows:

1). Develop and implement a tagging, marking, and release plan for the 2017 Brood Year (BY) juvenile White Sturgeon based on the annual release target objectives as determined by the Priest Rapids Fish Forum (PRFF), and in accordance with stocking targets outlined in the Priest Rapids White Sturgeon Stocking Statement of Agreement (SOA) dated March 11, 2016.
2). Monitor dispersal of the 2017BY juvenile White Sturgeon, based on the movements of acoustic-tagged fish within each release group, and determine the extent of outmigration from both Wanapum and Priest Rapids reservoirs.
3). Collect broodstock from John Day Reservoir downstream of McNary Dam. This work was conducted directly by Grant PUD and Public Utility District No. 1 of Chelan County, Washington (Chelan PUD), with coordination and data collection conducted by Blue Leaf Environmental (BLE). A summary of 2018 broodstock collection efforts is provided in Appendix A.

[1] 123 FERC ¶ 61,049 (2008)

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4). Conduct a juvenile White Sturgeon mark and recapture program in August 2018 to determine survival rate and a population abundance estimate of hatchery juvenile sturgeon released to date.
5). Conduct an adult White Sturgeon mark and recapture program in September and October 2018 to determine survival rate and population abundance estimates for resident adult wild fish and sub-adult hatchery sturgeon released into Rock Island Reservoir by the Columbia River Inter-Tribal Fish Commission (CRITFC) in 2003 (2002BY) that have subsequently moved downstream into the PRPA.

On February 4, 2019, Grant PUD prepared and disseminated the draft 2018 WSMP Annual Report for a thirty day comment period to members of the PRFF, which includes Ecology, U.S. Fish & Wildlife Service (USFWS), Washington Department of Fish & Wildlife, Colville Confederated Tribes, Yakama Nation, the Columbia River Inter-Tribal Fish Commission, Bureau of Indian Affairs, Wanapum Indians, and the Confederated Tribes of the Umatilla Indian Reservation. No comments were received. On March 7, 2019 Ecology approved the 2018 WSMP Annual Report (found in Appendix B of the WSMP Report).

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

Sincerely,

Ross Hendrick
Manager - License & Environmental Compliance

Cc: Breean Zimmerman – Ecology
Priest Rapids Fish Forum

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2018
White Sturgeon Management Plan
Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

Prepared for:

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

Prepared by:

Golder Associates Ltd.
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January 2019

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

Chris Mott	Grant PUD
Sima Usvyatsov	Golder Associates Ltd.
Ron Giles	Golder Associates Ltd.
Corey Wright	Blue Leaf Environmental
Nicole Ogan	Blue Leaf Environmental
Larry Hildebrand	RiverRun Consulting

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

List of Abbreviations

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

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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") and are owned by Public Utility District No. 2 of Grant County, Washington (Grant PUD). The PRPA is approximately 99 km long (61.5 miles), with the upstream and downstream boundaries defined by Rock Island Dam (River Mile [RM] 453.5 and Vernita Bar (RM392.0) below Priest Rapids Dam (Figure 1).

On April 17, 2008, the Federal Energy Regulatory Commission (FERC) issued Grant PUD a 44-year license (FERC No. 2114) to operate the Priest Rapids Project. As part of the Washington Department of Ecology Section 401 Water Quality Certification for the Project (401 Certification), Article 401 of the FERC license requires Grant PUD to conduct a Monitoring and Evaluation (M&E) program to evaluate Project operations on White Sturgeon (*Acipenser transmontanus*) populations within the PRPA.

In response, Grant PUD developed a White Sturgeon Management Plan (WSMP), with the overarching goal to restore and maintain White Sturgeon populations to levels commensurate with the available aquatic habitat in the PRPA. The 2018 M&E program was developed as part of this ongoing evaluation effort.

The study objectives and tasks which were completed under the 2018 M&E program (FERC License Year 11) were as follows:

1). Develop and implement a tagging, marking, and release plan for the 2017 Brood Year (BY) juvenile White Sturgeon based on the annual release target objectives as determined by the Priest Rapids Fish Forum (PRFF), and in accordance with stocking targets outlined in the Priest Rapids White Sturgeon Stocking Statement of Agreement (SOA) dated March 11, 2016.

2). Monitor dispersal of the 2017BY juvenile White Sturgeon, based on the movements of acoustic-tagged fish within each release group, and determine the extent of outmigration from both Wanapum and Priest Rapids reservoirs.

3). Collect broodstock from John Day Reservoir downstream of McNary Dam. This work was conducted directly by Grant PUD and Public Utility District No. 1 of Chelan County, Washington (Chelan PUD), with coordination and data collection conducted by Blue Leaf Environmental (BLE). A summary of 2018 broodstock collection efforts is provided in Appendix A.

4). Conduct a juvenile White Sturgeon mark and recapture program in August 2018 to estimate survival rate and the population abundance of hatchery juvenile sturgeon released to date.

5). Conduct an adult White Sturgeon mark and recapture program in September and October 2018 to estimate survival rate and population abundance for resident adult wild fish and sub-adult hatchery sturgeon released into Rock Island Reservoir by the Columbia River Inter-Tribal Fish Commission (CRITFC) in 2003 (2002BY) that have subsequently moved downstream into the PRPA.

The following introductory sections summarize work conducted within the PRPA relevant to the 2018 study objectives and provide the rationale for the 2018 White Sturgeon M&E program.

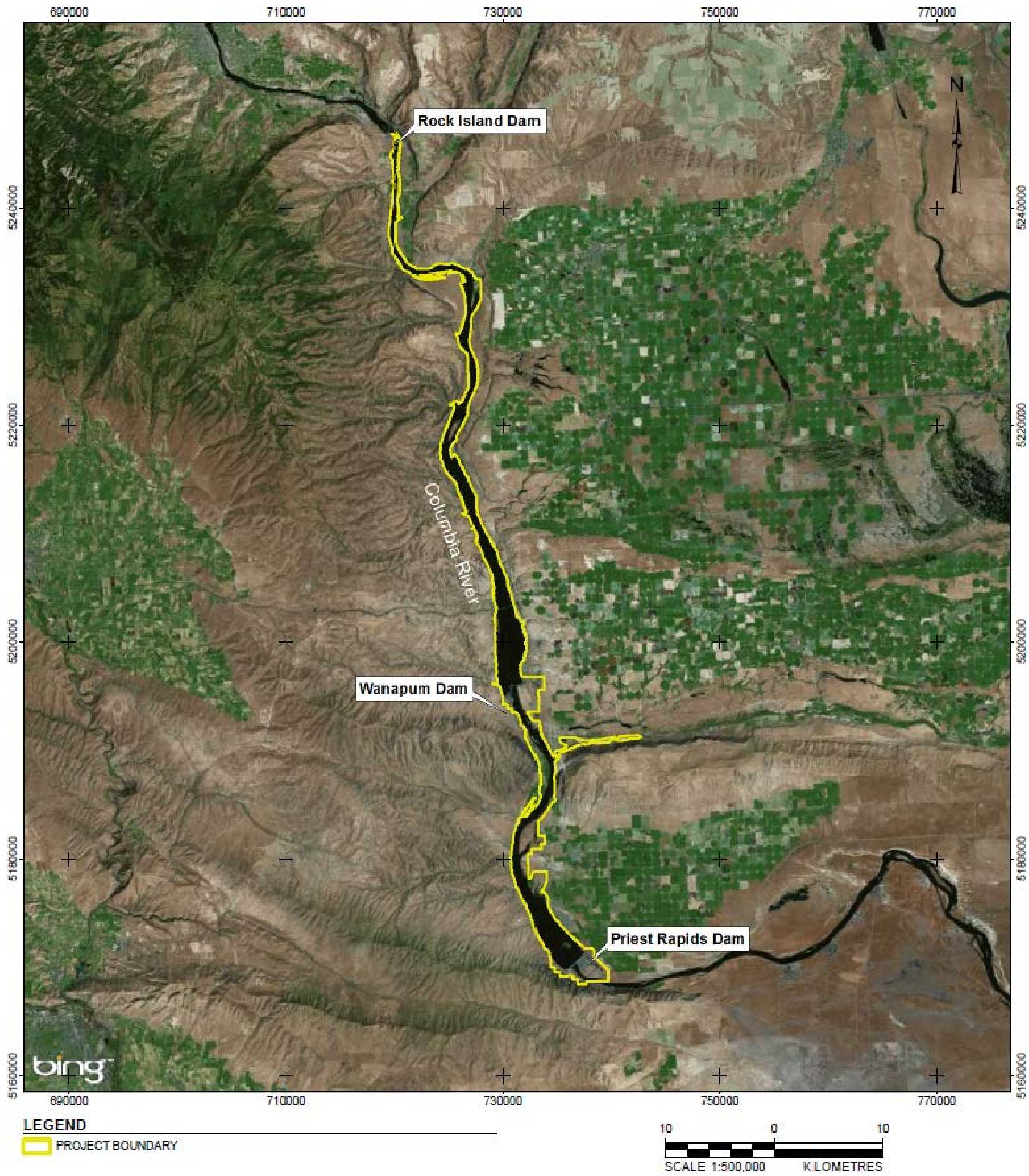


Figure 1 The Priest Rapids Project area.

Juvenile White Sturgeon 2017BY Releases into the PRPA

Since 2011, hatchery–raised juvenile White Sturgeon have been released annually into the PRPA with the exception of 2012. As of May 1, 2017, the PRPA juvenile White Sturgeon supplementation program had released 32,697 hatchery-raised juvenile sturgeon from five brood years (i.e., 2010, 2012, 2013, 2014, 2015, and 2016) into the PRPA. For the reasons described in previous annual reports, release numbers, strategies, and locations have varied from year to year (Golder 2012, 2014, 2015, 2016, 2017, and 2018). Under the 2016 SOA, revised hatchery juvenile White Sturgeon annual stocking targets were established for years 2017 (FERC License Year 9 of the WSMP) to 2020 (Year 13). The release numbers, locations, and strategies used in 2018 during the 2017BY release are provided.

Broodstock Capture and Spawning

White Sturgeon broodstock capture efforts below McNary Dam were initiated by Chelan PUD in 2012. Blue Leaf Environmental (BLE) continues to lead and coordinate this work, with funding and logistical support provided by both Chelan PUD and Grant PUD. In the current Grant PUD study, a summary of the 2018 broodstock collection are attached as memo report (Appendix A).

Spawning of the broodstock captured in 2017 and subsequent rearing of the 2017BY progeny were conducted by personnel at the Yakama Nation Sturgeon Hatchery (YNSH) under contract to Grant PUD. This 2018 Grant PUD report summarizes the 2017 and 2018 hatchery activities as they pertain to the objectives of the 2018 M&E program.

Monitor Dispersal of the 2017BY Juvenile White Sturgeon

The movements of acoustic-tagged White Sturgeon in the PRPA are monitored using Vemco VR2W® acoustic receivers deployed at strategic locations in Wanapum and Priest Rapids reservoirs, and immediately downstream of Priest Rapids Dam. The receivers were first deployed in 2010 and have since been maintained on an annual basis, with up to four service sessions conducted per year to download data and maintain the array (i.e., cleaning, repairs, and battery exchange). This report provides details of the array maintenance and data processing, a summary of the post-release dispersal of 2017BY in the PRPA, and any evidence of entrainment.

Juvenile White Sturgeon Population Indexing

A critical component of the M&E program is an assessment of the abundance and survival of each juvenile White Sturgeon brood year release. These data are needed to inform future annual release numbers in response to brood year specific abundance and survival estimates. In 2014, 2016, and 2017 baited small-hook set line gear were used to capture hatchery juvenile White Sturgeon in the PRPA and estimate their survival and abundance (Golder 2015 ,2017 and 2018). Methods used in 2018 were based on the 2016 study design and are described in this 2018 report, along with a summary of the results and a discussion on the effectiveness of the program at meeting the study objectives.

Adult White Sturgeon Population Indexing

Under the WSMP, White Sturgeon adult population indexing is conducted every three years to estimate the population of adults White Sturgeon in the Project area. Previous population assessments in 2012 and 2015 used baited large-hook setlines to estimate the sub-adult and adult White Sturgeon population in the PRPA. Sampling effort and sample design in 2012 and 2015 were similar, with set line locations selected using a general random tessellation stratified (GRTS) design. In 2018, sample effort was similar to previous studies; however, for consistency in future monitoring efforts, site selection during the 2018 study was changed to the same approached used by the 2018 juvenile indexing study.

1.1 Consultation

Pursuant to the reporting requirements, Grant PUD provided a complete draft of the WSMP 2018 Annual Report to the PRFF on February 4, 2019 for review. Written comments were received from WDFW and Colville Confederated Tribe on 7 March, 2019. A summary of written comments from the PRFF as received by Grant PUD on the draft 2018 WSMP Comprehensive Annual Report have been compiled along with responses from Grant PUD (Appendix X). The summary is based on review comments provided (Appendix X).

2.0 Methods

Study methods used in 2018 were very similar to the 2017 study, with a similar approach and level of effort applied for the study components common to both years, which includes hatchery juvenile White Sturgeon tagging and release, VR2W acoustic receiver station servicing, and juvenile White Sturgeon population indexing. The 2018 juvenile White Sturgeon indexing study design and methodology was identical to the 2016 and 2017 studies and was described in detail in the 2016 report (Golder 2017).

The 2018 adult White Sturgeon indexing methods were based on the 2015 study. The overall level of sample effort and fish handling procedures used during the 2018 adult indexing were essentially identical to the 2015 study. However, for consistency with the juvenile survey, the adult indexing study design and GRTS sample site selection methodology was modified to replicate the approach developed for the juvenile indexing program. The following sections provide general descriptions of methods used and more detail has been provided to explain where the 2018 methodology deviated from previous studies, or if 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 11, 2018 were obtained from the Columbia River Data Access in Real Time webpage (DART 2018).

2.2 2017BY Rearing and Marking, and Release

In 2017, the broodstock capture efforts by Grant PUD and Chelan PUD resulted in the capture of 6 ripe females and 6 ripe males. The broodstock were transported to the YNSH and spawned on May 27, 2017. One female did not produce enough viable eggs to contribute to the brood production effort, which resulted in a 5x6 spawning matrix that produced 30 genetic crosses (5 unique crosses and 25 half-sib crosses). During rearing, brood representing 6 genetic crosses were lost in late August 2017 when the water supply system to the rearing tank failed. Furthermore, genetic testing results received in August confirmed that one of the female parents was autopolyploid (12N). Consequently, the progeny from this female, which represent six genetic crosses, were deemed ineligible for release due to genetic concerns and were euthanized (personal communication, Donella Miller, YNSH, August 29, 2017). With these losses, the genetic composition of the remaining 2017BY consisted of 18 genetic crosses (4 unique crosses, 14 half-sib crosses).

Under the revised release strategy outlined in the SOA (March 11, 2016), approximately 3,250 juvenile White Sturgeon were to be released in the PRPA in 2018: 2,000 fish into Wanapum Reservoir and 1,250 fish into Priest Rapids Reservoir. Fish were selected in equal proportions across all genetic crosses and were sorted into specific holding pens based on release location. Processing of the 2017BY (e.g., tagging, marking, etc.) was scheduled for mid-April 2018, with the fish to be released by early May to allow a minimum two-week post-marking recuperation period.

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

Approximately 1% (i.e., 32 fish) of the total juvenile release group were implanted with acoustic telemetry tags (Vemco® V9-2L coded pingers) to allow examination of post-release movements by a portion of the release group. The specifications of the acoustic tags are provided in Table 1. When possible, fish that weighed at least 235 g were selected to ensure that the tag weight did not contribute more than 2 percent to total weight of the tagged fish. For fish that received an acoustic tag, the tag was inserted into in the coelom through a horizontal incision in the lateral wall; the incision was closed with two interrupted single sutures (Figure 2). These acoustic-tagged fish were distributed between Wanapum and Priest Rapids reservoirs in the same proportion as the overall release, with 62% (n = 20) fish released in Wanapum Reservoir and 38% (n = 12) in Priest Rapids Reservoir.

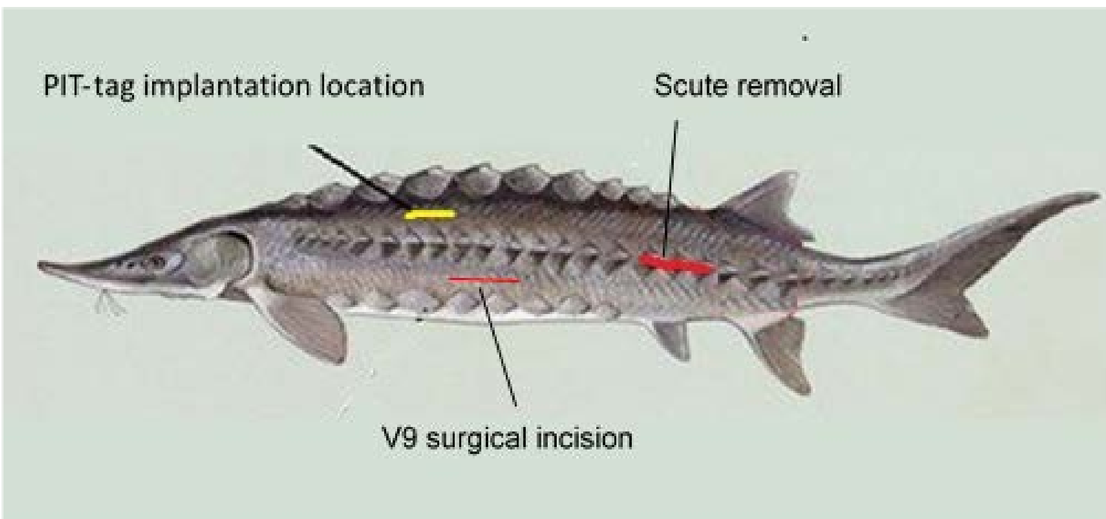


Figure 2 Juvenile White Sturgeon tag implantation and mark locations.

Table 1 Vemco V9-2L coded pinger tag specifications.

Vemco V9 Tag Parameters	V9-2L Specifications
Output (dB/m)	145
Wt in air (g)	4.7
Tag length (mm)	29
Tag diameter (mm)	9
Tag life at 170-310s burst interval (days)	912

Tagging logistics and data collection were coordinated by BLE, with assistance from Yakama Nation Sturgeon Hatchery (YNSH) staff during PIT-tagging and scute-marking activities. Data were recorded with a Biomark fish processing system and entered electronically into the P4 data processing program. The BLE biologist was responsible for implementing appropriate quality control/quality assurance protocols (e.g., fish handling and processing methods, daily data verification, and backup, etc.) during fish processing and data recording. The data fields recorded were selected to document the genetic origin, holding and rearing conditions, morphometry, fin abnormalities, and the identifying tags and marks applied to each fish (Table 2).

Table 2 Data recorded for the 2017BY White Sturgeon tagged and released in the Priest Rapids Project area in 2018.

Data Field	Description
Rec #	Sequential record number
Hatchery (Rearing)	Yakama Nation Sturgeon Hatchery (YNSH)
Proponent	Grant PUD
Tagging Date &Time (mm/dd/yyyy hh:mm)	Date and time when each fish is tagged
PIT-Tag Code	in HEX or DEC
Species	White Sturgeon
Fork Length (mm)	Measure for all fish; tip of snout to tail fork (nearest 1 mm)
Weight (g)	Measure for all fish (nearest 1 g)
Acoustic ID code	Vemco V9 5 digit code
Acoustic Serial #	Vemco 7 digit serial number
Acoustic Tag Model	V9-2L
Brood Year Cross	2017
Rearing Pen-Stock Id	TBD
Release Pen #	WP or PR
Scute removal	3 left lateral scutes below and anterior to dorsal
PIT-tag placement	left lateral, behind head
Notes	Record deformities and if fish are in poor health

2017BY Releases

In 2018, juvenile White Sturgeon were held in the hatchery for approximately three weeks post-tagging to allow recovery from the tagging process. The release of 2017BY in the PRPA was coordinated by Grant PUD biologists and technicians, who worked with staff and equipment provided by YNSH and Grant PUD. Since 2015, fish destined for Wanapum Reservoir have been released at Frenchman Coulee boat launch (RM424.5), while fish destined for Priest Rapids Reservoir have been released at the Wanapum Dam tailrace launch (RM415.6). Transport of the fish from the YNSH to the release sites was accomplished with a hatchery truck and White Sturgeon transport trailer. Fish were released from the trailer to the river through either a flexible flume or chute to avoid damage to the fish. Buckets of water and nets were used to evacuate any remaining fish from each transport vehicle. An effort was made to chase any fish away from around the wheels of the transport truck and trailer before driving out of the water.

Grant PUD biologists and field staff assisted with fish transfer and transport efforts, as well as monitored water temperature and dissolved oxygen of the transport and/or receiving waters during the following stages of the release:

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

Transport manifest forms were completed by field staff to record the above information, as well as the date and time of water quality checks and the arrival, release, and departure times. Total travel time from the YNSH to the Project release sites was approximately 2 hours one-way, with two water quality checks conducted approximately 40 minutes apart during transport

2.3 Broodstock Capture

The 2018 White Sturgeon broodstock capture program involved a collective effort from public utilities, government agencies, and consultants in support of the White Sturgeon conservation aquaculture program at YNSH. This capture effort consisted of guide-assisted angling conducted by BLE biologists, Chelan and Grant PUD personnel, and volunteers. All broodstock capture efforts in 2018 were conducted in John Day Reservoir over 14 days from May 14 to 27. Candidate broodstock were transported to YNSH by BLE staff with the Grant PUD White Sturgeon transport trailer, identical to previous broodstock capture efforts. Following transportation to the hatchery, fish were weighed and transferred to a holding pen. Once contained within a holding pen, additional gonad inspections were conducted to determine egg maturity (i.e., egg polarization index) and in preparation for egg take and fertilization efforts.

2.4 Juvenile White Sturgeon Population Indexing

The approach and methods used during the 2018 juvenile White Sturgeon population indexing program was effectively identical to the approach and methodology applied in 2016 and 2017 (Golder 2017). 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 Rapid reservoirs from September 6 to 27. Each set line was 122 m long and deployed with 40 gangions spaced 3 m apart. Each gangion consisted of a swivel snap, a length of 150# monofilament leader, and either a 2/0 or 4/0 circle hook. Sampling was conducted in Wanapum Reservoir by Golder and BLE field crews using two Golder research vessels to deploy gear and process fish. Sampling in Priest Rapids Reservoir was conducted by Grant PUD biologists using a Grant PUD research vessel. Set lines were left to sample overnight and were retrieved and reset the following day.

Set line locations in 2018 were selected in an identical manner as was done in the two previous studies using a single pass, unstratified, unequal probability general random tessellation stratified (GRTS) sampling design (Stevens and Olsen 2004). The GRTS sample locations were determined with the spsurvey package (Kincaid 2007) developed for the R statistical program (R version 3.4.3; R Core Team 2018). The 2018 survey used the same sample multi-density reservoir categories (“lower”, “mid”, and “upper” sections) used in the 2014, 2016, and 2017 studies (Golder 2017). These sections roughly reflected the transition from riverine to reservoir conditions in each pool. The Wanapum Reservoir GRTS sample sites were constrained to sections of the reservoir where water depth was typically 15 m or greater, based on available bathymetric data. In Priest Rapids Reservoir, site selection was constrained to the area encompassed within the ≥6 m bathymetric contour, which has been used in all previous GRTS sampling efforts within Priest Rapids Reservoir. The sample depth criteria for each reservoir were selected to exclude shallow areas within the lower, middle, and upper reservoir sections that exhibit dense aquatic macrophyte growth.

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

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

2.5 Juvenile White Sturgeon Growth, Survival and Abundance Estimation

Mark-recapture data from sampling conducted during the juvenile White Sturgeon sampling programs since 2014 were used to construct a Cormack-Jolly-Seber model that was used to estimate survival of hatchery juveniles released in Wanapum and Priest Rapids reservoirs. The analysis was conducted using the statistical environment R v. 3.5.1 (R Core Team 2018), interfaced with Program MARK (White and Burnham 1999) through the package ‘RMark’ (Laake 2013). Fish tagged in Wanapum Reservoir that were subsequently captured in Priest Rapids Reservoir were not marked as “emigrated”, since the analysis did not take into account reservoir of capture, only reservoir of release. Only hatchery fish released in the PRPA between 2011 and 2018 were included in the analysis. Wild fish and fish that were released elsewhere (including from Rocky Reach) and entrained into the PRPA were removed from analysis.

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

a) Survival:
   a. constant,
   b. separate constant values for first year post-release and all subsequent years,
   c. as function of release reservoir,
   d. as function of brood year,
   e. as additive function of brood year and first year post-release and all subsequent years.
b) Recapture:
   a. constant,
   b. separate constant values for first year post-release and all subsequent years,

c. as function of sampling year,
d. as function of release reservoir,
e. as function of age,
f. as additive function of release reservoir and age, and
g. as multiplicative function of release reservoir and age.

The candidate models were evaluated using Akaike's Information Criterion corrected for small sample size (AICc), where a lower value indicates better support for the model. The selected model-averaged results provided estimates of survival and recapture values. The survival estimates were used to calculate cumulative mean annual population values with 95% confidence intervals, to describe abundance of hatchery juvenile White Sturgeon released in the PRPA for each calendar year from 2011 to 2017. Survival and abundance estimates were only possible for brood year releases one or more years at large and could not be estimated for the 2017BY released in 2018.

2.6 Adult White Sturgeon Population Indexing

The adult White Sturgeon mark-recapture study in 2018 was conducted from September 9 to 20 (session 1) and from October 1 to 10 (session 2). The survey timing was selected based on previous capture and telemetry data that indicated White Sturgeon were more broadly dispersed throughout the reservoir, moving more, and actively feeding from late summer to early fall (Golder 2011). In addition, in previous studies where seasonal sampling occurred, White Sturgeon capture rates were highest from September to October (Golder 2003).

Sampling was conducted by Golder and BLE field crews using two research vessels to deploy gear and process fish. Set line deployment gear and methods were identical to those used during the 2015 adult indexing program (Golder 2016). Set lines were approximately 183 m long and consisted of 0.64 cm diameter nylon mainline, anchored at both ends with 25 kg piece of metal rail attached to float retrieval lines. Up to 30 gangions baited with pickled squid were attached to the ground line at 4.6 m intervals. Hook gangions were 0.7 m in length and consisted of a swivel-snap, a length of round or three-braid tarred ganging, and a single circle hook. Three sizes of barbed circle hooks [i.e., small hooks #7 (12/0), medium size hooks #5 (14/0), and large hooks #3 (16/0)] were used to allow capture of a wide range of size classes. Ten gangions of each hook size (i.e., 30 gangions total) were placed in random order on each line and for each size group. Set lines were set overnight and pulled approximately every 24 hours during sampling.

In previous adult indexing efforts in the PRPA, set line sample locations were selected using a general random tessellation stratified (GRTS) under a stratified sample design that divided the Project area into two main sample strata by reservoir, with Wanapum Reservoir further stratified to reduce sample effort within the Wanapum Dam forebay area, which encompassed the reach between the I-90 Bridge and Wanapum Dam. Based on telemetry data (Golder 2011), this area was assumed to be low use habitat and as such, GRTS site selection from this area was limited to 12 of the 66 total sites, with the remaining effort applied upstream of the I-90 Bridge. In 2018, the above sample design was rejected in favor of standardizing and applying the same sample design used in juvenile indexing program (see Section 2.4). The 2018 adult indexing survey used the same sample multi-density reservoir categories ("lower", "mid", and "upper" sections) as used in the 2018 juvenile indexing study.

In total, 192 GRTS sites were sampled over two sample sessions in fall 2018, with 96 sites sampled per session; 66 sites in Wanapum Reservoir and 30 sites in Priest Rapids Reservoir.

Sample effort in 2018 was comparable to that expended during the 2010, 2012, and 2015 adult indexing studies (Golder 2011, 2013, and 2016). Separate sets of GRTS sites were generated for each session to eliminate sampling bias and ensure complete randomization of sample locations for each session.

Fish were handled and processed in a manner similar to previous adult indexing capture programs (Golder 2016). All captured fish were scanned for a PIT-tag and a PIT-tag was applied if none was detected. Once the PIT-tag number was confirmed, weight and fork length were recorded. Sex and maturity of wild fish were assessed by surgical examination and visual inspection of the gonads with an otoscope. The assessment of sex and maturity followed the methods used in the upper Columbia River White Sturgeon Recovery Program (Table 3; UCWSRI 2006). All data were entered in the field, directly into Golder's Adult White Sturgeon capture database. DNA samples were obtained and preserved for all first-time captured wild fish. When required, a canopy was deployed over the rear half of the boat to protect fish from direct sunlight and reduced overall thermal stress and exposure to UV radiation during processing.

Table 3 Sexual maturity codes for White Sturgeon (adapted from Bruch et al. 2001).

Sex	Code	Developmental State Description
Male	Mv	**Virgin male juvenile**; Testes are ribbon-like in appearance with lateral creases or folds , dark grey to cream colored attached to a strip of adipose fat tissue.
	M1	**Developing male**; Testes are tubular to lobed, light to dark grey, and embedded in substantial amounts of fat. Testes moderately to deeply lobed have distinct lateral folds.
	M2	**Fully developed male**; Testes large, cream to whitish in color, deeply lobed and filling most of the abdominal cavity. If captured during active spawning, may release sperm if stroked posteriorly along the abdomen.
	M3	**Spent/recovering male**; Testes size are much reduced, with very distinct lobes and whitish to cream color.
	M0	**Male based on previous capture**; general unknown maturity
Female	Fv	**Virgin female juvenile**; small feathery looking, beige ovarian tissue attached to a thin strip of adipose fat tissue.
	F1	**Early developing female**; pinkish/beige ovarian tissue with brain-like folds and smooth to rough surface, imbedded in heavy strip of fat tissue. The visible whitish eggs are <0.5 mm in diameter. Ovarian tissue of F1 females that have previously spawned is often ragged in appearance.
	F2	**Early "yellow egg" female**; Yellowish/beige ovarian tissue with deep "brain-like folds embedded in extensive fat tissue giving it a bright yellow appearance. Eggs, 1 to 2 mm in diameter with no apparent grayish pigmentation.
	F3	**Late "yellow egg" female**; large yellowish ovaries with deep lateral folds and reduced associated fat. Yellow/greenish to grey eggs 2.5 mm in diameter. May indicate next year spawning.
	F4	**"Black egg" female**; Large dark ovaries filling much of the abdominal cavity. Exhibiting a distinct "bulls-eye". Very little fat, Eggs are still tight in the ovary, dark grey to black, shiny and large, >3 mm in diameter.
	F5	**Spawning female**; Loose flocculent-like ovarian tissue with eggs free in body cavity shed in layers from deep ovarian folds. Eggs large, from grey to black, similar to F4.
	F6	**Post spawn female**; ovaries immediately after spawning are folded with a mushy pinkish and flaccid appearance, with little or no associated fat. Post spawn females display a characteristic abdominal mid-line depression. Large dark degeneration eggs buried amongst small oocytes.
	F0	**Female based on previous capture**; general unknown maturity
Unknown	97	adult based on size, (i.e., 1.5 m FL or greater) no surgical examination
	98	juvenile/sub-adult based on size, (i.e., no surgical examination)
	99	gonad undifferentiated or not visible during surgical examination

2.7 Adult Population Abundance Estimates

In 2015, the combined Wanapum and Priest Rapids adult mark-recapture data from the September-October adult indexing programs in 2010, 2012, and 2015 were used to construct a POPAN model to estimate adult population abundance (Golder 2016). If sufficient mark-recapture data for wild and 2002BY sturgeon were collected in 2018, the POPAN models would be re-analyzed using the same approach. If insufficient data were collected in 2018, the 2015 model results and population estimates would be used as a baseline and new estimates for 2018 wild and 2002BY fish abundance would be calculated based on capture proportions. As such, a description of the 2015 POPAN analysis methodology has been provided below.

The 2015 analysis was implemented using the statistical environment R, v. 3.1.0 (R Development Core Team, 2014), interfaced with Program MARK (White and Burnham 1999) through the package 'RMark' (Laake 2013). Fish tagged in Wanapum Reservoir that were subsequently captured in Priest Rapids Reservoir were marked as loss-on-capture (i.e., the fish were removed from the system due to emigration) when analyzing the data. Only wild and 2002BY fish were included in the analysis.

A total of three POPAN models were constructed. All three included the following parameters:

1). a constant survival term;
2). year-specific recapture parameters; and
3). a group-specific super-population parameter (N), modeled separately for each reservoir and 2002BY and wild sturgeon.

The three models differed in their specifications of probability of entry into the system (combined birth and immigration), which were constructed as follows:

1). Model 1 – constant probability of entry, identical for both 2002BY and wild fish.
2). Model 2 – constant probability of entry, by group – different for 2002BY and wild fish.
3). Model 3 – probability of entry fixed at zero for 2002BY fish, and modeled as constant for wild fish. This simulated lack of entrainment from upstream reservoirs after 2010 (zero entry for hatchery fish), while allowing for natural recruitment (constant entry for wild fish).

The models were evaluated using Akaike's Information Criterion corrected for small sample size (AICc), where a lower value indicates better support for the model. In addition to AIC values, the output also included AICc weights (as proportions), which indicate the probability that the model is the best among the entire set of candidate models. For instance, an AICc weight of 0.9 for a model, indicates that given the data, that model has a 90% probability of being the best one among all examined candidate models.

Following the estimation of survival (Phi), the super-population (N) and the probability of entry (pent), occasion-specific population estimates, and their 95% confidence intervals were calculated using the "popan.derived" function. These calculations of derived parameters were performed using model-averaging, where the estimates (and variability) from all three models were taken into account, using the AICc weight given to each model during the initial model fitting.

2.8 Telemetry Receiver Array Download and Maintenance

Since 2010, up to 12 acoustic telemetry receivers (Amirix Vemco model VR2W®) have been deployed in the PRPA to monitor the movements of acoustic-tagged adult and hatchery juvenile White Sturgeon (Table 4). In 2018, the primary use of the receiver array was to monitor the movements of acoustic-tagged hatchery juvenile White Sturgeon that represented 1% of the total fish released. These data were used to estimate entrainment rates of hatchery fish from Wanapum Reservoir into Priest Rapids Reservoir, as well as entrainment from Priest Rapids Reservoir into McNary Reservoir. In Wanapum Reservoir, acoustic telemetry data were used to verify upstream movement of fish and to corroborate evidence of avian mortality on juvenile White Sturgeon that approach Rock Island Dam.

In 2018, data from receivers were downloaded on April 25-26, July 20-21, and October 25-26. Receiver batteries were replaced during the April service session. During the July download session, crews were unable to locate the receiver near RM426 (VRRM424.9) in Wanapum Reservoir. Given that the station was relatively new (deployed in 2016) and constructed with stainless steel components, the loss of this station was attributed to vandalism as opposed to failure of the mooring. Since the installation of the array in 2010, two other stations in the vicinity (VRRM432.5 on March 1, 2011; VRRM426.5 April 19, 2016) have been lost under similar circumstances. Consequently, any future deployment of acoustic monitoring equipment within this section of reservoir will require concealment (e.g., subsurface floats, hidden or inaccessible cable attachment points, etc.,), which potentially may reduce the tag detection probability compared to the original station configuration that used a mid-channel mooring.

Table 4 Current acoustic receiver station locations, deployment dates, and status in the Priest Rapids Project area as of November 2018.

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

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

2.9 Juvenile Movements

The downloaded telemetry data from the receiver array were screened for errors and spurious detections, which were defined as acoustic tag IDs that were detected only once on any given day; these single detections were reviewed separately, and if considered erroneous, were removed from the dataset prior to analysis. Upstream-most and downstream-most detections by monitoring stations in the PRPA were determined for each fish, as was cumulative distance moved by each fish between its release date and date of last detection. Movements were plotted for acoustic-tagged fish that were likely entrained from Wanapum Reservoir into either Priest Rapids or McNary reservoirs based on consistent and multiple detections of fish released in Wanapum Reservoir by acoustic stations in the receiving reservoir. For each entrained fish, days at large prior to entrainment and approximate time of entrainment were estimated, when possible.

2.10 General Data Recording and Analysis

Custom field databases were designed and used to record field data for specific study components. In 2018, three copies of a juvenile White Sturgeon indexing database, with custom data fields specific to the study data requirements, were used by field crews to record indexing data in the both Wanapum and Priest Rapids reservoirs. These database copies were merged at the end of the 2018 study into a single database that contained all indexing data recorded in the PRPA from 2014 to 2018. Within and between the various relational databases developed for the M&E studies, queries were used to extract data, screen for errors, and analyze annual and inter-year data to determine movement, growth, and capture history of adult and hatchery juvenile White Sturgeon. Additional post-collection error screening and data proofing was conducted using both Excel and R. Summary tables and simple figures were produced in Excel® using pivot tables and data filters. More complicated figures were created in R using the package ggplot2 (Wickham 2009). Customized datasheets and manifests were used to record information during the juvenile release, and VR2W station installation, data downloading, and servicing.

3.0 Results

3.1 Discharge and Temperature During Study Components

Discharge, water temperature, and air temperature were important considerations in scheduling of the juvenile and adult White Sturgeon indexing studies. Ideally, each of these studies should be conducted in mid-September to mid-October, when catch rates are highest and when air and water temperatures begin to cool from summer highs. To accommodate both adult and juvenile indexing studies in 2018, one of the two studies had to start in August when water and air temperatures were high. Juvenile indexing was conducted during the hotter weather in August based on the substantially reduced capture, handling, and processing time for juvenile White Sturgeon as compared to adults. Additional mitigative measures employed to reduce stress on sturgeon (i.e., monitoring water temperatures and frequent water changes in holding tanks, deployment of a shade canopy) also helped reduce the overall risk of injury to all sturgeon handled during both indexing programs. Summaries of the discharge and temperature conditions during the 2018 study components (i.e., 2017BY release and juvenile movements, broodstock capture, and juvenile and adult White Sturgeon indexing) are provided in the sections that follow.

In 2018, peak mean daily flows in the PRPA, as measured in Wanapum Reservoir below Rock Island Dam, were recorded on May 14 (9,228 m^3/s) during a sustained period of high flows from mid-April to early June (DART 2018). Lowest mean daily discharge was recorded on October 7 (1,193 m^3/s). Peak mean daily water temperature was recorded on August 7 (19.8°C). The lowest mean daily water temperature was recorded on February 22 (2.9°C; Figure 3).

2017BY Juvenile Release

In most years, hatchery juveniles are typically released into the PRPA by late spring. As such, these releases typically occur during a rising hydrograph and when receiving water temperatures range from 8 to 12°C. The 2017BY were released on May 1 on the ascending limb of the spring freshet when mean daily discharge was 5,946 m^3/s. Total river discharge continued to increase rapidly after the release and attained a seasonal high on May 14 (9,228 m^3/s) and remained high until late May, after which flows rapidly decreased. Mean daily Columbia River water temperature on the day of the 2017BY release was 8.5°C.

2018 Broodstock Collection

Broodstock collection was not conducted within the PRPA in 2018. The rationale behind the schedule and duration of the broodstock capture program, physical conditions during sampling, and collection results are provided in Appendix A.

Juvenile White Sturgeon Indexing

White Sturgeon juvenile indexing in 2018 was conducted from August 6 to 29 (Figure 3), whereas previous juvenile indexing studies were conducted in September of each year since 2016. Consequently, total river discharge, air, and water temperatures were higher during the 2018 indexing study compared to previous studies (Golder 2017, 2018). During sampling, average mean daily discharge was 2,888 m^3/s and ranged from 2,201 m^3/s on August 26 to 3470 m^3/s on August 8. Large variations in hourly and daily discharge were evident during the juvenile indexing due to load-following by upstream and downstream hydroelectric facilities. These daily fluctuations increased the level of difficulty associated with setting and retrieving set lines at certain locations, especially within the fast-flowing upper sections of each reservoir. Mean water temperature during sampling was 19.3°C (SD = ±0.2) and ranged between 18.9 and 19.8°Cover the duration of the study.

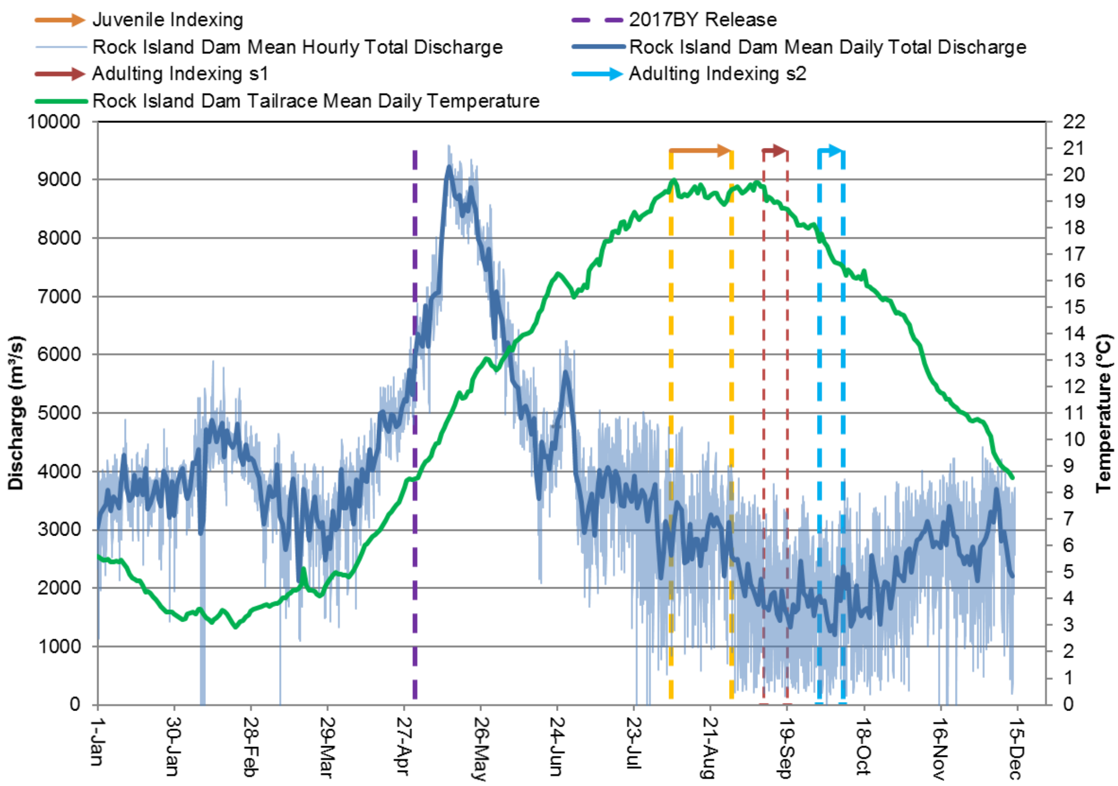


Figure 3 **Mean daily discharge (dark blue line), mean hourly discharge (light blue ribbon), and mean hourly water temperature (green line) of the Columbia River in the Priest Rapids Project area, as measured below Rock Island Dam in 2018. Vertical purple dashed line denotes the 2017BY juvenile White Sturgeon release date. Horizontal arrow between the dotted vertical lines indicates the juvenile White Sturgeon indexing (yellow) and adult White Sturgeon indexing Session 1 (red) and 2 (blue) sample periods.**

3.2 2017BY Juvenile Marking and Release

The 2018 Grant PUD juvenile White Sturgeon release program entailed the marking and release of 3,224 juvenile White Sturgeon (2017BY). These fish were the progeny from the five ripe females and six ripe males that were captured, transported to Yakama Nation Sturgeon Hatchery, and spawned in May 2017. All 2017BY fish were PIT-tagged and scute marked from April 9 to 11, 2018.

The release proportion by reservoir outlined in the Priest Rapids White Sturgeon Stocking SOA stipulated the release of 1,983 fish (62%) in Wanapum Reservoir at the Frenchman Coulee Launch (RM426.5) and 1,241 fish (38%) in Priest Rapids Reservoir at the Wanapum Dam tailrace launch (RM415.6; Table 5). Mean fork length and weight of the 2017BY when tagged was 285 mm (SD ± 43 mm) and 144 g (SD ± 56 g), respectively. Acoustic telemetry tags were surgically implanted in 32 2017BY, with 20 acoustic-tagged fish released in Wanapum Reservoir and 12 acoustic-tagged fish released in Priest Rapids Reservoir.

All fish were released on May 1, 2018, approximately 21 days after tagging. Five shed PIT-tags were found in the rearing tanks, either during a sweep of the tanks with a magnetic wand during the holding period, or after the tanks were drained and cleaned. No mortalities occurred during the post-tagging holding period.

During transport to the release locations, oxygen levels ranged between 8 and 12 mg/L and both the river water and transport tank water were ~10°C during release. Two shed PIT-tags (both damaged) were recovered from inside the fish transport trailer after the fish were released. In addition, one fish was killed by the transport trailer wheels during the release into Priest Rapids Reservoir, despite efforts by the crew to flush all fish away from the wheels after release with a pump and water hose. The PIT-tag implanted in this fish was damaged and could not be read. Undamaged shed tags were scanned and removed from the YNSH hatchery fish release database.

Table 5 Number of 2017BY juvenile White Sturgeon released in Wanapum and Priest Rapids reservoirs and the mean fork length (FL) and mean weight of fish in each release. May 1, 2018.

	2018 White Sturgeon 2017BY Release		
Release Location Reservoir (River Mile)	**No. of Fish (acoustic-tagged)**	**Mean FL (± SD) mm**	**Mean Weight (± SD) g**
Wanapum (424.5)[1]	1,983 (20)	289 (43)	150 (56)
Priest Rapids (415.6)[2]	1,241 (12)	279 (41)	136 (59)
Total	3,224 (32)	285 (43)	144 (58)

[1] Frenchman Coulee Launch

[2] Wanapum Tailrace Launch

During tagging, fin deformities were recorded for 43% (1,398 of 3,224 fish) of the 2017BY. Fin deformity, when noted, was primarily associated with the pectoral fins (Table 6).

Table 6 Fin deformity type and occurrence noted during processing of 2017BY juvenile White Sturgeon that were subsequently released in the Priest Rapids Project area, 2018.

2017BY Primary Fin Deformity	Fin Deformity Sub-type	No. of fish with Primary Deformity	No. of fish with Sub-type Deformity
Caudal deformity only		51	
	Deformed, curled, or damaged		51
Both caudal and pectoral deformity		28	
	Two deformed, curled, or damaged fins		18
	One deformed, curled, or damaged fin; one missing fin		1
	Three deformed, curled, or damaged fins		8
	Two deformed, curled, or damaged fins; one missing fin		1
Pectoral deformity only		1,313	
	One deformed, curled, or damaged fin		830
	One missing fin		80
	Two deformed, curled, or damaged fins		334
	One deformed, curled, or damaged fin; one missing fin		53
	Two missing fins		16
Other deformities		6	
	Deformed rostrum, operculum, other fins		6
Total fish with fin deformities		1,398 (43%)	
Total fish without fin deformity		1,826 (57%)	
Total 2017BY Release		3,224	

3.3 2018 Broodstock Capture and Juvenile Production

In 2018, angling for White Sturgeon broodstock took place over 14 days from May 14 to 27 (see Appendix A). In total, 124 individual White Sturgeon were captured, with 1 fish captured twice for a total of 125 sturgeon landings. Of the individuals captured, 99 were greater than 150 cm FL, and based on size, were considered mature sturgeon. The gonads of these fish were surgically inspected to determine stage of maturity and broodstock candidacy. The remaining 25 fish captured were less than 150 cm FL and were immediately released after measured for fork length and weight. In total, 6 females and 6 males were transported to YNSH. Of these fish, 5 females and 5 males were successfully spawned on June 7 to complete a 5x5 spawning matrix to produce 25 genetic crosses (5 unique crosses and 20 half-sib crosses); a sixth ripe female and sixth male did not produce viable gametes to contribute to the brood production effort.

3.4 2017BY Juvenile White Sturgeon Movements

Acoustic telemetry data from the 2017BY acoustic-tagged juveniles, recorded from May 1 to October 26, 2018, were analyzed to determine the post-release dispersal of juvenile White Sturgeon from their release locations in each reservoir.

In Wanapum Reservoir, 15 of 20 acoustic-tagged fish released at Frenchman Coulee (RM424.5) were subsequently detected at one or more acoustic receiver stations deployed in the PRPA, with the first detection recorded on May 8, upstream of the release site at RM437.1. The five fish not detected (tags 26837, 26840, 26842, 26843, and 26853) in 2018 likely remained near either the release site or the nearby overwintering area at RM426.0, which may be verified by future telemetry data, should these fish eventually move in range of an active receiver. Potentially, all acoustic-tagged fish could have been detected immediately after release by the former monitoring station at RM 424.9, which was lost due to vandalism sometime between April 25 and July 20. The telemetry data collected allowed a calculation of total cumulative distance moved by each fish within the reservoir. Mean cumulative movement was 39 km (SD = ±13 km; [24 miles ± 8 miles]); some fish moved substantial distances (e.g., maximum cumulative movement = 70 km; [44 miles]), while others moved to a lesser extent (e.g., minimum cumulative movement = 14.4 km; [9 miles]). In total, upstream movement up to and beyond RM437.1 was confirmed for 14 of the 15 acoustic-tagged fish detected, with three of these fish detected at the upstream-most monitoring station below Rock Island Dam near RM452.4, approximately 45 km [28 miles] from the release site. The other fish in this group exhibited less upstream movement and were detected in the vicinity of RM446.9 (n = 4), RM442.0 (n = 5), RM437.1 (n = 2). Only 1 of the 15 fish detected moved downstream after release and was last detected in the Wanapum Dam forebay near RM416.8 (Figure 4).

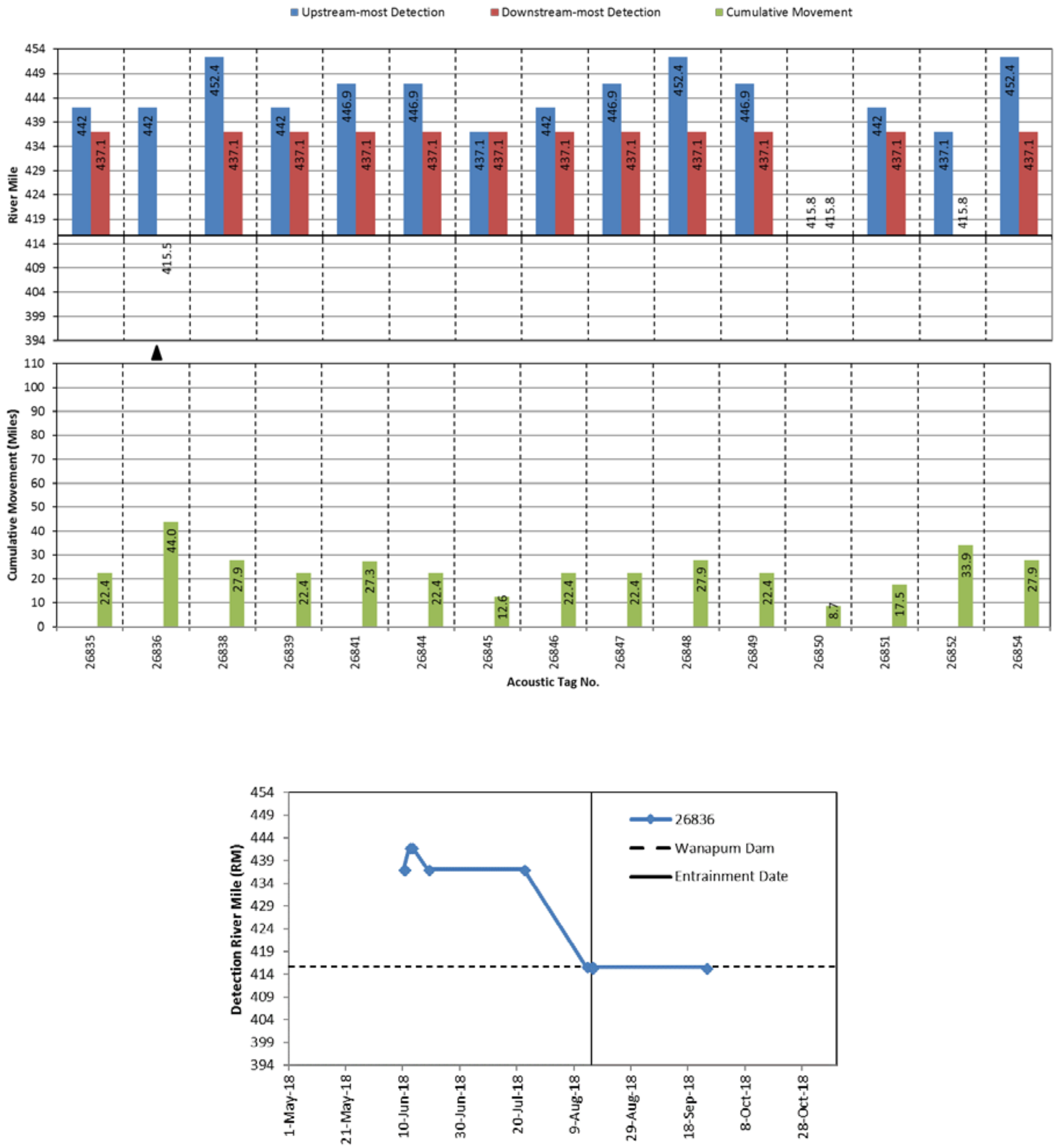


Figure 4 **Movements of acoustic-tagged 2017BY White Sturgeon released in Wanapum Reservoir showing upstream-most and downstream-most detections (upper panel), cumulative movements (middle panel), and daily movement plots of fish entrained from Wanapum Reservoir into Priest Rapids Reservoir (lower panel), May 1 to October 26, 2018. Black triangle in upper panel indicate a fish entrained from Wanapum Reservoir into Priest Rapids Reservoir whose movements are shown in the lower panel.**

Entrainment of 2017BY juvenile White Sturgeon from Wanapum Reservoir into Priest Rapids Reservoir was detected for only 1 of the 20 acoustic-tagged fish (5.0%) released on May 1. This fish (tag 26836) initially exhibited substantial upstream movement after release in Wanapum Reservoir, but subsequently moved downstream and was detected in the Wanapum Dam forebay near RM415.8 at 20:19 h (PDT) on August 14. One hour later, this fish was entrained through Wanapum Dam into Priest Rapids Reservoir and was detected in the Wanapum Dam tailrace near RM415.5. Wanapum Dan discharge on August 14 ranged between 1,795 m³/s (63,400 cfs) at 03:00 h and 4,522 m³/s (159,700 cfs) at 20:00 h. The time of entrainment corresponded to peak mean hourly discharge at Wanapum Dam. After entrainment, the fish did not exhibit further downstream movement and was last detected in Wanapum Dam tailrace near RM415.5 on September 24, 2018.

In Priest Rapids Reservoir, 12 acoustic-tagged 2017BY White Sturgeon were released into the Wanapum Dam tailrace at RM415.6 on May 1. After release, all 12 acoustic-tagged fish were initially detected near the release site (Figure 5). Mean cumulative movement was 6 km (SD = ±8 km; [4 miles ± 5 miles]). Six fish exhibited some downstream movement and recorded higher cumulative movement (i.e., cumulative movement from 3 to 18 km; [2 to 11 miles]), while six others remained near the release site (e.g., minimum cumulative movement = 0.2 km; [0.1 miles]). All 12 acoustic-tagged fish were only detected in the upper section of Priest Rapids Reservoir and were not detected downstream of RM410.

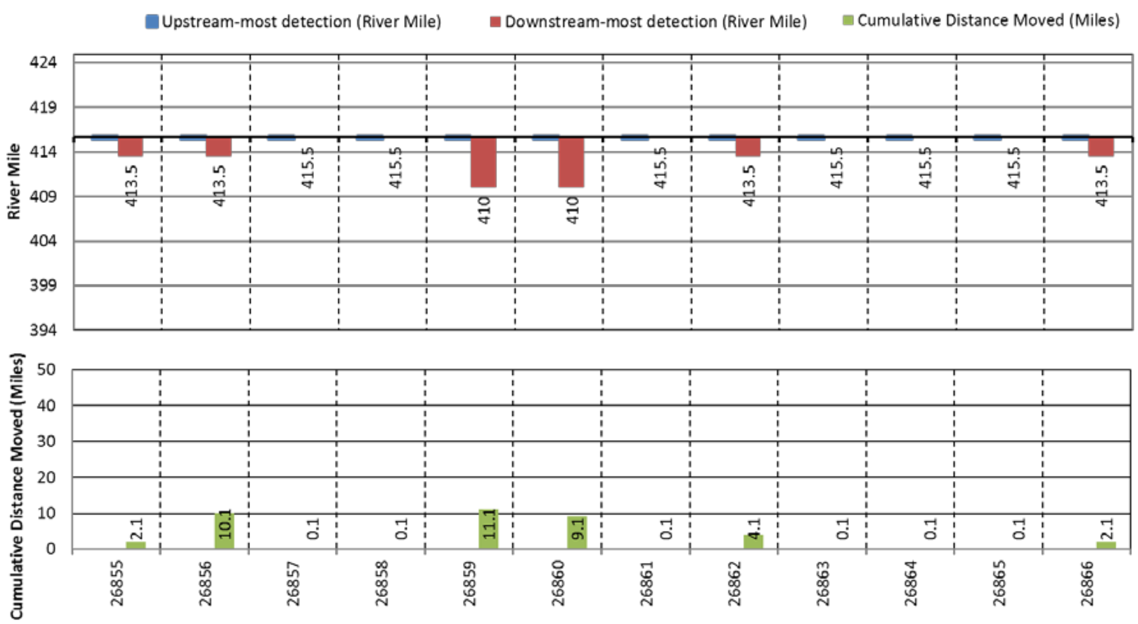


Figure 5 **Movement of acoustic-tagged 2017BY White Sturgeon released in Priest Rapids Reservoir showing upstream-most and downstream-most detections (upper panel) and cumulative movements (middle panel), May 1 to October 29, 2018.**

3.5 Juvenile White Sturgeon Population Assessment

3.5.1 Sample Effort

In Wanapum and Priest Rapids reservoirs, areal-based GRTS unequal probability site selection assigned approximately equal number of sites among the three defined sections in each reservoir (i.e., lower, middle, and upper sections). In Wanapum Reservoir, sample effort in each section was equal. In Priest Rapids Reservoir, logistical constraints resulted in slightly higher sample effort in the middle section (n = 33 sites) compared to the lower (n = 29 sites) and upper (n = 28 sites) sections. Sample intensity within the upper reservoir section was from 6 to 7 times higher compared to the lower reservoir sections (samples sites per unit area; Table 7).

The mean depth and the range of depths sampled was greater in Wanapum Reservoir (mean = 20.1 m, range = 8.5 to 49.0 m) than in Priest Rapids Reservoir (mean = 10.3 m, range = 2.0 to 23.0 m). Not unexpectedly, lower mean sample depths were recorded in the upper sections of both Wanapum and Priest Rapids reservoirs compared to their lower and middle sections.

Due to severe weather, gear at seven overnight sets in the lower section of Wanapum reservoir could not be retrieved and remained deployed for approximately 46 hours. In previous indexing effort, catch by set lines deployed for more than 24 hours has been low and we suspect that fish, when given sufficient time, eventually work the circle hooks free and avoid capture. Sample effort of less than 20 hours was recorded at some sites due to variation in deployment and retrieval order. In Wanapum Reservoir, set lines were successfully deployed at all the selected GRTS sites identified in the lower and middle sections and in-the-field selection of oversample replacement sites was not required. In the upper section of Wanapum Reservoir, oversamples were selected in-the-field to replace five sites that were considered unsuitable for sampling due to fast flow and/or the presence of underwater obstructions. In Priest Rapids Reservoir, oversamples were selected to replace four sites in the middle and seven sites in the upper section that were considered unsuitable.

Table 7 **Details of GRTS sample site distribution among Wanapum and Priest Rapids reservoir sections, areal extent of reservoir sections, estimates of sampling intensity, and set line sample depths and durations recorded during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.**

	Reservoir							
	Wanapum (15 m Bathymetric Contour)				**Priest Rapids (6 m Bathymetric Contour)**			
	Lower	**Middle**	**Upper**	**All**	**Lower**	**Middle**	**Upper**	**All**
Number of sample GRTS sites selected	90	90	90	270	30	30	30	90
Actual number of GRTS sites sampled per section	90	90	90	270	29	33	28	90
Sampling area (Ha)	1,664	727	308	2,699	1,369	346	213	1,928
Samples/100Ha	5.4	12.4	29.2	10.0	2.2	8.7	14.1	4.7
Sample depths (m)								
mean	20.8	20.8	18.7	20.1	12.9	9.4	8.7	10.3
min	10.0	8.7	8.5	8.5	2.3	3.0	2.7	2.0
max	36.0	49.0	37.0	49.0	23.0	17.5	18.3	23.0
Sample duration (h)								
mean	23.0	21.2	21.6	21.9	22.7	22.4	22.2	22.4
min	19.6	18.5	16.9	16.9	18.5	16.7	18.5	16.7
max	46.1	23.2	26.1	46.1	26.5	24.6	25.4	26.5

Throughout August, mean daily water temperature was at the seasonal maximum and remained above 19.0°C. Work crews started early and retrieved nearly all set lines (n = 341 of 360 sets) prior to mid-day to reduce heat related stress on fish during processing. As a result, most fish captured required minimal recovery time and appeared healthy and energetic when released.

3.5.2 2018 Juvenile White Sturgeon Indexing Catch

In total, 563 White Sturgeon were captured and processed during the juvenile indexing program in Wanapum (n = 454) and Priest Rapids (n = 109) reservoirs (Figure 6; Table 8). These captures represented 550 individual fish, with 13 fish captured twice in Wanapum, but no intra-session recaptures in Priest Rapids. Bycatch during the survey included 206 Northern Pikeminnow (*Ptychocheilus oregonensis*), 7 Largescale Suckers (*Catostomus macrocheilus*), and 1 Channel Catfish (*Ictalurus punctatus*).

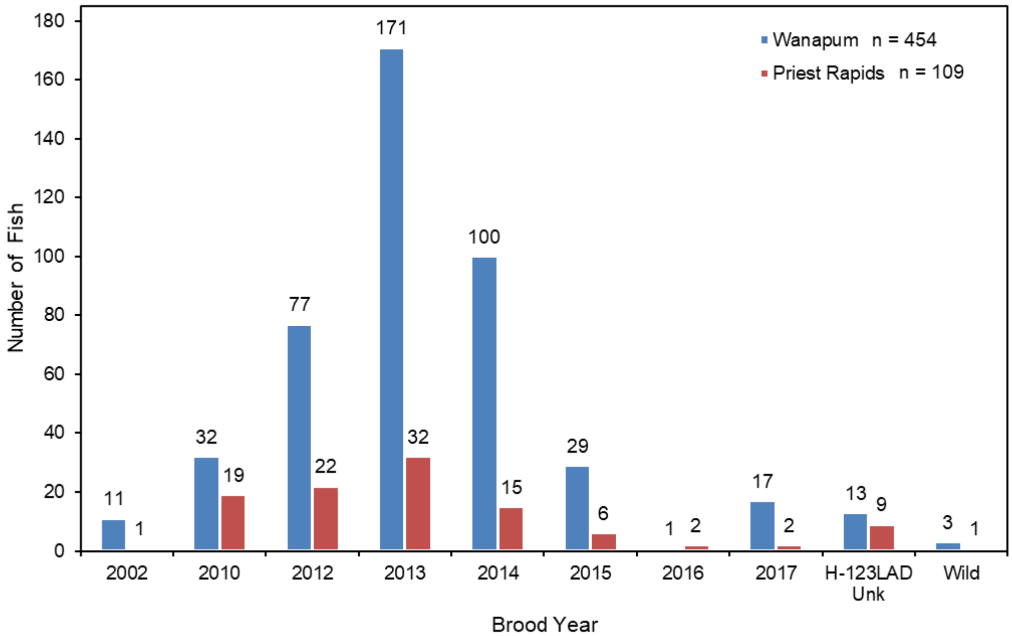


Figure 6 **Hatchery and wild sturgeon captured in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, August 6 to 29, 2018. Unknown category represents fish suspected to be of hatchery origin but without a PIT-tag to allow identification of origin and brood year.**

3.5.2.1 Wanapum Reservoir Catch

The 454 White Sturgeon captured in Wanapum Reservoir consisted primarily of hatchery origin fish released in Wanapum Reservoir (n = 420), and low numbers of entrained hatchery fish that had been released in either Rock Island Reservoir (2002BY; n = 11) or Rocky Reach Reservoir (2010BY; n = 6, 2012BY; n = 1). Three captures were considered wild fish based on the absence of PIT-tag or scute removal marks and no obvious fin deformities (Figure 6, Table 8).

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

Table 8 Hatchery and wild sturgeon captured in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

Brood Year	Release Reservoir	Release Location	Brood Source	Date	Number Released	Capture Reservoir		Total
						Wanapum	Priest Rapids	
2002	Rock Island	Unknown	Unknown	Unknown	20,600	11	1	12
2010	Rocky Reach	Unknown	All	21-Apr-11	6,376	6	2	8
	Wanapum	Columbia Siding	UCW[1]	26-Apr-11	2,020	17	1	18
			MCW[2]	29-Apr-11	2,996	8	1	9
			LCC[3]	27-29-Apr-11	2,000	1	2	3
			All	--	7,016	26	4	30
	Priest Rapids	Wanapum tailrace	UCW	26-Apr-11	900	--	6	6
			MCW	28-Apr-11	601	--	7	7
			LCC	28-Apr-11	600	--	--	0
			All	--	2,101	--	13	13
2012	Wanapum	Columbia Siding	MCW	14-May-12	1,135	15	1	16
		Columbia Cliffs	MCW	14-May-12	1,129	61	2	63
			All	--	2,264	76	3	79
	Priest Rapids	Wanapum tailrace	MCW	14-15-May-13	1,717	--	19	19
2012	Rock Island	Unknown	Unknown	Unknown	Unknown	1	--	1
2013	Wanapum	Rocky Coulee	MCW	06-May-14	3,331	136	14	150
			MCW	18-Sep-14	1,762	35	3	38
			All		5,093	171	17	188
	Priest Rapids	Wanapum tailrace	MCW	05-May-14	997	--	13	13
			MCW	17-Sep-14	504	--	2	2
			All		1,501	0	15	15
2014	Wanapum	Frenchman Coulee	MCW	1-May 2015	5,007	100	1	101
	Priest Rapids	Wanapum Tailrace	MCW	1-May 2015	1,495	--	14	14
2015	Wanapum	Frenchman Coulee	MCW	28-Apr-16	2,005	29	--	29
	Priest Rapids	Wanapum Dam Tailrace	MCW	28-Apr-16	1,253	--	6	6
2016	Wanapum	Frenchman Coulee	MCW	2-May-17	1,999	1	--	1
	Priest Rapids	Wanapum Dam Tailrace	MCW	2-May-17	1,249	--	2	2
2017	Wanapum	Frenchman Coulee	MCW	1-May-18	1,983	17	--	17
	Priest Rapids	Wanapum Dam Tailrace	MCW	1-May-18	1,241	--	2	2
Unknown[4]	Unknown	Unknown	Unknown	Unknown	n/a	13	9	22
Wild	n/a	n/a	n/a	n/a	n/a	3	1	4
All Sturgeon						454	109	563

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

Of the seven hatchery brood years released in the PRPA since 2011 (i.e., 2010BY, 2012BY, 2013BY, 2014BY, 2015BY, 2016BY, and 2017BY), the 2013BY were the dominant brood year caught in Wanapum Reservoir in 2018 (n = 131 or 38% of total catch), followed by 2014BY (n = 100), 2012BY (n = 76), 2015BY (n = 29), 2010BY (n = 26) and 2017 (n = 17; Figure 6; Table 8). The 2016BY contributed a very little (n = 1) to the 2018 catch. Hatchery fish release efforts prior to 2014BY contained distinct release groups differentiated based on either genetic lineage (i.e., 2010BY), release location (2012BY), or release timing (2013BY).

In 2018, the following differences in catch proportion of brood year and the within-brood year release groups were identified:

- 2010BY: Although initial release numbers of the three within-brood year release groups (i.e., LCC = 2,000; MCW = 2,996; UCW =2,020) were similar, substantially fewer of the LCC release group (n = 1) were captured in 2018 compared to the UCW (n = 17) and MCW (n = 8) groups.
- 2012BY: In 2013, fish were released in equal numbers at Columbia Siding (RM450.6; n = 1,135) and Columbia Cliffs Eddy (RM442.0; n = 1,129) to assess the effect of avian predation based on depth at the release location and proximity to upstream bird colonies. Of the 2012BY captured in 2018 (n = 76), the majority (i.e., 80%; n = 61) were fish released at the deeper downstream site near Columbia Cliffs Eddy (RM442.0).
- 2013BY: Released in two groups at Rocky Coulee launch (RM421.4) in May (n = 3,331) and September (n = 1,762) 2014 during the Wanapum fracture emergency response. The 2018 catch of the May-released fish (n = 136) greatly exceeded the catch of September-released fish (n = 35). Similar catch proportions of each release group were recorded in 2016 and 2017, which differed substantially from the original 2:1 stocking ratio of these groups.
- 2014BY: The total release of the 2014BY (n = 5,007) was comparable to 2013BY (n = 5,093); however, total 2014BY catch (n = 100) was 43% lower than of the 2013BY catch (n = 176), which suggests a difference in post-release survival between the two groups with assumed equal catchability and initial density.
- 2015BY: The catch of 2015BY released in 2016 (n = 2,005) has declined annually, with the highest catch recorded in 2016 (n = 69), and consecutively lower catches in 2017 (n = 41) and 2018 (n = 29). This decline in catch is somewhat counter intuitive in that lower catch is typically recorded in the release year when the fish are small, followed by increasing catch as fish grow, become more susceptible to (recruit to) the sampling gear, and feed more aggressively.
- 2016BY: One 2016BY was captured in each of 2017 and 2018. The continually low contribution of this brood year to the total catch in both years suggests that either survival was low or emigration from the PRPA was unexpectedly high.
- 2017BY: The 2017BY were captured low numbers in the 2018 release year (n = 17), but at levels greater than the 2016BY.

Thirteen untagged sturgeon (unknown origin) were captured in Wanapum Reservoir. These fish either had scute marks or had fin deformities (ranging from mild to severe), both of which suggested these were hatchery origin fish that had either shed their PIT-tag and/or were not marked at the hatchery. Although only three confirmed wild White Sturgeon were captured in 2018, their presence indicates that low level of natural recruitment either within the PRPA or in upstream reservoirs does occur.

3.5.2.2 Priest Rapids Reservoir Catch

The 109 White Sturgeon captured from Priest Rapids Reservoir in 2018 consisted mainly of hatchery fish released directly into Priest Rapids Reservoir (n = 71) and hatchery fish entrained from Wanapum Reservoir (n = 25; Figure 6;Table 8). Other sturgeon captured included entrained 2002BY (n = 2) and Rocky Reach-origin 2010BY (n = 2), and fish of unknown origin (n = 9). Based on all hatchery fish released in the PRPA and subsequently captured in Priest Rapids Reservoir, slightly more 2013BY (n = 32) were captured than 2012BY (n = 22), 2010BY (n = 17), and 2014BY (n = 15). Of the three most recent hatchery releases, the 2015BY were most abundant (n = 6) in the catch, with fewer individuals from the 2016BY (n = 2) and 2017BY (n = 2). Similar to Wanapum Reservoir, in addition to differences in catch proportion among brood years, similar differences in the catch proportion of within-brood year release groups were also evident in Priest Rapids Reservoir and very similar (nearly identical in some cases) to the catch proportion reported in previous studies:

- 2010BY: Release numbers of the three release groups (LCC, MCW, and UCW) were 600, 601, and 900, respectively. Similar numbers of all three release groups were captured in 2018; however, the two captures from the LCC release group were entrained fish from Wanapum, whereas most of the MCW group (n = 7 of 10 fish) and UCW group (n = 6 of 7 fish) captures were released in Priest Rapids Reservoir. The combined catch of fish entrained from Wanapum Reservoir (n = 4) and Rocky Reach Reservoir (n = 2) contributed 31% to the total 2010BY captured.
- 2012BY: In total, 22 of the 2012BY were caught in Priest Rapids Reservoir of which two (13%) were entrained from Wanapum.
- 2013BY: The 2013BY were released in two groups at Wanapum Dam tailrace launch in May (n = 997) and September (n = 504) 2014. The 2018 catch of the May-released fish (n = 27) exceeded the catch of September-released fish (n = 5). Entrained fish from Wanapum Reservoir made up 63% (n = 17) of the 2013BY catch in Priest Rapids Reservoir.
- 2014BY: In total, 15 of the 2014BY were caught. One (14%) was an entrained Wanapum fish, which was identical to the catch proportion of entrained 2014BY reported in 2017.
- 2015BY: The 2015BY catch (n = 6) consisted entirely of fish originally released in Priest Rapids Reservoir.
- 2016BY: In 2017, 2016BY were not captured and only two were captured in 2018, both from the group released in Priest Rapids Reservoir. Relative to the captures of other brood years in their first and second year after release, 2016BY fish have been captured in disproportionately low numbers in the PRPA.
- 2017BY: The two 2017BY captured in 2018 were from the group released in Priest Rapids Reservoir.

A small number (n = 9) of sturgeon of unknown origin were captured in Priest Rapids Reservoir in 2018. One confirmed wild fish was captured in Priest Rapids Reservoir.

3.5.3 Catch rates and distribution

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

In total, 317,472 hook-hours of set line sample effort was expended during the 2018 juvenile White Sturgeon indexing program (Table 9). Within each reservoir, sample effort per reservoir section was nearly identical. Overall CPUE in the PRPA was 0.18 fish/100 hook-hours, with higher CPUE recorded in Wanapum Reservoir (0.19 fish/100 hook-hours) than in Priest Rapids Reservoir (0.14 fish/100 hook-hours). In both reservoirs, a progressive increase in CPUE with increased upstream distance was recorded; this CPUE gradient was more evident in Wanapum Reservoir than in Priest Rapids Reservoir.

Overall, Ep was higher in Wanapum Reservoir (all sections, Ep = 0.65) than in Priest Rapids Reservoir (all sections, Ep = 0.41; Figure 7) as more zero-catch efforts were recorded in the latter (Figure 8). In Wanapum Reservoir, Ep was lower in the lower sections and higher in the middle and upper sections. However, in Priest Rapid Reservoir, the highest Ep was recorded in the lower section due to a larger number of sets that captured at least one fish, whereas the highest CPUE (0.23 fish/100 hook-hours) was recorded in the upper section due to the capture of large numbers of fish (i.e., 12 and 19 fish) at 2 of the 30 sample locations in the upper section.

Table 9 Total set line sample effort, catch, and CPUE in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

Reservoir	Reservoir Section	Sample Effort (hook-hours)	Catch (No. of fish)				CPUE (Fish/100 hook-hours)			
			Wild	H-123LAD	2002BY	Total	Wild	H-123LAD	2002BY	Wild & Hatchery
Wanapum	Lower	82,955	0	94	2	96	0.000	0.11	0.002	0.12
	Middle	76,003	2	178	1	181	0.003	0.23	0.001	0.24
	Upper	78,085	1	168	8	177	0.001	0.22	0.010	0.23
	all	237,044	3	440	11	454	0.003	0.19	0.005	0.19
Priest Rapids	Lower	26,256	1	23	1	25	0.004	0.09	0.004	0.10
	Middle	29,278	0	27	0	27	0.000	0.09	0.000	0.09
	Upper	24,894	0	57	0	57	0.000	0.23	0.000	0.23
	all	80,428	1	107	1	109	0.001	0.13	0.001	0.14
PRPA	Total	317,472	4	547	12	563	0.001	0.17	0.004	0.18

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

[2] 2002BY is the field designation of a CRITFC Hatchery juvenile White Sturgeon reared by the Columbia River Inter-Tribal Fish Commission from a brood year in 2002 and released in 2003.

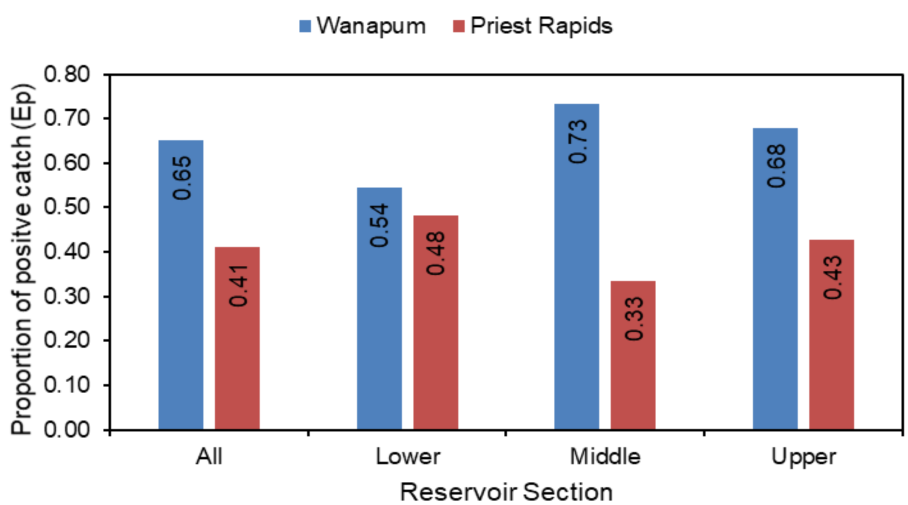


Figure 7 Proportion of positive catches recorded in the Priest Rapids Project area within the lower, middle, and upper section of each reservoir during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

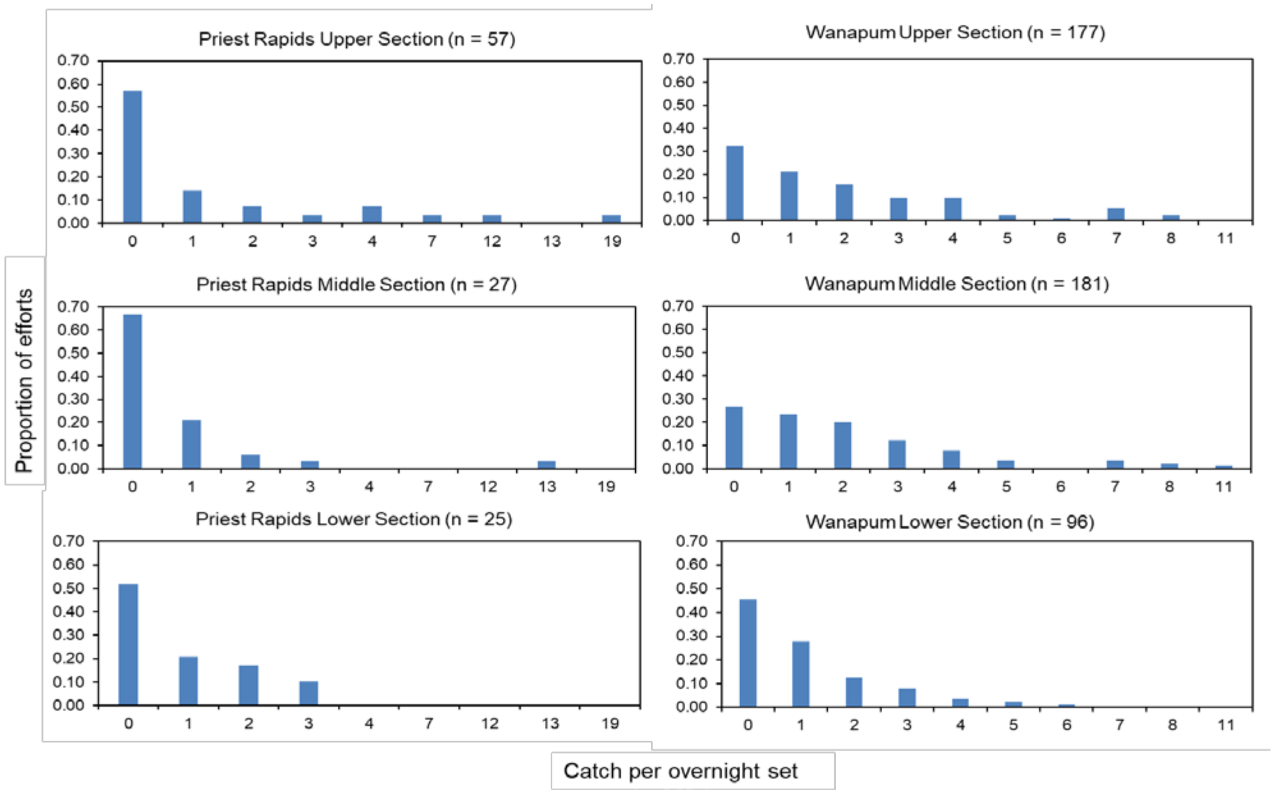


Figure 8 **Frequency histograms of sturgeon catch-per-overnight-set in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.**

The GRTS unstratified unequal probability sample design distributed effort over the areal extent of each reservoir. Histogram plots of catch, effort and CPUE by River Mile indicated general areas within each reservoir where higher captures of sturgeon were encountered (Figure 9). Catch and CPUE varied considerably by River Mile over the length of both reservoirs. Overall, the lower sections of each reservoir had much lower catch rates compared to upstream locations, with the highest catch locations within the middle and upper sections of each reservoir, corresponding to areas that likely provide either suitable holding, rearing, or feeding habitat for White Sturgeon.

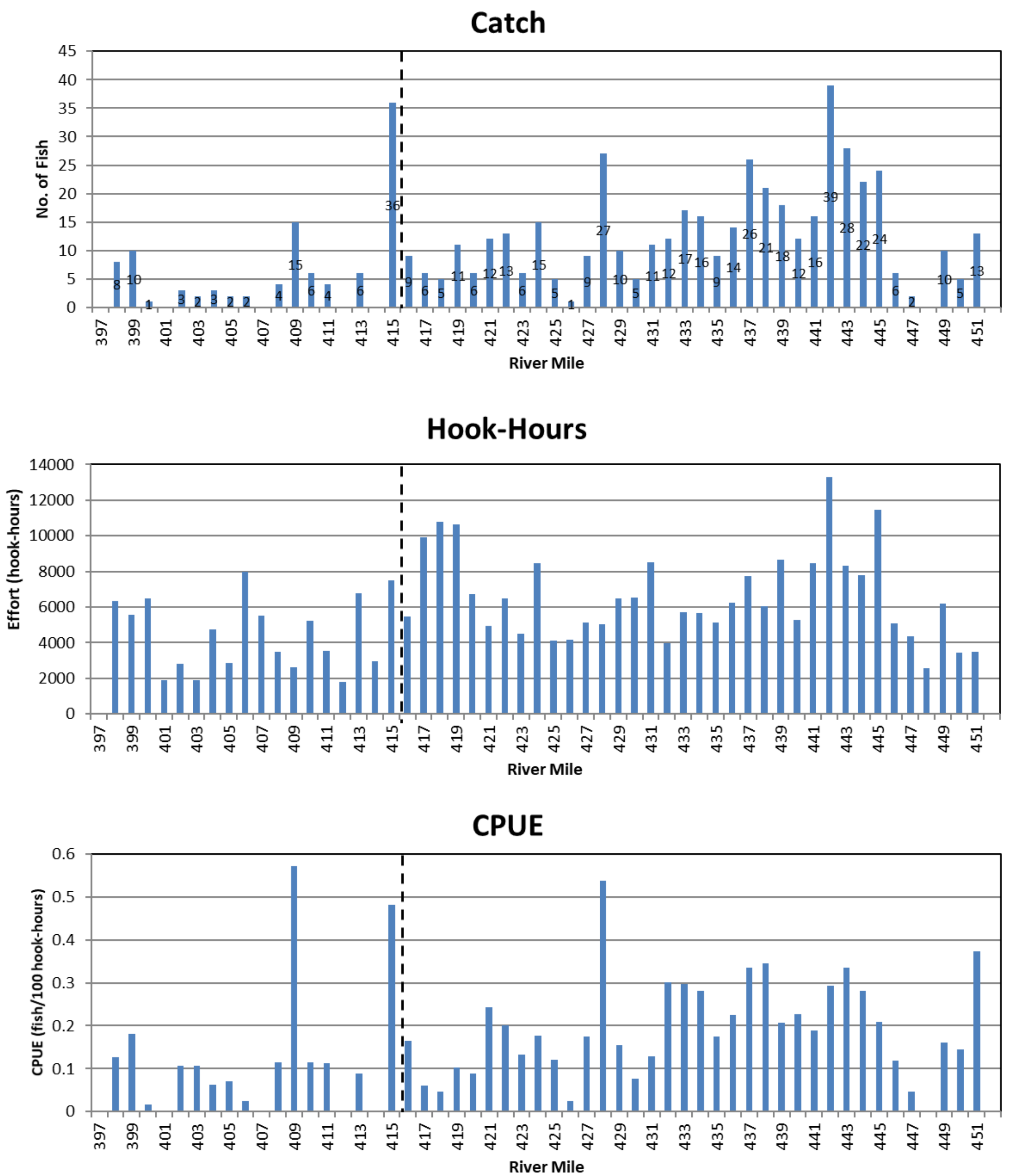


Figure 9 Juvenile sturgeon catch, effort, and CPUE distribution by River Mile in the Priest Rapids Project area, during the juvenile White Sturgeon indexing program from August 6 to 29, 2018. Dash vertical line represents the location of Wanapum Dam.

In Wanapum Reservoir, a higher Ep was recorded for the 2010BY and 2012BY in the upper reservoir section than in the middle and lower sections (Figure 10). For the 2014BY, and to a lesser extent the 2015BY, higher Eps were recorded in the middle reservoir section than in the upper and lower sections. The highest Eps were recorded for the 2013BY, with similar proportions of positive catches among all sections of Wanapum Reservoir. This general trend in Ep for these brood years was also recorded in 2016 and 2017. Low Eps for 2002BY, 2016BY, and 2017BY were recorded in 2018, with slightly higher positive catch recorded in middle and upper sections than in the lower section of Wanapum Reservoir.

In Priest Rapids Reservoir, the highest Ep was recorded in the lower section, with lower Eps recorded in the middle and upper sections of the reservoir (Figure 10). Among brood year releases, the 2013BY contributed a high proportion of the catch in the lower and upper reservoir sections. A higher proportion of 2010BY and 2012BY was recorded in the catch from the upper reservoir section compared to the middle and lower reservoir sections, whereas either similar or very low Eps were recorded among all reservoir sections for 2002BY, 2014BY, 2015BY, 2016BY and 2017BY.

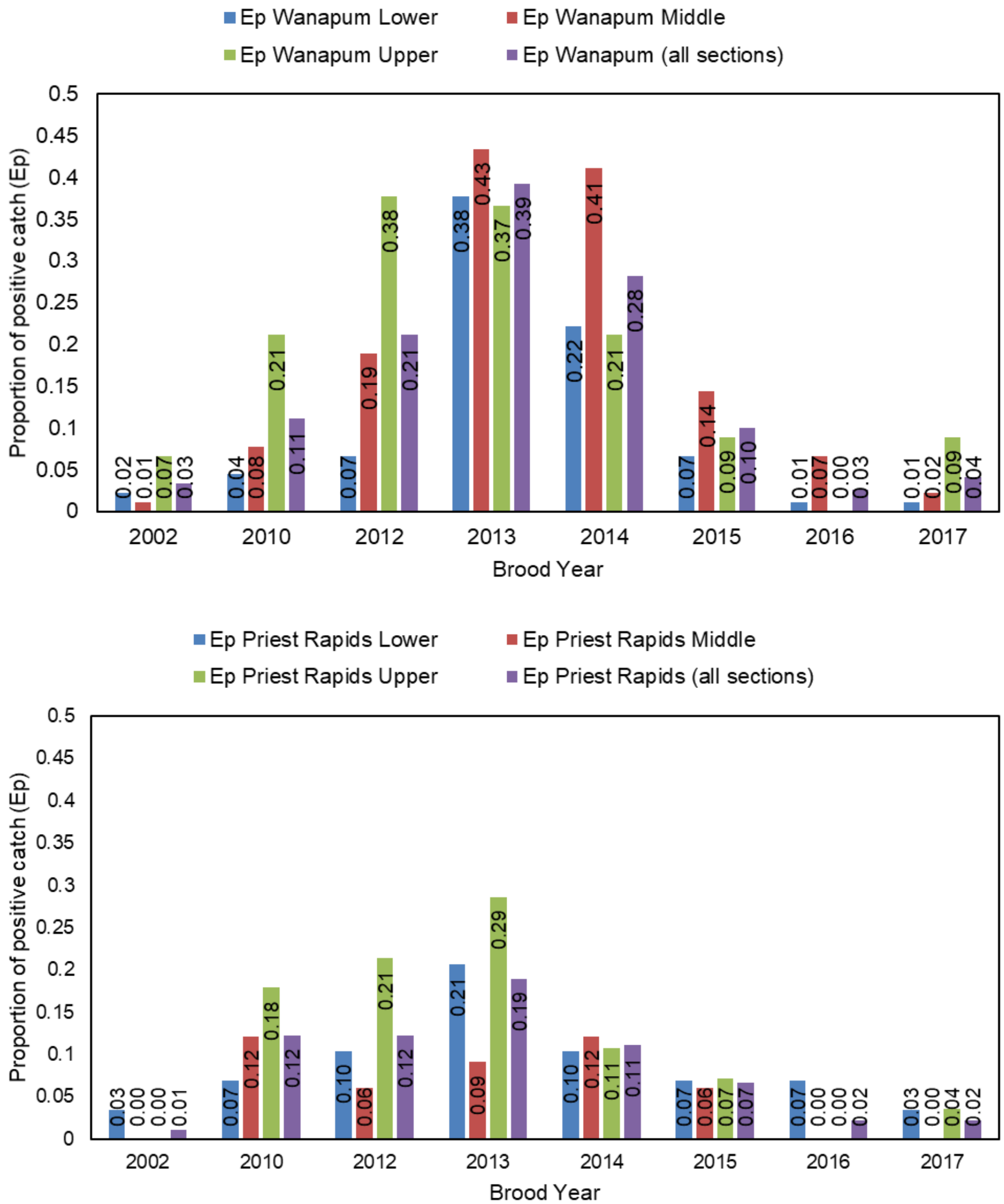


Figure 10 Proportion of positive catch (Ep) of wild and hatchery sturgeon in Wanapum (upper panel) and Priest Rapids (lower panel) reservoirs recorded during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

For each reservoir, Ep estimates for the entire reservoir and reservoir sections were calculated for each sturgeon catch group (e.g., hatchery brood year, wild, etc.) based on release reservoir, as well as for within-brood year release groups, where applicable (Table 10 and Table 11). As the Ep estimates are derived from catch data, the general trends identified in the catch comparisons between brood years and the various within-brood year release groups identified in Table 8 are also reflected in Ep estimates. Consistent with previous sampling years, the following notable differences in catch proportion among release groups within specific brood years (i.e., 2010BY, 2012BY, and 2013BY) were most evident in Wanapum Reservoir, but to a lesser extent in Priest Rapids Reservoir due to low catch:

- 2010BY: higher Eps were recorded for the UCW and MCW release groups compared to the LCC release group, which was rarely captured.
- 2012BY: Higher Eps were recorded in both reservoirs for the downstream release group (i.e., Columbia Cliffs near RM442) than for the upstream release group (i.e., Columbia Siding near RM451).
- 2013BY: In both reservoirs, higher Eps were recorded for fish released in May than for fish released in September.

The differences in Ep values among brood released in similar numbers provides some indication of how release strategies (e.g., release location, time of release), and environmental conditions (e.g., high flow versus low flow years; reservoir conditions) may affect juvenile abundance, survival, and emigration. However, chance events and other confounding variables may have a potentially equal or even a larger influence on brood year survival and abundance in the population.

Table 10 Proportion of set lines with positive catch (Ep) in Wanapum Reservoir during the juvenile White Sturgeon indexing program, August 6 to 29, 2018. Double dashes (--) indicates zero values.

			Wanapum Reservoir Section (No. Sample Sites)			
			Ep			
Brood year	**Release Reservoir**	**Release group**	**Lower (n = 90)**	**Middle (n = 90)**	**Upper (n = 90)**	**All (n = 270)**
2002BY	Rock Island		0.02	0.02	0.06	0.03
2010BY	Rocky Reach		0.01	0.03	0.02	0.02
2010BY	Wanapum	UCW[1]	0.02	0.04	0.12	0.06
		MCW[2]	0.02	0.04	0.09	0.05
		LCC[3]	0.00	0.00	0.01	<0.01
		all	0.04	0.08	0.21	0.11
2012BY	Wanapum	Columbia Cliffs	0.06	0.16	0.32	0.18
		Columbia Siding	0.01	0.04	0.09	0.05
		all	0.07	0.19	0.38	0.21
2013BY	Wanapum	May	0.31	0.36	0.32	0.33
		September	0.12	0.13	0.09	0.11
		all	0.38	0.43	0.37	0.39
2014BY	Wanapum		0.22	0.41	0.21	0.28
2015BY	Wanapum		0.07	0.14	0.09	0.10
2016BY	Wanapum		0.01	0.07	--	0.03
2017BY	Wanapum		0.01	0.02	0.09	0.04
Wild			--	0.02	0.01	0.01
Unknown[4]			0.04	0.01	0.08	0.04
All			0.54	0.73	0.68	0.65

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

Table 11 Proportion of set lines with positive catch (Ep) in Priest Rapids reservoir during the juvenile White Sturgeon indexing program, August 6 to 29, 2018. Double dashes (--) represent zero values.

			Priest Rapids Reservoir (No. Sample Sites)			
			Ep			
Brood year	Release Reservoir	Release group	Lower (n = 29)	Middle (n = 33)	Upper (n = 28)	All (n = 90)
2002BY	Rock Island		0.03	--	--	0.01
2010BY	Rocky Reach		0.00	0.06	--	0.02
2010BY	Priest Rapids	UCW[1]	0.07	0.03	0.11	0.07
		MCW[2]	--	0.03	0.11	0.04
		LCC[3]	--	--	--	--
		all	0.07	0.06	0.18	0.10
2010BY	Wanapum	LCC	--	0.06	--	0.02
		MCW	--	--	0.04	0.01
		UCW	--	--	0.04	0.01
		all	--	0.06	0.04	0.03
2012BY	Priest Rapids		0.07	0.06	0.18	0.10
2012BY	Wanapum	Columbia Cliffs	--	--	0.07	0.02
		Columbia Siding	0.03	--	--	0.01
		all	0.03	--	0.07	0.03
2013BY	Priest Rapids	May	0.07	0.06	0.14	0.09
		September	0.07	--	--	0.02
		all	0.14	0.06	0.14	0.11
2013BY	Wanapum	May	0.10	0.06	0.14	0.10
		September	0.03	0.03	0.07	0.04
		all	0.10	0.06	0.14	0.10
2014BY	Priest Rapids		0.07	0.12	0.11	0.10
2014BY	Wanapum		0.03	--	--	0.01
2015BY	Priest Rapids		0.07	0.06	0.07	0.07
2015BY	Wanapum		--	--	--	--
2016BY	Priest Rapids		0.07	--	--	0.02
2016BY	Wanapum		--	--	--	--
2017BY	Priest Rapids		0.03	--	0.04	0.02
2017BY	Wanapum		--	--	--	--
Wild			0.03	--	--	0.01
Unknown[4]			0.07	--	0.14	0.07
All			0.48	0.33	0.43	0.41

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

3.5.4 Size, Growth, and Condition

Sturgeon captured during the juvenile White Sturgeon indexing program in the PRPA ranged from 31.0 to 139.0 cm FL (mean = 60.8 cm FL; n = 441; Table 12) in Wanapum Reservoir and from 31.0 to 197.0 cm FL (mean = 64.2 cm FL, n = 109) in Priest Rapids Reservoir. Length-frequency histograms of brood years 2010BY through 2017BY captured in Wanapum and Priest Rapids were similar and generally overlapped (Figure 11), with the smallest 2010BY captured (48.0 cm FL), though six years older, comparable in size to the largest 2017BY fish captured (41.5 cm FL).

Table 12 Fork length (cm) of sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 6 to 29, 2018. The fork length recorded during first capture was used for individuals captured twice or more during the survey.

Program	Brood Year	Wanapum Fork Length (cm)					Priest Rapid Fork Length (cm)					Combined Fork Length (cm)				
		n	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**	**n**	**Mean**	**SD**	**Min**	**Max**
CRITFC	2002	**11**	100.1	30.8	66.0	139.0	**1**	150.0	-	150.0	150.0	**12**	104.3	32.7	66.0	150.0
Chelan PUD	2010	**6**	85.0	13.1	66.5	102.0	**2**	81.0	18.4	68.0	94.0	**8**	84.0	13.2	66.5	102.0
Chelan PUD	2012	**1**	80.0	-	80.0	80.0	-	-	-	-	-	**1**	80.0	-	80.0	80.0
Grant PUD	2010	**26**	73.8	14.3	48.0	97.0	**17**	76.3	15.0	55.5	117.0	**43**	74.8	14.4	48.0	117.0
	2012	**74**	60.8	10.8	43.0	88.0	**22**	65.6	14.8	48.0	104.0	**96**	61.9	11.9	43.0	104.0
	2013	**166**	62.2	11.5	39.5	88.0	**32**	61.0	10.7	46.5	85.0	**198**	62.0	11.3	39.5	88.0
	2014	**98**	56.3	7.5	41.0	73.0	**15**	52.0	8.1	43.5	74.0	**113**	55.8	7.7	41.0	74.0
	2015	**26**	47.8	7.8	36.0	64.0	**6**	47.0	9.6	36.5	64.0	**32**	47.6	8.0	36.0	64.0
	2016	**1**	51.0	-	51.0	51.0	**2**	48.8	0.4	48.5	49.0	**3**	49.5	1.3	48.5	51.0
	2017	**17**	35.9	3.1	31.0	41.5	**2**	34.8	5.3	31.0	38.5	**19**	35.8	3.2	31.0	41.5
Unknown[1]	Unknown	**12**	63.4	9.8	47.5	77.5	**9**	62.9	11.3	53.0	88.0	**21**	63.2	10.2	47.5	88.0
Wild	Unknown	**3**	65.5	15.3	48.0	76.0	**1**	197	-	197	197	**4**	98.4	66.9	48.0	197.0
All Sturgeon	All	**441**	60.8	14.8	31.0	139.0	**109**	64.2	21.3	31.0	197.0	**550**	61.5	16.4	31.0	197.0

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

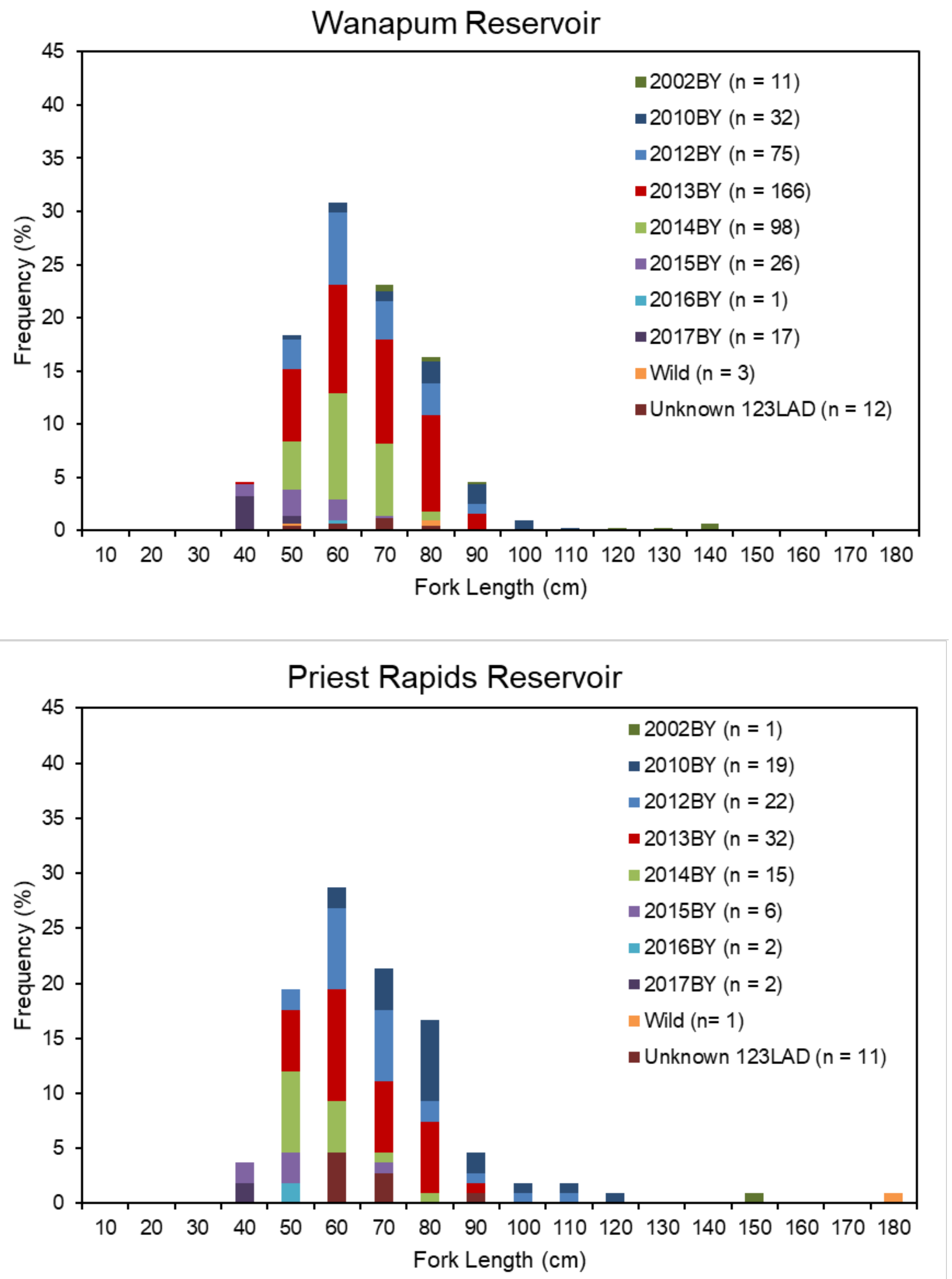


Figure 11 Length-frequency distribution by brood year for hatchery sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

In Wanapum Reservoir, fish weight ranged from 130 g to over 20,000 g (mean = 1,804 g; n = 439). In Priest Rapids Reservoir, the range was smaller, with the smallest fish at 460 g and the largest at 11,500 g (mean = 2,147; n = 76; Table 13). Mean weight of fish captured in Wanapum Reservoir was similar to fish captured in Priest Rapids Reservoir. Relationships between $\log^{10}$ FL and $\log^{10}$ weight were highly significant and regression parameter estimates were similar between reservoirs (Figure 12. Relative weight, as a condition factor, was slightly higher in Wanapum Reservoir (mean = 94%; n = 415) and ranged from 40 to 143%, compared to Priest Rapids Reservoir (mean = 93%; n = 96), with a range from 47 to 128% (Figure 13).

Table 13 Weight (g) of sturgeon captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

Program	Brood Year	Wanapum					Priest Rapids					All				
		n	Mean	SD	Min	Max	n	Mean	SD	Min	Max	n	Mean	SD	Min	Max
CRITFC	2002	9	7,098	6,552	1,935	20,000	-	-	-	-	-	9	7,098	6,552	1,935	20,000
Chelan PUD	2010	6	5,152	2,307	2,280	8,221	2	3,990	2,857	1,970	6,010	8	10,458	6,319	3,570	19,500
Chelan PUD	2012	1	3,390	-	3,390	3,390	-	-	-	-	-	1	3,390	-	3,390	3,390
Grant PUD	2010	26	3,207	1,862	675	7,215	17	3,696	2,806	1,120	11,200	43	3,400	2263	675	11,200
	2012	74	1,629	1058	495	5,300	22	1,958	1,445	625	6,280	96	1,705	1,158	495	6,280
	2013	166	1,918	1115	365	4,985	32	1,572	992	525	4,545	198	1,862	1101	365	4,985
	2014	98	1,224	560	350	2,970	15	970	571	520	2,395	113	1,190	565	350	2,970
	2015	26	682	345	285	1,540	6	923	613	340	1,840	32	727	407	285	1,840
	2016	1	865	-	865	865	2	710	7	705	715	3	762	90	705	865
	2017	17	259	79	130	410	2	270	127	180	360	19	260	81	130	410
Unknown[1]	Unknown	12	1,838	943	610	3,690	9	1,814	1,248	895	4,800	21	1,828	1,055	610	4,800
Wild	Wild	3	2,123	1,146	800	2,810		-	-	-	-	3	2,123	1,146	800	2,810
All Sturgeon	All	439	1,804	1,706	130	20,000	107	1,876	1,743	180	11,200	546	1,821	1,711	130	20,000

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

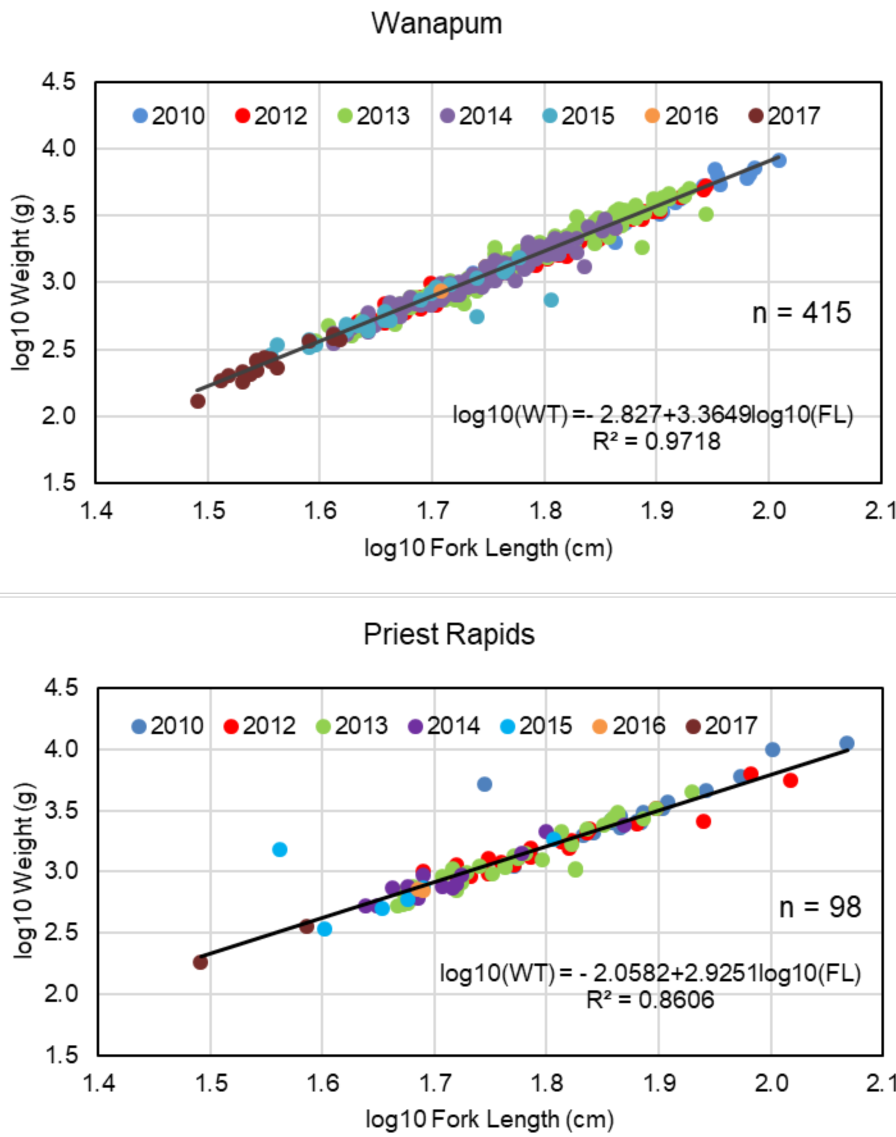


Figure 12 **Linear regression of $\log_{10}$ fork length and $\log_{10}$weight for hatchery juvenile White Sturgeon of each brood year captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.**

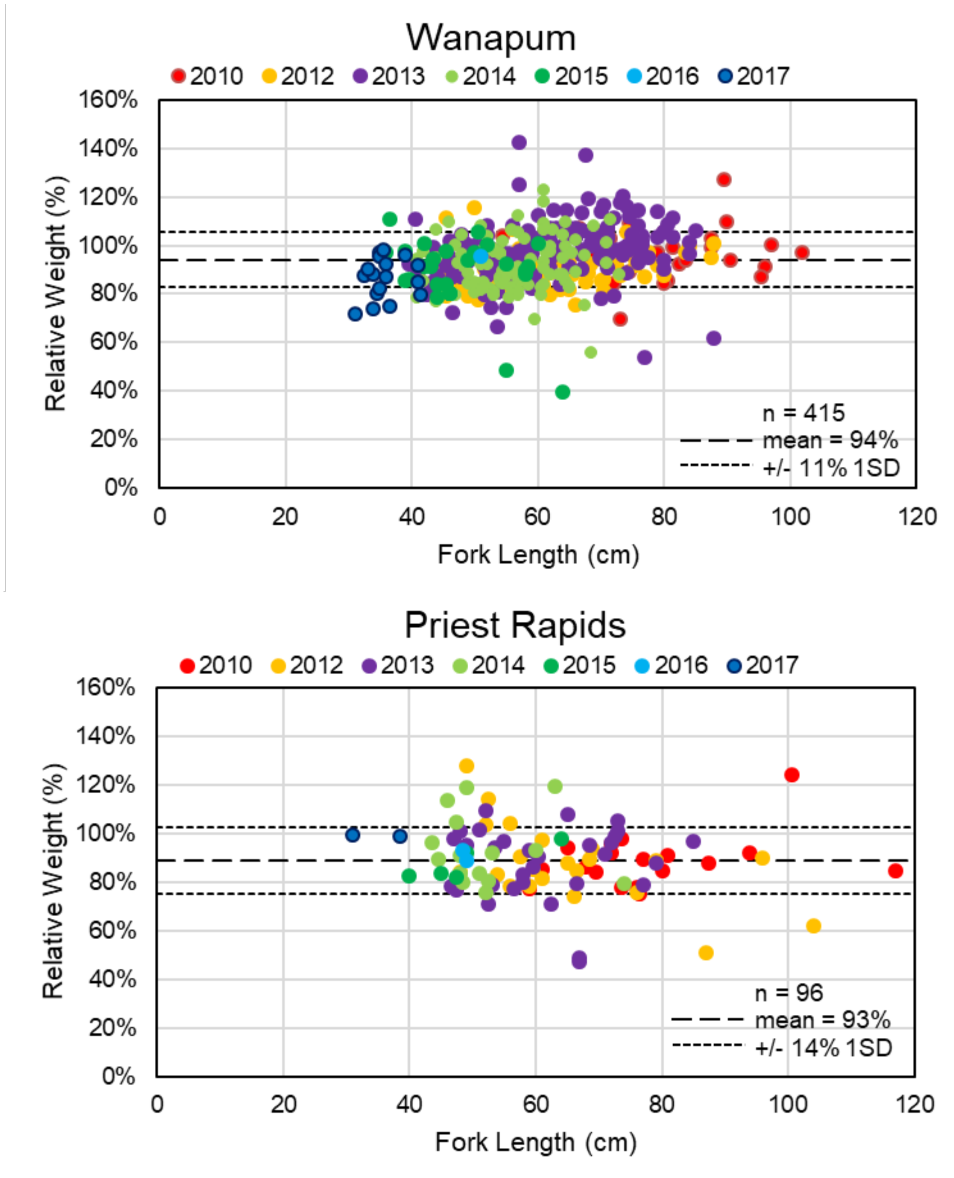


Figure 13 Relative weight and fork length relationship for hatchery juvenile White Sturgeon of each brood year captured in Wanapum and Priest Rapids reservoirs during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

Annual growth rate was calculated for each brood year based on the difference in fork length between release and capture, divided by the total days at large (Table 14). Highest growth rate was associated with the 2017BY (n = 19), at large for only 0.32 years, with a mean annual growth rate of 22.9 $cm{\cdot}y^{-1}$ and a range between 13.8 and 46.5 cm y^{-1}. For the 2016BY (n = 3), mean growth rate after 1.30 years at large was 16.9 $cm{\cdot}y^{-1}$ and ranged from 14.3 to 20.7 $cm{\cdot}y^{-1}$, although this estimate was based on a small sample size. Growth rate in terms of length appears to rapidly decline after the second year post-release, but then remains relatively uniform, with a mean annual growth rate between 6 and 8 cm y^{-1} after the second year at large. For example, the mean growth rate of the 2015BY (n = 32) at large in the PRPA was 7.4 $cm{\cdot}y^{-1}$ and ranged between 0.6 and 14.9 cm y^{-1}. The 2010BY (n = 43), seven years after release exhibited a mean increase in fork length of 6.4 cm y^{-1} since release. Growth rates of fish in Wanapum and Priest Rapids reservoirs were similar for all brood years.

Table 14 Time at large (years) and growth, as change in fork length (FL; cm) and growth rate (FL; cm y1), for Yakama Nation Sturgeon Hatchery fish captured during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

Reservoir	Program	BY	n	Time at Large (Years)				Growth (cm)				Growth Rate (cm· y^{-1})			
				Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Wanapum	Chelan PUD	2010	6	7.33	0.01	7.32	7.35	57.9	13.6	36.0	72.6	7.9	1.9	4.9	9.9
		2012	1	5.27	-	5.27	5.27	54.0	-	54.0	54.0	10.2	-	10.2	10.2
	Grant PUD	2010	26	7.31	0.01	7.29	7.33	46.6	14.2	17.0	75.0	6.4	1.9	2.3	10.3
		2012	74	5.27	0.01	5.24	5.29	31.6	10.9	10.4	57.2	6.0	2.1	2.0	10.9
		2013	166	4.21	0.15	3.90	4.32	34.6	12.5	6.4	62.1	8.2	2.9	1.5	14.4
		2014	98	3.31	0.02	3.28	3.33	24.9	7.6	7.0	39.9	7.5	2.3	2.1	12.0
		2015	26	2.31	0.01	2.29	2.33	17.2	8.6	3.4	34.7	7.5	3.7	1.5	14.9
		2016	1	1.27	-	1.27	1.27	26.4	-	26.4	26.4	20.7	-	20.7	20.7
		2017	17	0.31	0.01	0.29	0.32	6.8	1.9	4.6	10.9	22.1	6.0	14.9	34.0
Priest Rapids	Chelan PUD	2010	2	7.34	0.00	7.34	7.34	49.2	13.9	39.3	59.0	6.7	1.9	5.4	8.0
	Grant PUD	2010	17	7.30	0.02	7.28	7.35	47.9	14.4	28.6	91.0	6.6	2.0	3.9	12.4
		2012	22	5.25	0.02	5.23	5.29	35.7	14.7	17.8	72.0	6.8	2.8	3.4	13.6
		2013	32	4.22	0.13	3.89	4.32	34.0	11.1	17.1	58.8	8.0	2.6	4.2	13.6
		2014	15	3.30	0.02	3.27	3.33	20.7	8.4	10.3	43.4	6.2	2.5	3.1	13.1
		2015	6	2.31	0.02	2.28	2.34	16.7	9.1	1.4	29.4	7.2	3.9	0.6	12.6
		2016	2	1.32	0.01	1.31	1.32	19.8	1.5	18.7	20.8	15.0	1.0	14.3	15.7
		2017	2	0.29	0.03	0.27	0.31	9.1	7.6	3.7	14.4	30.1	23.1	13.8	46.5
All	Chelan PUD	2010	8	7.33	0.01	7.32	7.35	55.7	13.3	36.0	72.6	7.6	1.8	4.9	9.9
		2012	1	5.27	-	5.27	5.27	54.0	-	54.0	54.0	10.2	-	10.2	10.2
	Grant PUD	2010	43	7.31	0.02	7.28	7.35	47.1	14.1	17.0	91.0	6.4	1.9	2.3	12.4
		2012	96	5.26	0.02	5.23	5.29	32.5	11.9	10.4	72.0	6.2	2.3	2.0	13.6
		2013	198	4.21	0.15	3.89	4.32	34.5	12.3	6.4	62.1	8.2	2.9	1.5	14.4
		2014	113	3.31	0.02	3.27	3.33	24.4	7.8	7.0	43.4	7.4	2.4	2.1	13.1
		2015	32	2.31	0.02	2.28	2.34	17.1	8.5	1.4	34.7	7.4	3.7	0.6	14.9
		2016	3	1.30	0.03	1.27	1.32	22.0	4.0	18.7	26.4	16.9	3.4	14.3	20.7
		2017	19	0.31	0.01	0.27	0.32	7.0	2.6	3.7	14.4	22.9	8.3	13.8	46.5

3.5.5 Gear performance

In total, 111 gangions (15.6% of the Wanapum gear inventory) were lost and/or damaged in Wanapum Reservoir; approximately equal numbers of gangions with 2/0 and 4/0 hooks were lost or damaged (Table 15). Lost hooks where the entire hook broke away from the gangion represented less than 2% (14 of 800 hooks) of the inventory.

Gear loss in Priest Rapids Reservoir was approximately half the rate recorded in Wanapum Reservoir, with only 34 (9%) damaged hooks of the 400 hooks gear allotment, with approximately equal numbers of 2/0 and 4/0 hooks damaged. Lost hooks represented approximately 4% (n = 16 of 400) of the gear allotment for Priest Rapids.

In Wanapum Reservoir, total catch by the 4/0 hook size was 25% higher than the 2/0 hook size. In Priest Rapids Reservoir, catch by the 4/0 hooks was 46% higher than 2/0 hooks. Overall, both hooks sizes caught fish of similar size, with 4/0 hooks catching slightly large fish on average due to the capture of a few very large fish (Table 16).

Table 15 Hook rate and overall gangion damage in the Priest Rapids Project area during the juvenile White Sturgeon indexing program, August 6 to 29, 2018.

Reservoir	Hook Size	Gangions		Hook/Gangion Fate				
		No. Set	Gear Inventory	Bent	Lost	Total	Proportion of Set Gangions with Lost or Damaged Hooks	Proportion of Gangion Inventory with Lost or Damaged Hooks
		n	n	n	n	n	%	%
Wanapum	**2/0**	5,438	400	56	6	62	1.1	15.5
	4/0	5,358	400	55	8	63	1.2	15.8
Total		10,796	800	111	14	125	1.2	15.6
Priest Rapids	**2/0**	1,800	200	11	9	20	1.1	10.0
	4/0	1,800	200	7	7	14	0.8	7.0
Total		3,600	400	18	16	34	0.9	8.5
PRPA		14,396	1,200	129	30	159	1.1	13.3

Table 16 White Sturgeon catch by hook size in the Priest Rapids Project area during the juvenile White Sturgeon juvenile indexing program, August 6 to 29, 2018.

Reservoir	Hook Size	Catch	Fork Length (cm)			
		n	Mean	SD	Min	Max
Wanapum	2/0	194	58.6	12.0	34.0	96.0
	4/0	260	62.5	16.3	31.0	139.0
Priest Rapids	2/0	38	61.8	12.5	31.0	88.0
	4/0	71	65.5	24.8	36.5	197.0

3.5.6 Hatchery Juvenile White Sturgeon Abundance Estimates

Capture success during the 2018 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 sturgeon released in Wanapum and Priest Rapids reservoirs (Table 17). Of the 35 models tested and used to calculate model-averaged values of recapture and survival estimates, the multiplicative brood year + age class model received a weighting of 99.8%. In this model, recapture was estimated as a function of age-class and reservoir, and survival was estimated as a function of brood year and an effect of time (first year post-release and all subsequent years post-release). The estimated model-averaged survival estimates were used to calculate cumulative mean annual population values with 95% confidence intervals to describe abundance of hatchery juvenile White Sturgeon released in the PRPA for each calendar year from 2011 to 2018 (Figure 16; Table 18).

Recapture rates increased with fish age, from 0.031 at age-2 to 0.094 at age-8 in Priest Rapids Reservoir, and from 0.104 at age-2 to 0.162 at age-8 in Wanapum Reservoir (Table 17). Overall, recapture rates in Wanapum Reservoir were 2-3 times higher compared to fish of the same age in Priest Rapids Reservoir.

For all brood years, mean survival estimates were lower in the first year post-release than in subsequent release years (Table 17). The highest mean survival estimates were recorded for the 2013BY (0.445 first year post-release, 0.865 all subsequent years), with slightly lower survival estimates recorded for the 2012BY (0.404, 0.844) and 2010BY (0.371, 0.825). For brood years released from 2015 onward, a notable decline in survival was evident, with survival estimates for the 2014BY (0.271, 0.748) and 2015BY (0.190, 0.652) releases substantially lower than the preceding brood years. The 2016BY survival (0.012, 0.091) was the poorest of all brood years released to date. Recaptures of 2017BY were recorded in 2018, but a survival estimate could not be calculated for brood years less than one year at large.

After the initial release of hatchery fish in 2011, the 2012 population abundance estimated for both reservoirs decreased, as hatchery fish were not released in that year. From 2012 to 2015, each successive annual release of hatchery fish was reflected in step increases in cumulative annual population estimates (Figure 16). Since 2015, the annual hatchery sturgeon population estimate in each reservoir has steadily decreased due to lower estimated survival of subsequent brood year releases compared to previous releases. With the release of the 2017BY, the 2018 hatchery fish abundance estimate in Wanapum Reservoir was 5,765 (95% CI = 4,851 – 6,678) or 23% of total hatchery releases to date (n = 25,365 fish). In Priest Rapids Reservoir, the 2018 hatchery fish abundance estimate was 2,667 fish (95% CI = 2,332 – 3,002) or 25% of total hatchery releases to date (n = 10,556 fish).

Table 17 Estimates of annual recapture and survival parameters for hatchery juvenile White Sturgeon in the Priest Rapids Project area, derived from reservoir specific Cormack-Jolly-Seber models.

Reservoir	**Parameter**	**Estimate**		
		Mean	**Lower 95% Confidence Limit**	**Upper 95% Confidence Limit**
Priest Rapids	Recapture, Age-2	0.031	0.025	0.038
	Recapture, Age-3	0.037	0.032	0.042
	Recapture, Age-4	0.045	0.040	0.050
	Recapture, Age-5	0.054	0.046	0.063
	Recapture, Age-6	0.065	0.051	0.082
	Recapture, Age-7	0.078	0.057	0.107
	Recapture, Age-8	0.094	0.062	0.138
Wanapum	Recapture, Age-2	0.102	0.086	0.122
	Recapture, Age-3	0.111	0.100	0.122
	Recapture, Age-4	0.120	0.110	0.130
	Recapture, Age-5	0.129	0.112	0.149
	Recapture, Age-6	0.140	0.112	0.173
	Recapture, Age-7	0.150	0.111	0.201
	Recapture, Age-8	0.162	0.109	0.233
Shared by both Wanapum and Priest Rapids	Survival, 2010BY-First-Year, Post-Release	0.371	0.343	0.400
	Survival, 2010BY-All Subsequent Years	0.825	0.724	0.894
	Survival, 2012BY-First-Year, Post-Release	0.404	0.346	0.464
	Survival, 2012BY-All Subsequent Years	0.844	0.771	0.897
	Survival, 2013BY-First-Year, Post-Release	0.445	0.392	0.499
	Survival, 2013BY-All Subsequent Years	0.865	0.794	0.914
	Survival, 2014BY-First-Year, Post-Release	0.271	0.223	0.325
	Survival, 2014BY-All Subsequent Years	0.748	0.653	0.824
	Survival, 2015BY-First-Year, Post-Release	0.190	0.151	0.236
	Survival, 2015BY-All Subsequent Years	0.652	0.535	0.753
	Survival, 2016BY-First-Year, Post-Release	0.012	0.006	0.025
	Survival, 2016BY-All Subsequent Years	0.091	0.040	0.194

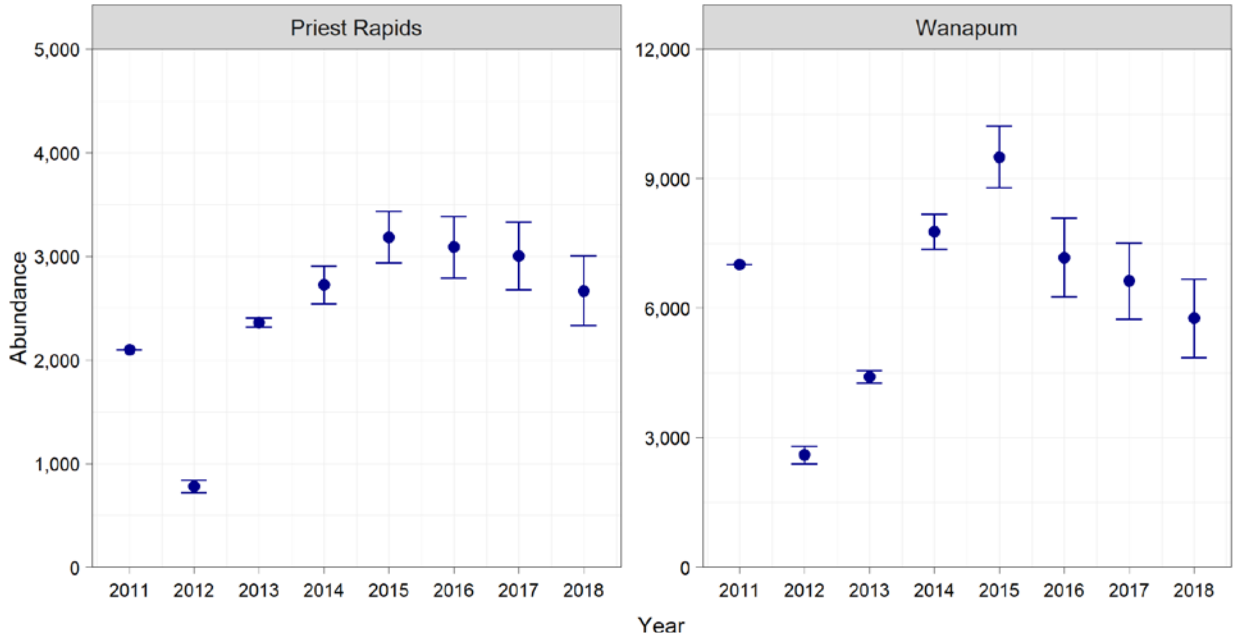


Figure 14 **Estimated abundance of hatchery juvenile White Sturgeon (based on survival of 2010BY and 2017BY releases in the Priest Rapids Project area) by calendar year for Wanapum and Priest Rapids reservoirs, from 2011 to 2018.**

Table 18 **Estimated total abundance of the hatchery juvenile White Sturgeon (2010BY to 2017BY) releases in the Priest Rapids Project area in 2018 by calendar year and in relation to annual and cumulative hatchery releases, 2011 to 2018.**

	Calendar Year							
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Pool	**Abundance Estimate (95% CI)**							
Wanapum 2018	**7,015** (7,015 – 7,015)	**2,602** (2,399 – 2,804)	**4,410** (4,271 – 4,550)	**7,776** (7,372 – 8,180)	**9,505** (8,789 – 10,220)	**7,177** (6,273 – 8,080)	**6,633** (5,750 – 7,515)	**5,765** (4,851 – 6,678)
Annual Hatchery Release No.	7,015	0	2,264	5,092	5,007	2,005	1,999	1,983
Cumulative Release No.	7,015	7,015	9,279	14,371	19,378	21,383	23,382	25,365
Priest Rapids 2018	**2,101** (2,101 – 2,101)	**779** (719 - 840)	**2,360** (2,318 – 2,402)	**2,723** (2,541 – 2,905)	**3,185** (2,937 – 3,432)	**3,090** (2,793 – 3,387)	**3,003** (2,678 – 3,329)	**2,667** (2,332 – 3,002)
Annual Hatchery Release No.	2,101	0	1,717	1,500	1,495	1,253	1,249	1,241
Cumulative Release No.	2,101	2,101	3,818	5,319	6,814	8,067	9,316	10,566

3.6 Adult White Sturgeon Population Assessment

In Wanapum and Priest Rapids reservoirs, areal-based GRTS unequal probability site selection assigned equal numbers of sites among the three defined sections (i.e., lower, middle, and upper sections) in each reservoir (Table 19). Sample intensity (samples/100 Ha) in the upper reservoir sections of each reservoir was from 6 to 7 times higher compared to the lower reservoir sections due to the decline in the areal extent of the available sample area from downstream to upstream. As the site selection criteria for each reservoir was identical to methodology used during the juvenile White Sturgeon indexing program, the adult White Sturgeon indexing site location attributes (i.e., depth and sample duration) were nearly identical to the juvenile indexing site location, with similar means and ranges. All adult indexing set lines were successful retrieved after maximum deployment times that ranged from 17.8 to 24.5 hours.

Table 19 Details of GRTS sample site distribution among Wanapum and Priest Rapids reservoir sections, areal extent of reservoir sections, estimates of sampling intensity, and set line sample depths and durations recorded during the adult White Sturgeon indexing program, September 10 to October 10, 2018.

	Reservoir							
	Wanapum (15 m Bathymetric Contour)				Priest Rapids (6 m Bathymetric Contour)			
	Lower	Middle	Upper	All	Lower	Middle	Upper	All
Number of sample GRTS sites	44	44	44	132	20	20	20	60
Sampling area (Ha)	1,664	727	308	2,699	1,369	346	213	1,928
Samples/100Ha	2.6	6.1	14.3	4.9	1.5	5.8	9.4	3.1
Sample depths (m)								
mean	21.4	20.3	18.3	20.0	13.6	9.3	8.0	10.3
min	7.6	10.0	6.0	6.0	4.6	3.0	3.1	3.1
max	41.4	31.0	40.2	41.4	40.7	18.7	18.4	40.7
Sample duration (h)								
mean	20.9	20.2	20.4	20.5	20.4	21.7	21.5	21.2
min	19.1	18.2	17.8	17.8	19.2	20.7	19.8	19.2
max	24.0	22.3	21.9	24.0	21.5	23.4	24.5	24.5

The average of mean daily flow during sample session 1 (September 10 to 19; 1,693 m^3/s) and session 2 (October 1 to 10; 1,703 m^3/s) were similar; however, hourly discharge over any given 24-hour period was highly variable (see Figure 3). During session 1, a peak mean daily discharge of 1,963 m^3/s was recorded on September 17, with hourly discharges between 317 m^3/s at 02:00 h and 3,151 m^3/s at 17:00 h. Similarly, during session 2, a peak mean daily discharge of 2,369 m^3/s was recorded on October 10, with hourly discharges between 308 m^3/s at 05:00 h and 3,862 m^3/s at 13:00 h.

The average mean daily water temperature during session 1 was 18.9°C, but cooled to 17.0°C during session 2. Ambient air temperature was also notably cooler during session 2 compared to session 1. Air and water temperatures during the sample sessions did not appear to delay recovery of sturgeon after capture and processing and fish all recovered quickly.

In total, 119,146 hook-hours of set line sample effort was expended in the Project area (Priest Rapids and Wanapum reservoirs) during the two sample sessions (Table 20). The combined sample effort in 2018 from both sessions resulted in the capture of 236 White Sturgeon (includes fish captured twice), which consisted of 9 wild fish, 206 YNSH hatchery fish (i.e. H-123LAD; 2010-2017BY releases), and 21 CRITFC hatchery fish (2002BY) for an overall CPUE of 0.20 fish/100 hook-hours. The 2018 catch was considerably different from the previous adult indexing catch in 2015 despite similar levels of effort. In the 2015 study, 532 White Sturgeon were captured, which consisted of 60 wild fish, 75 H-123LAD fish, and 397 CRITFC hatchery fish for an overall CPUE of 0.44 fish/100 hook-hours.

Table 20 Total set line sample effort, catch, and CPUE in the Priest Rapids Project area during the adult White Sturgeon indexing program, September 10 to October 10, 2018.

Session[a]	Reservoir	Sample Effort (hook-hours)	Catch (No. of fish)				CPUE (fish/100 hook-hours)			
			Wild	H-123LAD[b]	2002BY[b]	Total	Wild	H-123LAD	2002BY	Wild & Hatchery
1	**Wanapum**	40,485	4	73	5	82	0.01	0.18	0.01	0.20
	Priest Rapids	19,016	1	24	1	26	0.01	0.13	0.01	0.14
		59,501	**5**	**97**	**6**	**108**	**0.01**	**0.16**	**0.01**	**0.18**
2	**Wanapum**	40,550	4	72	12	88	0.01	0.18	0.03	0.22
	Priest Rapids	19,095		37	3	40	-	0.19	0.02	0.21
		59,645	**4**	**109**	**15**	**128**	**0.01**	**0.18**	**0.03**	**0.21**
Total by Reservoir	**Wanapum**	83,945	8	145	17	170	0.01	0.18	0.02	0.21
	Priest Rapids	37,934	1	61	4	66	<0.01	0.16	0.01	0.17
Overall Total		**119,146**	**9**	**206**	**21**	**236**	**0.01**	**0.17**	**0.02**	**0.20**

[a] Sample Session 1, September 10 to 19, 2018; Sample Session 2, October 1 to 10, 2018;

[b] H-123LAD Hatchery juvenile White Sturgeon reared at Yakama Nation Sturgeon Hatchery, brood years 2010 to 2017; 2002BY Hatchery juvenile White Sturgeon reared by the Columbia River Inter-Tribal Fish Commission from a brood year in 2002 and released in 2003.

Catch distribution did not always correspond with effort, as there were several locations in the lower and middle sections of each reservoir where few fish were captured even though considerable effort was expended (Figure 15). However, consistent with previous indexing studies, the highest CPUEs were recorded at sites located near areas where sturgeon are known to aggregate. The locations of these aggregations occur throughout each reservoir, but more commonly in the middle and upper sections of each reservoir.

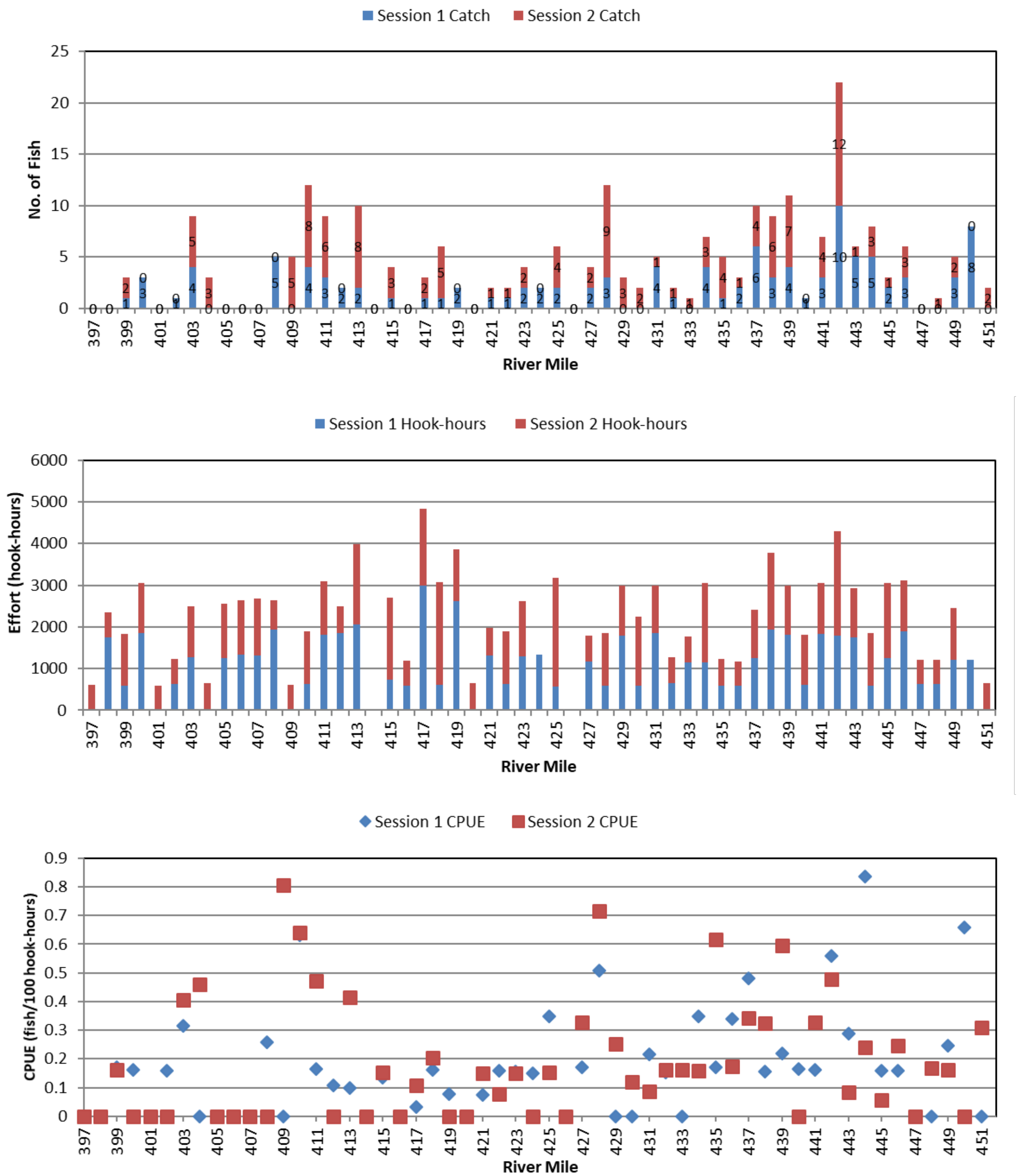


Figure 15 White Sturgeon set line sampling catch, effort, and CPUE distribution by River Mile for session 1 (September 10 to 19) and session 2 (October 1 to 10), 2018 in the Priest Rapids Project area during the adult White Sturgeon indexing program. Dash vertical line represents the location of Wanapum Dam.

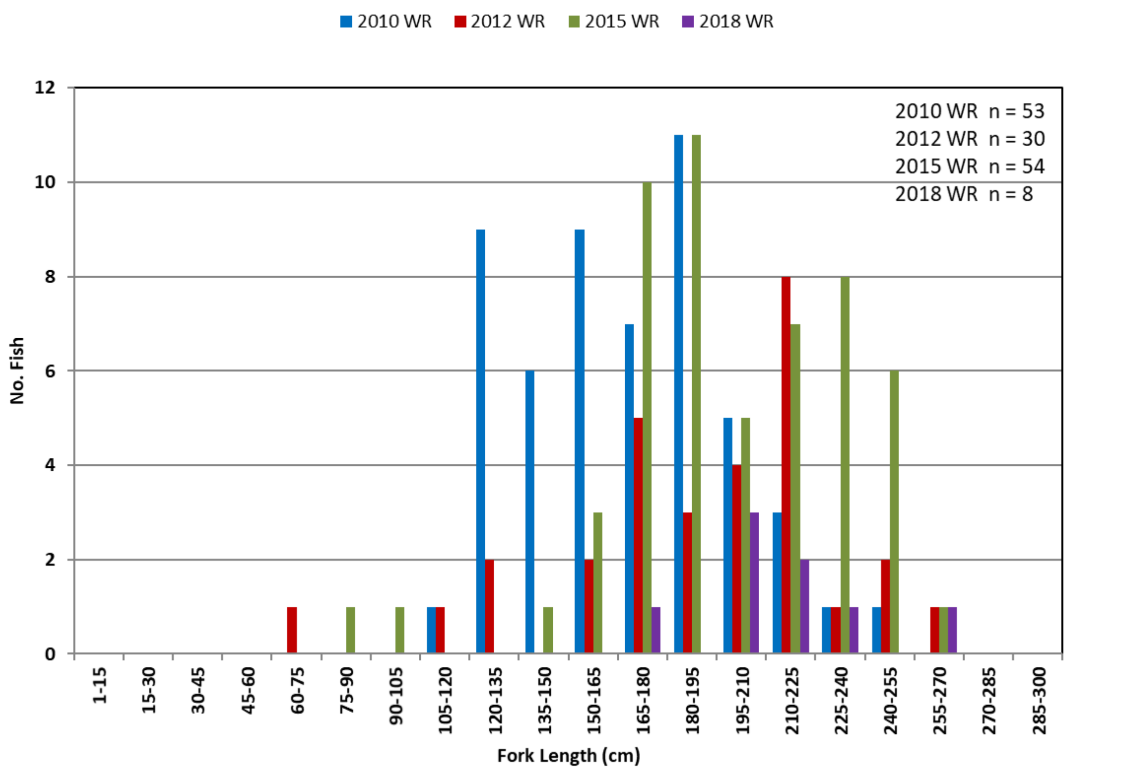
3.6.1 White Sturgeon Size Distribution-Wild

The eight wild White Sturgeon captured during the 2018 adult population indexing program in Wanapum Reservoir were, on average, larger than fish captured in previous adult indexing studies in 2010, 2012 and 2015. Mean fork length (FL) was 213.2 cm FL and ranged from 165.5 to 259.0 cm FL (Table 21). The length frequency distribution of the 2018 catch was shifted to the right compared to the frequency distributions of previous studies due absence of smaller, subadult wild fish in the 2018 catch (Figure 16). The total number of wild fish captured in 2018 was substantially lower when compared to previous indexing efforts.

Historically, very few wild fish have been captured in Priest Rapids Reservoir during indexing studies (Table 21; Figure 16). In 2018, one juvenile wild White Sturgeon was captured (FL = 57.5 cm). Although one juvenile wild White Sturgeon was captured in 2015, previous indexing efforts captured more wild fish and these fish primarily consisted of subadults or adults.

Table 21 Fork length of wild White Sturgeon captured in the Priest Rapids Project area during adult White Sturgeon indexing programs in 2010, 2012, 2015 and 2018.

Adult Indexing Study Year	Wanapum Catch FL (cm)					Priest Rapids Catch FL (cm)					All Catch FL (cm)				
	n	**mean**	**SD**	**min**	**max**	**n**	**mean**	**SD**	**min**	**max**	**n**	**mean**	**SD**	**min**	**max**
2010	**53**	169.8	31.3	116.0	241.0	**5**	166.4	34.4	137.5	205.0	**58**	169.6	31.3	116.0	241.0
2012	**30**	190.3	41.8	60.5	258.0	**3**	162.8	43.8	118.0	205.5	**33**	187.8	42.0	60.5	258.0
2015	**54**	198.4	36.9	81.0	256.0	**3**	139.3	65.4	65.5	190.0	**57**	195.3	40.3	65.5	256.0
2018	**8**	213.2	27.5	165.5	259.0	**1**	57.5	-	57.5	57.5	**9**	195.9	57.9	57.5	259.0
All	**145**	187.1	38.0	60.5	259.0	12	149.7	50.3	57.5	205.5	157	184.2	40.1	57.5	259.0



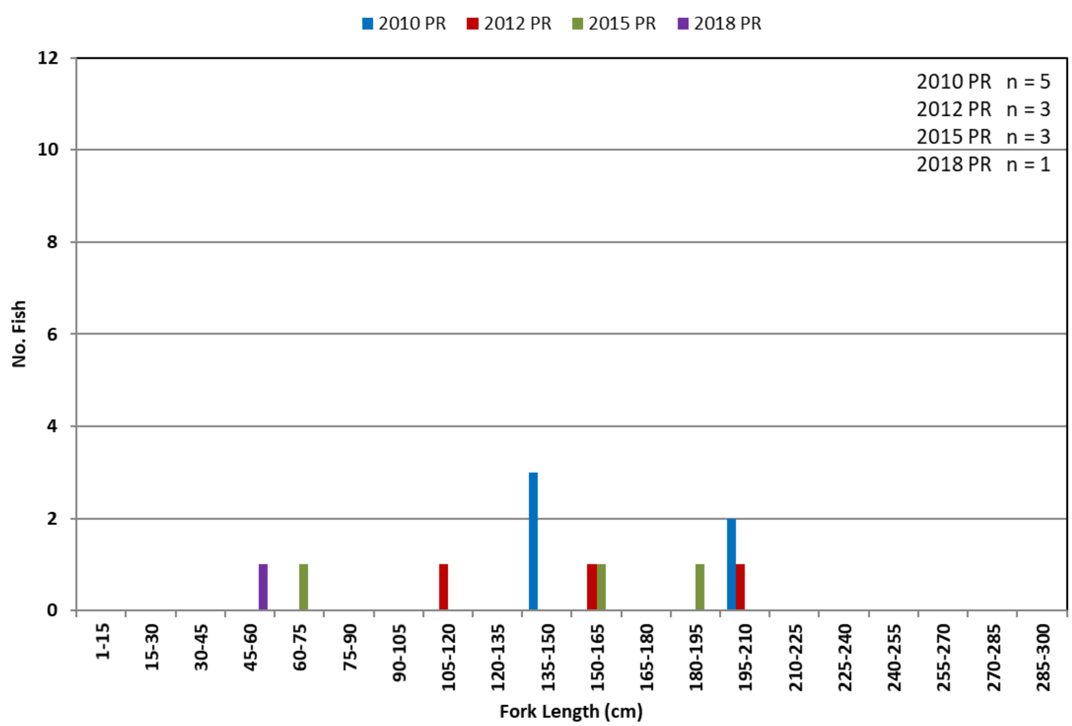


Figure 16 **Length-frequency distributions of wild White Sturgeon captured in Wanapum Reservoir (WR) and Priest Rapids Reservoir (PR) during the 2010, 2012, 2015, and 2018 adult indexing programs.**

Of the combined catch of nine wild fish from both reservoirs in 2018, three were recaptures from previous indexing studies. Two of three fish were first captured during the 2010 and 2015 indexing studies. The third fish captured in 2018 was first captured during fall indexing in 2010 and then again during broodstock capture efforts in 2013 (Table 22). Two of the fish had increased in fork length approximately 2 cm/year and gained weight since their previous capture; the third fish had only grown approximately 1 cm/year and had apparently lost 12 kg in weight.

Table 22 Growth of wild White Sturgeon, previously captured and tagged in the Priest Rapids Project area during in 2010 and 2015 adult indexing studies and recaptured during the 2018 adult indexing study.

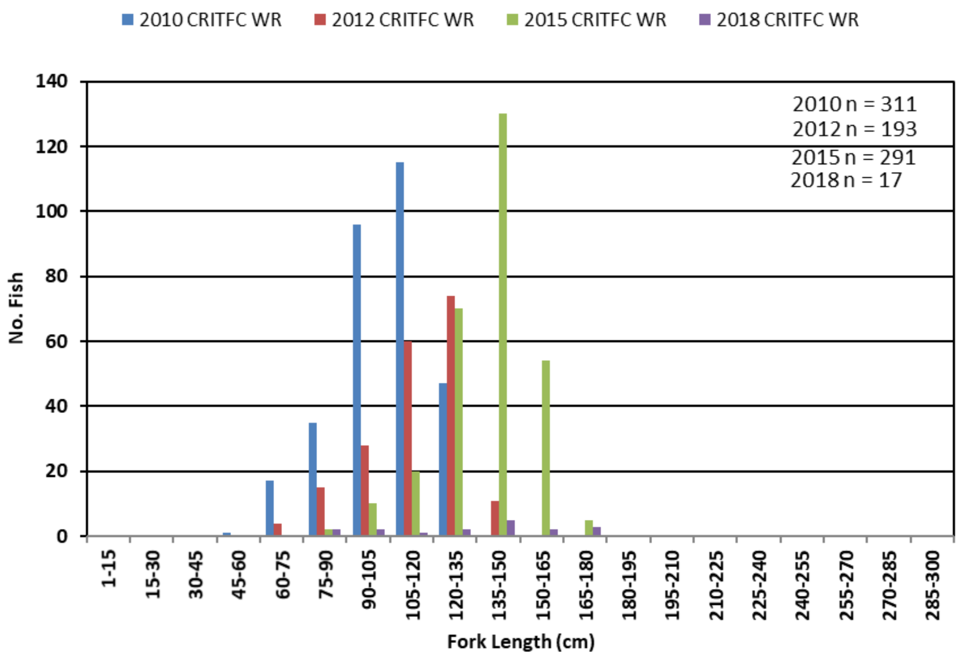
		First Capture			**Last Capture**			**Years at Large**	**ΔFL**	**ΔWt**	**Growth FL**	**Growth Wt**
PIT-tag	Reservoir	Date	FL (cm)	Wt (kg)	Date	FL (cm)	Wt (kg)		(cm)	(kg)	(cm/year)	(kg/year)
985120025269201	Wanapum	24-Sep-10	202.0	78.0	19-Sep-18	221.5	93.0	8.0	19.5	15	2.4	1.9
985120017185588[a]	Wanapum	16-Oct-10	220.0	108.0	18-Sep-18	236.0	113.4	7.9	16	5.4	2.0	0.7
985120025264152	Wanapum	13-Oct-15	204.5	82.1	17-Sep-18	208.0	70.3	2.9	3.5	-11.8	1.2	-4.0

[a] Fish was captured during broodstock collection on June 6, 2013; FL = 223 cm, weight not recorded.

3.6.2 White Sturgeon Size Distribution-2002BY Sturgeon

The 2002BY, which were released in Rock Island Reservoir in 2003 and subsequently entrained downstream into the Priest Rapids Project area, have been captured in high numbers in both Wanapum and Priest Rapids reservoirs during the previous indexing studies in 2010 (n = 469), 2012 (n = 279), and 2015 (n = 389) studies (Table 23). Starting in 2015 and continuing each year since, set lines and targeted angling have been used in an attempt to remove the 2002BY cohort from the Project area. These removal efforts have apparently been successful based on the results of the 2018 study and the capture of only 21 2002BY fish (17 fish in Wanapum Reservoir and 4 in Priest Rapids Reservoir), which represents a 95% reduction when compared to the 2015 catch. The mean fork length and length range of the 2002BY fish caught in 2018 was almost identical to values recorded in 2015 and suggests the removal effort was not size selective, with equal removal of both large and smaller fish (Figure 17). Of the 21 fish captured, four in Wanapum Reservoir and one in Priest Rapids Reservoir had been previously captured during either indexing or broodstock capture efforts conducted since 2010 (Table 24). Time between the first and second captures in Wanapum Reservoir ranged between 3.1 and 7.9 years. Annual growth of these fish was robust and ranged between 5.0 and 5.4 cm/year. Time between the first and second captures of the one recaptured fish in Priest Rapids Reservoir was 6.1 years and grew 2.3 cm/year.

Due to the low catch of 2002BY, intersession captures (i.e., fish captured during session 1 and recaptured in session 2) were not recorded in Wanapum Reservoir during the 2018 indexing study. One of the four 2002BY captured in Priest Rapids Reservoir in 2018 was an intersession recapture, initially captured on September 15 in the lower section near RM399.7 during session 1, and recaptured on October 6 in the middle section near RM404.4 during session 2.



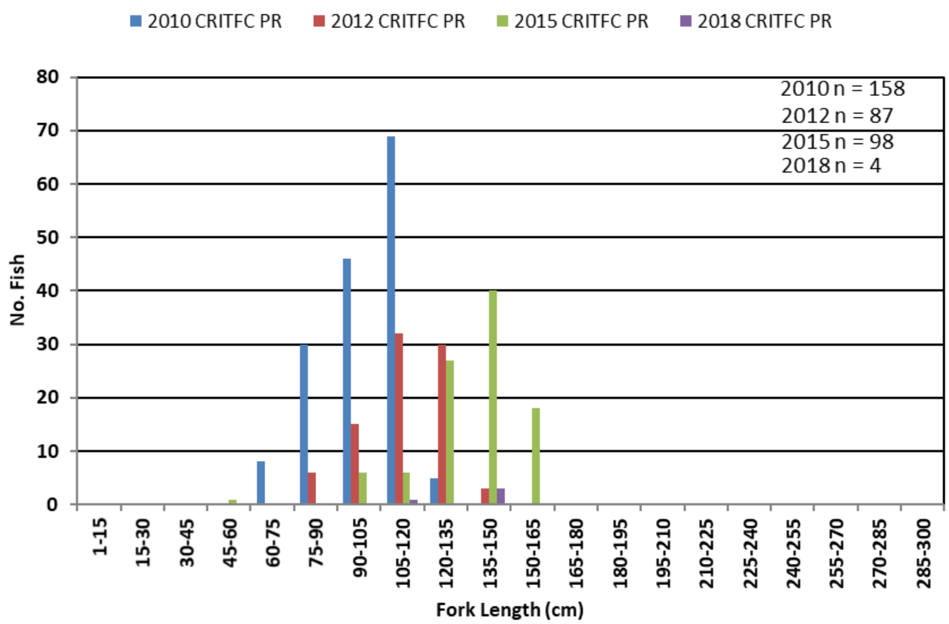


Figure 17 **Length-frequency distribution of 2002BY White Sturgeon captured in Wanapum Reservoir (WR; top) and Priest Rapids Reservoir (PR; bottom) during the 2010, 2012, 2015, and 2018 adult indexing programs.**

Table 23 Fork length of 2002BY sturgeon captured during the 2010, 2012, 2015, and 2018 adult indexing studies in the Priest Rapids Project area.

Adult Indexing Study Year	Wanapum Catch FL (cm)					Priest Rapids Catch FL (cm)					All Catch FL (cm)				
	n	**mean**	**SD**	**min**	**max**	**n**	**mean**	**SD**	**min**	**max**	**n**	**mean**	**SD**	**min**	**max**
2010	**311**	104.1	15.1	58.0	132.5	**158**	101.3	14.3	64.5	132.5	**469**	103.2	14.9	58.0	132.5
2012[a]	**192**	115.1	16.2	62.5	144.0	**86**	113.9	14.3	79.0	141.0	**278**	114.7	15.6	62.5	144.0
2015	**291**	137.7	15.6	77.0	170.0	**98**	135.4	16.1	57.5	165.0	**389**	137.1	15.7	57.5	170.0
2018	**17**	134.2	30.7	81.5	178.7	**4**	133.4	17.5	107.2	144.0	**21**	134.0	28.3	81.5	178.7
All	**811**	119.4	21.8	58.0	178.7	**346**	114.5	20.7	57.5	165.0	**1,157**	117.9	21.6	57.5	178.7

[a] Previous total reported in 2012 were 193 fish in Wanapum and 87 fish in Priest Rapids due to the inclusion of two fish later confirmed as Yakama Nation Sturgeon Hatchery fish

Table 24 Growth of 2002BY, previously captured and tagged in the Priest Rapids Project area during adult indexing studies in 2010, 2012, and 2015, and recaptured during the 2018 adult indexing study.

		First Capture			**Last Capture**			**Years at Large**	**□FL**	**□Wt**	**Growth FL**	**Growth Wt**
PIT-tag	Reservoir	Date	FL (cm)	Wt (kg)	Date	FL (cm)	Wt (kg)		(cm)	(kg)	(cm/year)	(kg/year)
985120019479330	Wanapum	16-Sep-12	118.5	13.6	03-Oct-18	149.0	21.8	6.0	30.5	8.2	5.0	1.4
985121029507682	Wanapum	16-Sep-15	133.0	18.1	05-Oct-18	149.5	24	3.1	16.5	5.9	5.4	1.9
985120021602966[a]	Wanapum	15-Oct-10	68.0		15-Sep-18	111.0	9.09	7.9	43.0	-	5.4	-
985120021599940	Wanapum	25-Jun-12	68.5	2.2	17-Sep-18	99.5	6.69	6.2	31.0	4.5	5.0	0.7
985120021829048	Priest Rapids	12-Sep-12	93.5		09-Oct-18	107.2	9.3	6.1	13.7	-	2.3	-

[a] Fish was also captured on September 13, 2013; FL = 77 cm, Wt = 3.2 kg.

3.6.3 White Sturgeon Size Distribution- 2010-2017BY Fish

In 2015, 2010BY to 2014BY hatchery sturgeon contributed 14% (n = 75 of 532 fish) to the total adult indexing catch. In 2018, the 2010BY to 2017BY hatchery sturgeon contributed 86% (n = 206 of 239 fish) to the total catch. This was a substantial increase from the adult indexing study in 2012, when only two hatchery fish (<1% of the total catch) were captured (Golder 2013).

With the exception of 2016BY, representatives from all other brood year releases were captured during the 2018 adult indexing study, and for each reservoir, the total catch proportion by brood year, catch length-frequency distribution, fork length mean, range, and annual growth closely mirrored the juvenile indexing results. These data have been provided elsewhere in this report (Figure 18; Table 25 and Table 26).

During the adult White Sturgeon indexing, the majority of 2010-2017BY (60.7%; n = 125) of the total catch were captured by 12/0 hooks, the smallest hook size (Table 27), with lower catch on 14/0 hooks (29.6%; n = 61), and 16/0 hooks (9.7%; n = 20). The 12/0 hooks successfully captured both small and large fish. Catch on larger hooks sizes will likely increase as the hatchery fish grow and recruit to the large hook sizes.

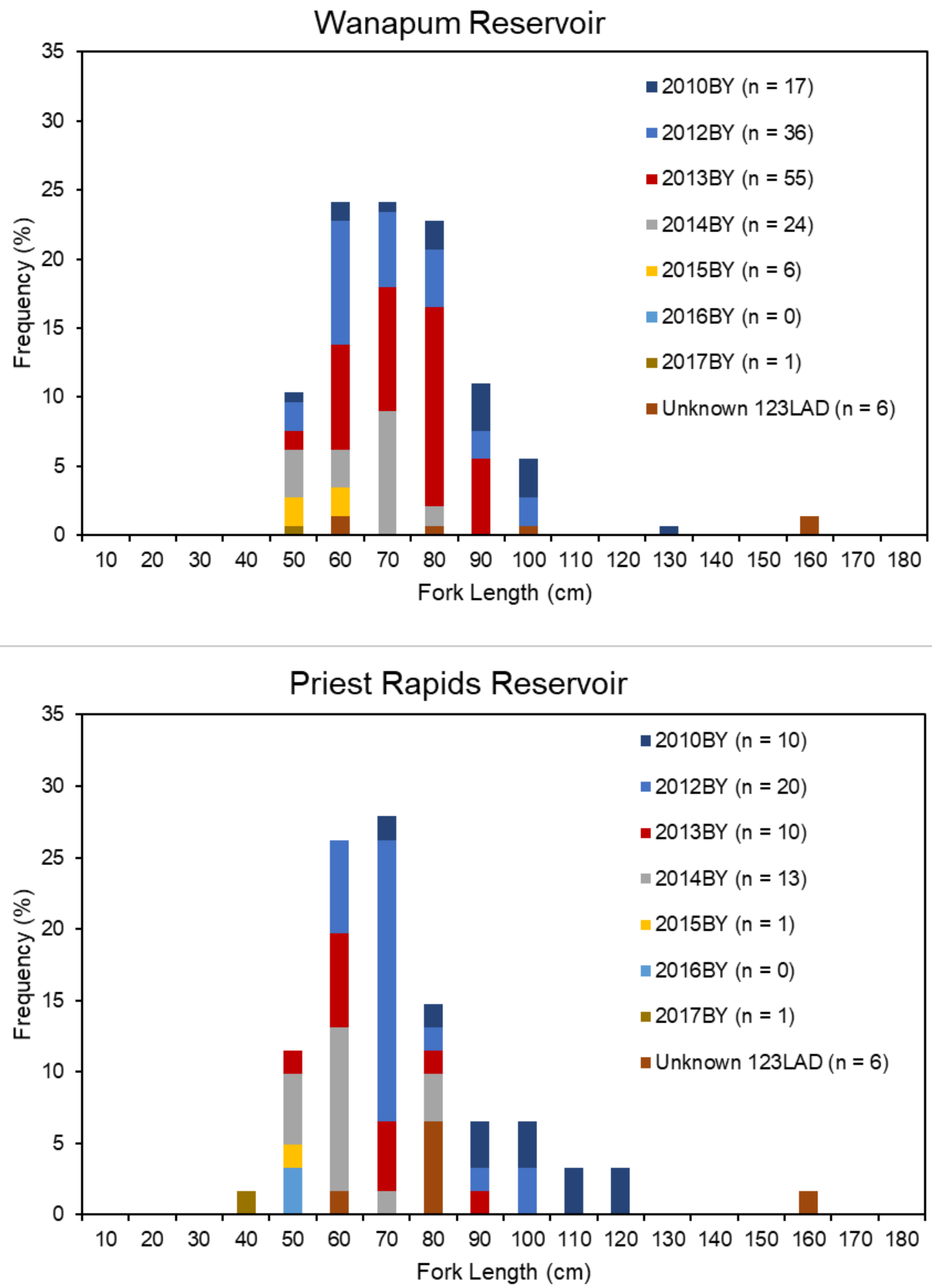


Figure 18 **Length-frequency distribution of 2010-2017BY White Sturgeon captured in Wanapum Reservoir (WR; top) and Priest Rapids Reservoir (PR; bottom) during the 2018 adult indexing program.**

Table 25 Fork length (cm) of 2010-2017BY White Sturgeon captured during set line sampling in the Priest Rapids Project area during adult indexing studies, September 10 to October 10, 2018.

Program	Brood Year	Wanapum Catch FL (cm)					Priest Rapids Catch FL (cm)					All Catch FL (cm)				
		n	mean	SD	min	max	n	mean	SD	min	max	n	mean	SD	min	max
Chelan PUD	2010	**5**	97.2	17.2	80.0	126.0	**3**	113.6	4.5	108.5	117.2	**8**	103.3	15.7	80.0	126.0
Grant PUD	2010	**12**	79.6	16.8	53.0	112.0	**7**	87.2	12.6	69.5	108.0	**19**	82.4	15.5	53.0	112.0
	2012	**36**	65.7	14.3	46.5	100.0	**20**	68.9	11.5	52.0	95.0	**56**	66.8	13.4	46.5	100.0
	2013	**55**	69.2	10.8	46.0	89.4	**10**	62.0	13.4	44.0	90.0	**65**	68.1	11.4	44.0	90.0
	2014	**24**	61.1	9.0	44.5	78.0	**13**	57.3	11.3	44.0	80.0	**37**	59.8	9.9	44.0	80.0
	2015	**6**	50.3	7.7	42.5	59.5	**1**	43.0	-	43.0	43.0	**7**	49.2	7.6	42.5	59.5
	2016	**-**	-	-	-	-	**-**	-	-	-	-	**-**	-	-	-	-
	2017	**1**	40.9	-	40.9	40.9	**1**	37.0	-	37.0	37.0	**2**	39.0	2.8	37.0	40.9
Unknown		**6**	98.9	47.4	50.5	159.5	**6**	86.1	35.6	58.0	157.0	**12**	92.5	40.5	50.5	159.5
All sturgeon	All	**145**	69.0	18.0	40.9	159.5	**61**	70.3	21.2	37.0	157.0	**206**	69.4	19.0	37.0	159.5

Table 26 Growth as change in fork length (FL; cm) and growth rate (FL; cm/year) of 2010-2017BY White Sturgeon captured in the Priest Rapids Project area during adult indexing studies, September 10 to October 10, 2018.

Reservoir	Program	Brood Year	n	Time at Large (Years)				Growth (cm)				Growth Rate (cm/year)			
				mean	SD	min	max	mean	SD	min	max	mean	SD	min	max
Wanapum	Chelan PUD	2010	**5**	7.4	0.0	7.4	7.5	69.2	19.2	53.8	101.8	9.3	2.6	7.2	13.6
	Grant PUD	2010	**12**	7.4	0.0	7.4	7.5	51.5	17.7	28.0	88.0	6.9	2.4	3.8	11.9
		2012	**36**	5.4	0.0	5.3	5.4	36.1	14.1	15.5	71.6	6.7	2.6	2.9	13.3
		2013	**55**	4.3	0.1	4.0	4.4	41.9	11.3	19.2	60.3	9.7	2.6	4.4	14.9
		2014	**24**	3.4	0.0	3.4	3.4	29.6	9.1	9.9	45.7	8.7	2.7	2.9	13.5
		2015	**6**	2.4	0.0	2.4	2.4	21.5	8.8	11.8	31.9	8.9	3.7	4.8	13.4
		2016	**-**	-	-	-	-	-	-	-	-	-	-	-	-
		2017	**1**	0.4	-	0.4	0.4	13.2	-	13.2	13.2	34.4	-	34.4	34.4
Priest Rapids[1]	Chelan PUD	2010	**3**	7.4	0.0	7.4	7.5	83.1	2.1	80.8	85.0	11.2	0.2	10.9	11.4
	Grant PUD	2010	**7**	7.4	0.0	7.4	7.5	58.0	15.5	35.3	83.0	7.8	2.1	4.8	11.2
		2012	**20**	5.4	0.0	5.3	5.4	39.7	11.4	21.6	62.7	7.4	2.1	4.0	11.6
		2013	**10**	4.4	0.0	4.4	4.4	35.7	14.7	10.9	62.3	8.1	3.4	2.5	14.3
		2014	**13**	3.4	0.0	3.4	3.4	26.8	11.9	15.2	51.8	7.8	3.5	4.4	15.3
		2015	**1**	2.4	-	2.4	2.4	19.2	-	19.2	19.2	8.1	-	8.1	8.1
		2016	**-**	-	-	-	-	-	-	-	-	-	-	-	-
		2017	**1**	0.4	-	0.4	0.4	13.6	-	13.6	13.6	36.5	-	36.5	36.5
All	Chelan PUD	2010	**8**	7.4	0.0	7.4	7.5	74.4	16.2	53.8	101.8	10.0	2.2	7.2	13.6
	Grant PUD	2010	**19**	7.4	0.0	7.4	7.5	53.9	16.8	28.0	88.0	7.3	2.3	3.8	11.9
		2012	**56**	5.4	0.0	5.3	5.4	37.4	13.2	15.5	71.6	7.0	2.5	2.9	13.3
		2013	**65**	4.3	0.1	4.0	4.4	40.9	12.0	10.9	62.3	9.5	2.8	2.5	14.9
		2014	**37**	3.4	0.0	3.4	3.4	28.7	10.1	9.9	51.8	8.4	3.0	2.9	15.3
		2015	**7**	2.4	0.0	2.4	2.4	21.2	8.1	11.8	31.9	8.8	3.4	4.8	13.4
		2016	**-**	-	-	-	-	-	-	-	-	-	-	-	-
		2017	**2**	0.4	0.0	0.4	0.4	13.4	0.3	13.2	13.6	35.5	1.5	34.4	36.5

Table 27 Capture of 2010-2017BY White Sturgeon by hook size in the Priest Rapids Project area during adult indexing studies, September 10 to October 10, 2018.

Reservoir	Hook Size	2010-2017BY Catch Fork Length (cm)				
		n	**mean**	**SD**	**min**	**max**
Wanapum	**12/0**	95	65.0	15.8	42.5	159.5
	14/0	41	71.9	14.6	40.9	112.0
	16/0	9	98.9	24.8	77.5	153.4
Total		145				
Priest Rapids	**12/0**	30	69.5	23.3	37.0	157.0
	14/0	20	70.8	21.7	43.0	117.2
	16/0	11	71.6	14.6	55.0	108.5
Total		61				
PRPA		206				

3.6.4 Adult Indexing White Sturgeon Abundance Estimates

Insufficient numbers of 2002BY were captured in 2018 to repeat the 2015 abundance estimation analysis. Therefore, the 2018 estimates of the remaining 2002BY and wild populations, after four years of removal efforts, were based on the original 2015 population estimates adjusted by proportional differences in 2015 versus 2018 catches and CPUEs and relatively weak or incomplete quantitative data, anecdotal information, and speculation on how many fish were removed during the targeted fishery from 2016 to 2018.

The 2015 POPAN model estimated survival and recapture probability estimates had a high uncertainty that the dataset used was not sufficient to provide a reliable mark-recapture population estimate. This uncertainty was reflected in the wide 95% CIs of the derived population and survival estimates of both reservoirs. Consequently, this uncertainty also applies to the 2018 estimates.

Estimates of the Wanapum 2002BY population decreased from 3,767 fish (95% CI = 2,447-5,087) in 2010 to 1,251 fish (204-2,298) in 2015 (Table 28). In 2018, the 2002BY catch was approximately 6% of the 2015 catch (i.e., 17 fish in 2018 vs 291 fish in 2015), and by applying this ratio, an estimate of the remaining 2002BY population in Wanapum Reservoir in 2018 would be approximately 75 fish (12-137). Similarly, the 2018 catch of wild fish in Wanapum declined from 54 fish in 2015 to 8 fish in 2018 (i.e., 14% of the 2015 catch). Applying the same ratio, based on a 2015 population estimate of 249 fish, the wild fish population in Wanapum Reservoir in 2018 would be approximately 35 fish (5-65).

In Priest Rapids Reservoir, the 2002BY population was estimated at 503 fish (80-925) in 2015. In 2018, the 2002BY catch in Priest Rapids Reservoir was approximately 4% of the 2015 catch (i.e., 4 fish in 2018 vs 98 fish in 2015). Correspondingly, the 2002BY population in Priest Rapids Reservoir in 2018 was estimated to be approximately 20 fish (0-37). The wild population in Priest Rapids Reservoir was estimated at 21 fish in 2015 and in 2018 likely consisted of only a few fish (i.e., <10 individuals).

Table 28 Estimated population abundance of 2002BY Hatchery and wild White Sturgeon in the Priest Rapids Project area in 2010, 2012, and 2015; values in parentheses are 95% confidence intervals.

Reservoir	Year	Abundance estimate		
		2002BY Hatchery	Wild	Total
Wanapum	2010	3,767 (2,447-5,087)	536 (306-767)	4,303 (2,753-5,854)
	2012	2,419 (1,471-3,366)	391 (222-561)	2,810 (1,692-3,927)
	2015	1,251 (204-2,298)	249 (36-462)	1,500 (240-2,759)
Priest Rapids	2010	1,514 (971-2,057)	45 (15-74)	1,559 (986-2,132)
	2012	972 (584-1,360)	33 (11-54)	1,005 (595-1,415)
	2015	503 (80-925)	21 (0-41)	524 (80-967)

4.0 Discussion

The following sections provide a brief discussion of the 2018 (FERC License Year 11) M&E program results for the PRPA. In 2018, activities included tagging and release of 2017BY juvenile White Sturgeon, broodstock capture and 2018BY production (both conducted as separate programs), monitoring of acoustic-tagged 2017BY movements after release, and both adult and juvenile White Sturgeon indexing programs.

4.1 Juvenile White Sturgeon Processing and Release (2017BY)

Tagging and marking of the 2017BY was completed by Apri1 11 2018, which was comparable to previous brood tagging efforts that endeavored to have all fish tagged by mid-April. The mean fork length and weight of the 2017BY fish at tagging was similar to means of these parameters for the 2010 to 2016BY releases (29.2 cm FL and 163 g, respectively), which suggests fair to good over winter and early spring growth rates (Table 29). Although there are potentially many variables that affect post-release survival, length and weight of fish at release have a substantive influence on first year survival, with smaller fish typically experiencing higher rates of predation and higher post-release mortality (Golder, unpublished data). However, other variables likely also have a substantial effect on survival and abundance. For example, the mean fork length and weight of the 2013BY and 2016BY at release were nearly identical, however, indexing studies to date suggest there may be substantial differences in post-release survival of these two groups (e.g., the 2018 indexing catch of 2013BY was 203 fish compared to the 2016BY catch of 3 fish).

In 2018, the 2017BYwere released on May 1 after a post-tagging holding period of approximately 3 weeks. Assuming the fish continued to feed and grow after tagging, the fork length and weight at release would have been higher than when the fish were tagged. Release sites in Wanapum Reservoir (i.e., Frenchman Coulee Launch; RM424.5) and in Priest Rapids Reservoir (i.e., Wanapum Dam Tailrace; RM415.6) have been used consistently since 2015.

During tagging of the 2017BY, fin deformities were observed and recorded in 43% (n = 1,398 of 3,224) of fish. This deformity rate was nearly identical to that recorded in the 2016BY (i.e., 42%; n = 1,371 of 3,248 fish), which suggests a common and consistent cause. Since the first release of the 2010BY in 2011, a certain percentage of each brood year release has exhibited fin deformities, with the highest deformity rate recorded for the 2013BY release (64%; n = 4,246 of 6,594; Golder 2014). Among all brood years, deformity of one or both pectoral fins has been most common, followed by deformity of the caudal fin. The cause of fin deformities was suspected to be related to mechanical damage to the fin during early stage development, but the exact cause is still unknown as fish deformities continue to persist despite various mitigation efforts applied by YNSH staff over time. Currently, the biological implications of fin deformities on post-release survival and growth are not fully understood. Fish with and without fin deformities from each brood year are captured during indexing studies in proportions that approximately equal the fin deformities rate reported for those brood years at release.

Table 29 Summary of hatchery White Sturgeon juveniles released in 2011 (2010BY), 2013 (2012BY), 2014 (2013BY), 2015 (2014BY), 2016 (2015BY), 2017 (2016BY), and 2018 (2017BY) in the Priest Rapids Project area.

							Fork Length (cm)		Weight (g)	
Brood Year	**Reservoir**	**Release Location**	**River Mile**	**Brood Source**	**Release Date**	**Number Released**	**Mean**	**SD**	**Mean**	**SD**
2010	Wanapum	Columbia Siding	450.6	UCW[1]	26-Apr-11	2,019 (20)	24.6	3	174	97
				MCW[2]	29-Apr-11	2,996 (30)	28.8	3.6		
				LCC[3]	27-29 April 2011	2,000 (20)	34.7	3.6		
				All	--	7,015 (70)	29.3	5.1		
	Priest Rapids	Wanapum Dam Tailrace	415.6	UCW	26-Apr-11	900 (9)	24.8	2.8	187	105
				MCW	28-Apr-11	601 (6)	29	3.6		
				LCC	28-Apr-11	600 (6)	35.9	2.9		
				All	--	2,101 (21)	29.8	5.3		
				Total 2010		**9,116 (91)**	**29.4**	**5.2**	**177**	**99**
2012	Wanapum	Columbia Siding	450.6	MCW	14-May-13	1,135 (13)	29.2	2.7	156	45
		Columbia Cliffs	442	MCW	14-May-13	1,129 (11)	29.8	2.6		
		All	--	MCW	--	2,264 (24)	29.5	2.6		
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	14-15 May 2013	1,717 (6)	28.5	2.4	149	41
				Total 2012		**3,981 (30)**	**29.1**	**2.6**	**154**	**44**
2013	Wanapum	Rocky Coulee	421.5	MCW	6-May-14	3,330 (32)	26.6	4.0	118	52
				MCW	18-Sep-14	1,762 (20)	29.1	4.4	152	74
				All	--	5,093 (52)	27.5	4.3	129	63
	Priest Rapids	Wanapum tailrace	415.6	MCW	5-May-14	996 (9)	27.2	4.2	131	56
				MCW	17-Sep-14	504 (5)	28.1	4.3	135	73
				All	--	1,500 (14)	27.5	4.2	133	63
				Total 2013		**6,592 (66)**	**27.5**	**4.3**	**130**	**63**
2014	Wanapum	Frenchman Coulee	424.5	MCW	April 30 to May 1 2015	5,007 (48)	31.3	2.9	199	55
	Priest Rapids	Wanapum Dam Tailrace	415.6	MCW	April 30 to May 1 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**
				Total 2010-2017		**35,921 (346)**	**29.2**	**4.2**	**162**	**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 in British Columbia
[2]Mid Columbia Wild (MCW) - the progeny of wild broodstock captured either in PRPA or below McNary Dam and reared at the Yakama Nation Sturgeon Hatchery (YNSH)
[3]Lower Columbia Cultured (LCC) - the progeny of captive broodstock originally captured below Bonneville Dam in the lower Columbia River

4.2 Broodstock Capture

In 2018, 13 days of angling effort was conducted below McNary Dam from May 14 to 27 to capture broodstock for the purpose of conservation aquaculture. Flows in May were high (mean monthly = 441 kcfs) and mean capture rate during broodstock collection was 9 fish/day, identical to levels recorded in 2017, which was also considered a high flow year. Six ripe females and six ripe males were captured and transported to Yakama Nation Sturgeon Hatchery for spawning. Of these fish, one male did not produce viable milt and one female's eggs were not developed enough to be induced to spawn. On June 7, a 5x5 spawning matrix was performed with the remaining viable fish to produce 25 families of brood. A detailed summary of the 2018 broodstock capture effort is provided in Appendix A.

4.3 Movements of 2017BY Acoustic-Tagged White Sturgeon Juveniles

The movements of acoustic-tagged 2017BY juvenile White Sturgeon released on May 1 in 2018 were monitored to determine post-release dispersal. Movements of these fish within each reservoir were examined in terms of direction of movement (i.e., upstream or downstream), distance moved after release, and the proportion of fish that were entrained either through Wanapum or Priest Rapids dams. In Wanapum Reservoir, loss of the acoustic monitoring station near RM425. 9, prevented early post-release detection of acoustic-tagged fish near RM 424 at Frenchman Coulee Launch. Consequently, initial detection of acoustic tagged fish in Wanapum Reservoir occurred several days to weeks later, after fish moved either upstream or downstream and were detected by receivers at RM437.1 or RM415.8.

In Priest Rapids Reservoir, all acoustic-tagged fish released in the Wanapum Dam tailrace were immediately detected by the acoustic receiver located at RM415.5. The shore-based cable systems used to deploy acoustic receivers in both Priest Rapids and McNary reservoirs were found to have varying levels of detection efficiency that were site specific. Telemetry data to date suggest that at certain locations, the shore-based receivers likely have lower tag detection efficiency than receivers deployed using the standard mid-channel mooring system. High flows in 2018, especially in May and June immediately after release of the 2017BY, may have reduced detection efficiency by acoustic receiver stations due to hydraulic noise and turbulence.

4.3.1 Wanapum Reservoir

In Wanapum Reservoir, 15 of the 20 acoustic-tagged fish were detected after release; the five tagged fish not detected (tags 26837, 26840, 26842, 26843, and 26853) were assumed to be located in an area of the reservoir outside the range of the acoustic receivers, either near the release site or the known high-use holding and overwinter habitat located near RM426. This section of the reservoir was previously monitored by the lost receiver deployed at RM424.9. The post-release dispersal pattern of the 15 detected 2017BY was predominantly in an upstream direction, with 14 of the 15 fish (93%) detected at monitoring stations upstream of the release site, with three of these fish detected at the upstream-most receiver below Rock Island Dam at RM454.43. In total, three fish eventually moved downstream into the Wanapum Dam forebay, and of these, one fish (5%, n = 1 of 20 tagged fish) was entrained. Other brood year releases at Frenchman Coulee that exhibited mainly upstream movement after release also exhibited lower entrainment rates (i.e., 2014BY 14.6%, n = 7 of 48 tagged fish; 2015BY 12%, n = 3 of 25 tagged fish; Table 19). Conversely, the 2016BY release exhibited less upstream movement (i.e., n = 8 of 20 tagged fish), with the majority of fish either remaining near the release site (n = 6) or moving downstream into the Wanapum Dam forebay (n = 6), and of these fish, five were entrained

(25%, n =5 of 20 tagged fish). Whether certain brood year releases have a genetic behavioral propensity to either move upstream or downstream after release cannot be determined from the limited amount of data available, although genetic and behavioral differences among the 2010BY release subgroups (i.e., LCC, MCW, and UCW) was suspected due to evidence of higher emigration of the LCC from the Project area compared to the two other subgroups.

Other variables, such as flow conditions, release location, and chance likely influence post-release dispersal and probability of entrainment; however, a clear relationship between any one physical variable (e.g., flow) is not apparent. For example, the release of the 2016BY prior to a high flow period in 2017 was identified as a possible cause of increased entrainment in that year. However, in 2018, the 2017BY were released under almost identical conditions (i.e., same release site, time of year, and high flow conditions), but lower entrainment was recorded.

The one 2017BY fish that was entrained (tag 26836) was unique in that the acoustic receivers in the Wanapum Dam forebay and tailrace detected the fish immediately before and after entrainment within approximately a one-hour time period on August 14. Typically, during previous brood year releases when entrainment events were detected, the actual time of entrainment was less certain due to either large time lags between detections or missing detections at either the forebay or tailrace stations (or both), but with subsequent detections at a downstream station. The 2017BY was entrained at 20:00 h, which corresponded to the peak mean hourly discharge at Wanapum Dam (4,522 m^3/s; 159,700 cfs). Survival of this fish after entrainment is unknown as the fish was not detected by downstream monitoring stations and was last detected in Wanapum Dam tailrace near RM415.5 on September 24, 2018. Additional telemetry data and subsequent detection of this fish would be required to confirm survival.

4.3.2 Priest Rapids Reservoir

Telemetry data from the 12 acoustic-tagged 2017BY fish released in Priest Rapids Reservoir at the Wanapum Dam tailrace launch (RM415.6) indicated that all the tagged fish (100%; n = 12 of 12 fish) remained in the upper section of Priest Rapids Reservoir after release over the duration of the monitoring period. High fidelity to the Wanapum tailrace release site has been recorded for all brood year releases since 2011. Potentially, downstream movement by the tagged 2017BY may be detected over the three-year life expectancy of the acoustic tags; however, telemetry data to date suggests relatively limited use of the lower section of the Priest Rapids Reservoir and only moderate use of the upstream portion of the middle section (e.g., from RM408 to 410).

Entrainment from Priest Rapids Reservoir into McNary Reservoir was not detected for 2017BY acoustic-tagged fish, but entrainment has been confirmed for previous brood year releases (Table 30).

Table 30 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	11.3
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

4.4 Juvenile Indexing Sampling Effort and Catch

The 2018 juvenile White Sturgeon population indexing study design and sample effort was identical to the 2016 and 2017 studies. The selection of GRTS sample sites was constrained to deeper habitat in both Wanapum and Priest Rapids reservoirs, where sturgeon were more likely to occur, in an effort to increase captures. The number of fish captured in 2018 (n = 563) was nearly identical to the total 2017 catch (n = 568 fish). Compared to the 2017 indexing study, higher catch was recorded in Priest Rapids Reservoir in 2018 (109 fish in 2018 compared to 78 fish in 2017) and a slightly lower catch was recorded in Wanapum Reservoir (454 fish in 2018 compared to 490 fish in 2017). The reduction in catch from 2016 (n = 887) to 2018 (n = 563) was uniform across all brood years and was attributed to lower susceptibility to the sampling gear by the older brood years, which were released in larger numbers relative to more recent releases. In addition, a targeted removal of the 2002BY sturgeon by researchers, anglers, and tribal fisheries was initiated in 2015 and increased substantially in 2016. When captured, harvestable fish were selected based on slot size [96.5 cm to 183.0 cm (38” to 72”) total length] as opposed to a specific identifying mark (e.g., scute marks) or the presence of at PIT-tag. Given the substantial variation in fork length and growth among the hatchery fish released into the PRPA since 2011, some of these fish, especially those from the earlier brood years, would have grown into the slot size and were likely harvested from the hatchery population.

4.4.1 Distribution by Brood Year and Reservoir

Wanapum Reservoir

In Wanapum Reservoir, fish from the 2013BY release contributed from 36 to 41% of the total catch during juvenile indexing studies in 2016 (n = 269 of 746 fish captured), 2017 (n = 200 of 490 fish captured), and 2018 (n = 171 of 454 fish captured). In all years, 2013BY were distributed almost equally throughout Wanapum Reservoir, with similar catch rates in the lower, middle, and upper sections of the reservoir, whereas other brood year releases were mainly caught in the middle and upper sections. Based on the catch proportion and catch distribution of 2013BY in all three study years, this brood year likely experienced higher survival than other brood years. A possible explanation was that release of the 2013BY in 2014 occurred during repair of the Wanapum Dam fracture. This produced lower reservoir levels that resulted in more riverine habitat conditions, which may have reduced avian predation and resulted in higher survival (Golder 2017). This is supported in part by a lower detection rate of 2013BY PIT-tags relative to other brood years during mortality surveys at a known Cormorant rookery in the Rock Island Dam forebay (RISFWC; see Table 32).

Similar catch proportions of subgroups with 2010BY, 2012BY, and 2013BY have been recorded since 2016 (Table 31). The consistency of the catch differential among subgroups within brood years over three sample years provides strong evidence that the reported catch proportions likely reflects the relative population abundance of each subgroup in the Project area. These findings also provide some insight into the effect that genetic differences and behavior may have on emigration (i.e., reduced LCC 2010BY). The study results also provide an indication of the effect different release strategies have on post-release survival as it pertains to predation (proximity to avian predators), habitat at the release site (shallow water versus deep water habitat), and the timing of annual hatchery releases (spring versus fall releases, prolonged hatchery holding times).

Table 31 Total catch of within-brood year release groups (subgroups) of 2010BY, 2012BY, and 2013BY during juvenile indexing studies in 2016, 2017, and 2018 in the Priest Rapids Project area and possible explanations of the catch difference among subgroups.

						Wanapum Reservoir: Juvenile Indexing Catch			
BY	Release Reservoir	Release Location	Brood source	Date	Number Released	2016	2017	2018	Total
	H1: Suspected genetic or behavioral difference between UCW and MCW compared to LCC origin fish resulted in greater emigration of LCC from Wanapum Reservoir.								
2010	Wanapum	Columbia Siding	UCW[1]	26-Apr-11	2,020	39	23	17	**79**
			MCW[2]	29-Apr-11	2,996	42	22	8	**72**
			LCC[3]	27-29-Apr-11	2,000	9	3	1	**13**
	H2: Survival (reduced avian predation) of fish released in deep water habitat (Columbia Cliffs), further downstream from Cormorant rookeries was higher compared to fish released shallow water habitat (Columbia Siding) upstream nearer the rookeries								
2012	Wanapum	Columbia Siding	MCW	14-May-12	1,135	33	22	15	**70**
		Columbia Cliffs	MCW	14-May-12	1,129	95	48	61	**204**
	H3: Survival of fish released in spring (May) is higher compared to fall (September) releases								
2013	Wanapum	Rocky Coulee	MCW	06-May-14	3,331	228	165	136	**529**
			MCW	18-Sep-14	1,762	41	35	35	**111**

In both the 2017 and 2018 juvenile indexing catches, the catch proportion of 2016BY in Wanapum Reservoir was less than 1% (2017, n = 1 of 490 fish; 2018 n = 1 of 454 fish). This suggested that present abundance of the 2016BY in the Project area is likely low. This is supported by telemetry data that showed an increased rate of entrainment and emigration of the 2016BY compared to other brood years. Additional data is required to support this assumption.

Priest Rapids Reservoir

In Priest Rapids Reservoir, the 2018 catch (n = 109 fish) was 28% higher than the 2017 catch (n = 78 fish), but lower than the 2016 catch (n = 141). The catch proportion of each brood year release was similar to the proportions recorded in Wanapum Reservoir, with 2013BY contributing 29% (n = 32 of 109 fish) of the total catch captured and lesser numbers of representative from other brood years. The proportion of fish captured in Priest Rapids Reservoir that were entrained from upstream reservoirs was 26% (n = 28 of 109 fish). For most brood years, entrained fish contributed a low proportion to the total catch in Priest Rapids Reservoir (e.g., between 0 and 13%); exceptions were the 2010BY and 2013 BY where 32% (n = 6 of 19) and 52% (n =17 of 32 fish) of fish were entrained.

In previous indexing studies, the Eps (proportion of setlines that catch at least one fish) and CPUE (catch/hook-hours) values calculated for each reservoir section in Priest Rapids Reservoir were usually in agreement, with highest Eps and CPUEs recorded in the same reservoir section. In 2018, Ep and CPUE metrics were not in agreement, with a high Ep and low CPUE recorded in the lower reservoir section (Ep = 0.48; CPUE = 0.10), but a lower Ep and the highest CPUE recorded in the upper reservoir section (Ep = 0.43; CPUE = 0.23). This discrepancy between the two metrics was due in part to unequal sampling effort among sections. Of the set lines deployed, a moderate number in the lower section captured only one or two fish (resulting in a high Ep) compared to the upper section, where fewer set lines caught fish, but three of the successful set lines captured 34% of the total reservoir catch (resulting in a high CPUE).

Indexing and telemetry data to date indicate sturgeon are highly aggregated in Priest Rapids Reservoir, with the greatest densities of fish located in the upper reservoir section in the vicinity of Wanapum Dam tailrace. Based on catch data, sturgeon are concentrated within select habitat areas that are discrete and of limited areal extent. Sturgeon sampling gear deployed in or near these high use areas have a higher probability of catching fish compared to set lines immediately adjacent to these high use areas. Unlike Wanapum Reservoir, where spawning and overwintering areas are spatially separated by large distances, high use sturgeon habitat in the tailrace of Wanapum Dam appears to serve as spawning, rearing, and overwintering habitat. Consequently, sturgeon exhibit less downstream migration and remain within the upper section of Priest Rapids Reservoir near Wanapum Dam where they cannot be easily or safely sampled due to high flows and access restrictions. Consequently, catch rate for the upper section of Priest Rapids Reservoir and population estimates in general for Priest Rapids Reservoir may be underestimated, as a large proportion of the population may not be effectively sampled.

4.4.2 Growth

In 2018, length frequency, growth rates, and relative length-weight relationships of White Sturgeon juveniles were generally similar for both reservoirs for all hatchery fish brood years, with higher growth rates recorded for fish less than one year at large (e.g., 2017BY mean = 22.1cm y^{-1}; n = 17) and slower annual growth rates were recorded for older cohorts (e.g.,2010 BY; mean = 6.4 m y^{-}1; 2012BY mean = 6.0 cm y^{-1}). A similar growth trend was reported in 2017 with the highest growth recorded for recent brood year releases and slower annual growth rates associated with older brood years (e.g., 2012BY, 6.4 cm y^{-1}; n = 84). Although increase in fork length slows as fish age, both 2017 and 2018 indexing studies determined that the 2012BY are growing slower than other brood years, even slower than the older 2010BY. In 2018, more 2012BY were captured in the upper section of Wanapum Reservoir (n = 50) than in either the middle (n = 20) or lower (n = 6) sections. Mean fork length of 2012BY captured in the upper section was notably lower (56.5 cm FL) than in either the middle (67.8 cm FL) or lower section (77.8 cm FL). This trend of either smaller fork length in the upper section of Wanapum Reservoir compared to fish in the middle and lower sections was first noted during the 2014 juvenile indexing program and appears to be supported by data collected by subsequent indexing efforts (Golder 2015). Possible explanations for this trend are 1) higher velocity habitat in the upper section require more energy for fish to hold and feed 2) the greater abundance of fish in the upper section results in increased competition for available food resources, or 3) genetic differences that affect food conversion and growth rate.

4.4.3 Juvenile White Sturgeon Population Estimates

A notable reduction in the 2018 model population estimates for each reservoir was evident compared to previous annual population estimates. The largest change was associated with the Wanapum Reservoir population estimate, which decreased from 12,504 fish (95% CI =11,233 –

13,766) in 2017 (Golder 2018) to 5,765 fish (95% CI = 4,851 – 6,678) in 2018 (Table 32). This reduction was due to the inclusion of additional modeling parameters in the 2018 model, which included effects of brood year on survival rates and the effect of time since release, where survival in first year post-release was allowed to differ from all subsequent survivals. In comparison, the previous models assumed a constant survival rate for all brood years without an effect of post-release period, resulting in estimates of 0.840 in Wanapum Reservoir and 0.659 in Priest Rapids Reservoir. The low survival in the first year post-release, estimated, in the current models, resulted in a strong reduction in annual population estimates. Further reduction in the overall 2018 model population estimate was attributed to lower survival estimated for the 2014BY, 2015BY, and 2016BY release groups.

With addition capture data, the survival and recapture probabilities of the most recent brood year releases could potentially increase if substantially more individuals from these brood years are captured (especially so for 2016BY), which would result in an increase in the population estimate. As fish from older brood years grow and become less susceptible to capture by the juvenile sampling gear, the recapture probability estimate of these older brood years will decrease, furthering reducing the accuracy of the population estimate if based on juvenile indexing data alone. In order to accurately estimate recapture probabilities of these older brood years, future modeling efforts may have to include the hatchery catch from the adult indexing program as the older brood years grow and recruit to the adult capture gear.

Harvest of larger individuals from the older brood years likely occurred during the culling and harvest efforts conducted in the PRPA from 2015 to 2018. If harvest effort and catch data are accurately documented and the PIT-tags of culled fish recorded, the effect of harvest efforts could be included in future data analysis and population modeling. However, if accurate records of catch are not available, population estimates based on the indexing data and modelling will likely be confounded by the harvest and culling programs.

Table 32 Estimated total abundance of the hatchery juvenile White Sturgeon (2010BY to 2017BY releases in the Priest Rapids Project area in 2017 (gray shaded) and 2018 by calendar year, 2011 to 2018.

	Calendar Year							
	2011	2012	2013	2014	2015	2016	2017	2018
Pool	Abundance Estimate (95% CI)							
Wanapum 2017	**7,015** (7,015 - 7,015)	**4,945** (4,597 – 5,257)	**6,415** (5,986 – 6,814)	**10,173** (9,589 – 10,727)	**12,862** (11,984 – 13,701)	**12,129** (10,935 – 13,283)	**12,504** (11,233 – 13,766)	--
Wanapum 2018	**7,015** (7,015 – 7,015)	**2,602** (2,399 – 2,804)	**4,410** (4,271 – 4,550)	**7,776** (7,372 – 8,180)	**9,505** (8,789 – 10,220)	**7,177** (6,273 – 8,080)	**6,633** (5,750 – 7,515)	**5,765** (4,851 – 6,678)
Priest Rapids 2017	**2,101** (2,101 - 2,101)	**912** (800 – 1,025)	**2,318** (2,211 – 2,433)	**2,642** (2,458 – 2,838)	**2,898** (2,657 – 3,161)	**2,827** (2,539 – 3,146)	**3,539** (3,296 – 3,824)	--
Priest Rapids 2018	**2,101** (2,101 – 2,101)	**779** (719 - 840)	**2,360** (2,318 – 2,402)	**2,723** (2,541 – 2,905)	**3,185** (2,937 – 3,432)	**3,090** (2,793 – 3,387)	**3,003** (2,678 – 3,329)	**2,667** (2,332 – 3,002)

4.5 Avian Mortality

Hatchery sturgeon have a tendency to disperse upstream after release in Wanapum Reservoir. Fish that move upstream into the Rock Island Dam tailwater area are exposed to a higher risk of avian predation from a Cormorant colony located in the Rock Island Dam forebay (PTAGIS mortality site = RISFWC). As of 2018, PIT-tag surveys of the colony conducted by Chelan PUD, to identify PIT-tags from fish eaten by Cormorants, have detected 976 PIT-tags (3.5%) from the 27,631 hatchery juvenile White Sturgeon released in the Wanapum Reservoir since 2011 (Table 33). For fish more than one year at large, the lowest level of avian predation (based on PIT tag detections) was recorded for the 2013BY. These fish were released at the temporary Rocky Coulee Launch (RM421.5) in the spring and fall of 2014 during the Wanapum Dam fracture emergency response.

Table 32 PIT-tags from hatchery White Sturgeon (2010BY to 2017BY) released into Wanapum Reservoir and subsequently detected at the Rock Island Dam bird colony (PTAGIS mortality site RISFWC). Data to November 1, 2018.

Brood Year	Release Location (RM)[b]	Wanapum Reservoir Hatchery Juvenile	PIT-tags Detected at RISFWC	Fork Length (mm)		Weight (g)		Percent of Wanapum Release PIT-tag detected at RISWSC
		White Sturgeon Release No.	n	Mean	S.D.	Mean	S.D.	%
2010	450.6	7,016	331	270	34	125	43	4.7
2012	450.6	1,135	174	293	26	151	42	15.3
	442.0	1,129	58	299	25	163	41	5.1
	All	2,264	232	294	26	154	42	10.2
2013[a]	421.5	5,093	13	284	36	138	51	0.3
2014	424.5	5,007	91	312	26	194	47	1.8
2015	424.5	2,005	58	296	25	160	40	2.9
2016	424.5	1,999	17	281	28	147	48	0.9
2017	424.5	1,983	2	276	18	113	33	0.1
Grand Total		**27,631**	**976**	**285**	**33**	**146**	**49**	**3.5**

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

4.6 Adult White Sturgeon Indexing

Capture efforts to remove the 2002BY from the Project area were conducted from 2015 to 2018. Due to inconsistent scute marking of the 2002BY, the criterion for harvest was based on a size slot limit that allowed the retention of sturgeon between 96.5 cm and 183.0 cm (38 to 72”) fork length. The removal was conducted by Grant PUD biologists and contractors, Yakama Nation fisheries personnel, and guided and unguided public anglers. The removal methods used consisted of a combination of baited set lines and angling. A comprehensive summary of the annual removal effort and the number of 2002BY harvested was not available at the time of writing of this report; however, based on the substantial decline in the 2018 adult indexing catch compared to the 2015 catch, the removal effort appeared successful. Set line removal efforts by Yakama Nation likely peaked in 2016, with less effort applied in 2017 and 2018. Available catch data shows the 2017 Yakama set line catch was 194 fish, with 133 of these captured in Priest Rapids Reservoir and the remainder in Wanapum Reservoir (C. Mott, Grant PUD, personal communication, April 24, 2017). Based on data provided by Grant PUD, and anecdotal information and discussions with a local fishing guide (S.Hurd, Fishing guide, personal communication, January 18, 2019), guide assisted angling harvested approximately 120 fish per year. Fishing guides reported that on several occasions, large 2002BY, identified as such based on scute marks, had to be released as they were larger than the maximum slot limit size. Consequently, the release of these larger fish was counter to the removal effort objective to remove mature 2002BY that could interbreed with the wild population. Guided angling effort in 2018 was reduced as anglers noted a decrease in catch compared to 2016 and 2017.

In 2018, the 2002BY catch from the adult indexing program was approximately 6% of the 2015 catch (i.e., 17 fish in 2018 vs 291 fish in 2015) Similarly, the 2002BY catch in Priest Rapids Reservoir in 2018 was approximately 4% of the 2015 catch (i.e., 4 fish in 2018 vs 98 fish in 2015). With the exception of one intersession capture in Priest Rapids Reservoir (i.e., one of four fish captured), low catch and insufficient intersession recaptures in 2018 did not permit a mark-recapture population estimate for the 2002BY to be calculated. Consequently, the 2018 population of the 2002BY was estimated based on catch proportions of this year class in each reservoir. The resulting 2002BY population estimates in the Wanapum Reservoir population decreased from 1,251 fish in 2015 to approximately 75 fish in 2018, with 95% CIs between 12 and 137 fish. Correspondingly, the 2002BY population in Priest Rapids Reservoir in 2018 was estimated to be approximately 20 fish, with 95% CIs between 0 and 37 fish.

The 2018 catch of wild fish in Wanapum Reservoir declined from 54 fish in 2015 to 8 fish in 2018 (i.e., 14% of the 2015 catch). The reduction in wild fish catch was at least partially related to the 2002BY removal effort as 28% of the 2015 wild catch was within the targeted slot size and therefore, this proportion of the wild population were susceptible to the removal effort (Golder 2016). The possibility also exists that wild fish larger and smaller that the slot size were inadvertently caught and killed as by-catch during the set line removal effort. Based on the 2018 proportion of the 2015 catch, the wild fish population in Wanapum Reservoir in 2018 was estimated at 35 fish, with 95% CIs between 5 and 65 fish. Historically, very few wild fish have been caught in Priest Rapids Reservoir. The wild population in Priest Rapids Reservoir was roughly estimated at only 21 fish in 2015 and in 2018 may only consist of a few fish (i.e., <10 individuals).

4.7 Summary

The juvenile sampling methodology based on small-hook set line sampling, when combined with release data, telemetry, and avian mortality data, allowed estimates of total juvenile hatchery sturgeon population released since 2011. Telemetry data recorded from a subsample of tagged fish in each brood year release provided an estimate of emigration. Sources of mortality (avian) was estimated and provided an indication of overall survival. Due to limit recaptures during indexing studies, population estimates for individual brood years have not been possible to date; however, CPUE and Ep estimates for each brood year were calculated and were used to infer differences in survival and abundance among brood years. Growth rates of hatchery brood year releases recorded in 2018 were comparable to rates recorded during previous studies. Adult indexing effort in 2018 captured insufficient numbers of 2002BY fish to calculate a population estimate for this cohort. However, based on the substantially reduced catch of 2002BY in 2018 compared to the 2015 adult indexing study, removal efforts conducted since 2015 have effectively reduced the 2002BY population.

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

MEMORANDUM

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

FROM: Corey Wright, *Blue Leaf Environmental*

DATE: June 22nd, 2018

SUBJECT: Broodstock Collection Below McNary Dam in 2018

In 2018 there was a collaborative effort with Oregon Department of Fish and Wildlife (ODFW) and Grant and Chelan PUD's to both perform annual white sturgeon (*Acipenser transmontanus*) broodstock collection and assist ODFW with capture and acoustic tagging of ripe sturgeon for a spawning behavior telemetry study. As in past years professional fishing guides were utilized to capture broodstock for the Mid-Columbia sturgeon recovery effort with additional effort this year from ODFW fishing single set setlines out of their research vessel concurrently with the guides. Fishing took place in the white sturgeon spawning sanctuary below McNary dam on the Columbia River. Similar to past years this effort was jointly supported by Chelan County PUD and Grant County PUD with BPA funding ODFW's contribution.

This year fishing took place over fourteen days from May 14th to May 27th. Similar to last year this year also had very high water levels with a mean flow of 441 kcfs for the month of May, a 51% increase in flows compared to the ten year mean of 292 kcfs. There were 124 individual white sturgeon captured and 1 fish was captured twice for a total of 125 sturgeon landings. The mean number of fish captured per day was 9 while the mean per day per boat was 3.0 down from 4.3 in 2017 which was also down from the 2012-2016 mean per day per boat of 5.2. The lower catch rates this year and last year can be attributed to higher than average flows. Of the individuals captured, 99 were greater than 150 cm, or mature spawning sized sturgeon, and 25 were less than 150 cm. As a part of ODFW's spawning study acoustic tags were implanted in 15 ripe males, 10 ripe females and one F3 female for a total of 26 tags released during the effort. For the broodstock collection effort 6 ripe females and 6 ripe males were transported to Marion Drain Hatchery. On the 7h of June a 5x5 spawning matrix was performed producing 25 families of brood, one male did not produce viable milt and one female's egg were not developed enough to spawn with this group.

During broodstock collection this year data was recorded directly into the Columbia Basin PIT Tag Information System (PTAGIS) P4 software with a tag list loaded of previously transported broodstock so that we didn't transport fish to the hatchery that had already been transported in past years. We ended up encountering sturgeon that had been previously transported to the hatchery this year and therefore looked back though catch data at McNary from 2012-2018 and summarized recaptures of previously transported fish in Table 1. We have recaptured one or more times a total of 12 sturgeon that were previously transported to the hatchery, 4 females and 8 males. Each year since 2014 a range of 1 to 6 sturgeon have been recaptured anywhere from 1 to 6 years post transport. Seven of the eight sturgeon previously transported have one recapture event post transport while one fish 3D9.1C2E0AAA13 was transported in 2012 and has been recaptured three times in 2014,2015 and 2018. All fish recaptured post transport were in good condition, had healed biopsy scars and no other signs of previous handling.

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

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

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

ACKNOWLEDMENTS

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

Table 2 . Catch data from white sturgeon broodstock collection efforts below McNary Dam from May 14th through May 27th 2018.

No.	Date	Sex	Fork (mm)	Total (mm)	Girth (mm)	Fate	Event Type	Mark @ Cap	PIT Tag
1	5/14/2018	UNK	1730	1980	630	R2R	Recapture		3DD.00778F2028
2	5/14/2018	M5	2160	2460	810	R2R	Mark	L17	3DD.0077907A95
3	5/14/2018	M5	1770	2000	710	R2R	Mark	L4, L8, L10, L11-13, L17, R10	3DD.007790D945
4	5/14/2018	M5	2380	2640	940	R2R	Mark		3D9.1C2DF7EE83
5	5/15/2018	JUV	590	685	235	R2R	Mark		3D9.1C2DC8C2AD
6	5/15/2018	F3	2450	2770	1070	R2R	Mark	L2,7,17	3DD.00779095AD
7	5/15/2018	M6	2140	2380	900	R2R	Mark	R3,5,14	3D9.1C2DF7BA32
8	5/15/2018	JUV	650	760	235	R2R	Mark		3D9.1C2DC8F625
9	5/15/2018	M5	2190	2470	840	R2R	Recapture	L1-2, R15	3D9.1C2DECBA0C
10	5/15/2018	M6	1920	2170	790	Hatchery	Recapture	L2	3D9.1C2D2F7E8E
11	5/15/2018	M6	2330	2620	870	R2R	Recapture	L2, R3	3DD.0077907ABD
12	5/16/2018	JUV	1050	1205	420	R2R	Mark		3D9.1C2DC933CE
13	5/16/2018	F3	2700	3000	1010	R2R	Recapture	L2	3DD.0077538A83
14	5/16/2018	JUV	865	1080	375	R2R	Mark		3D9.1C2DC66695
15	5/16/2018	M5	1930	2180	760	R2R	Mark	L8	3DD.0077913D7E
16	5/16/2018	M6	2270	2520	910	Hatchery	Recapture	L3,12	3DD.007753237D
17	5/16/2018	JUV	1170	1350	500	R2R	Mark		3D9.1C2DC94DFC
18	5/16/2018	JUV	760	890	280	R2R	Mark		3D9.1C2DC671C2
19	5/16/2018	F3	2520	2820	1000	R2R	Mark		3DD.007790B461
20	5/16/2018	F3	2580	2920	1170	R2R	Mark		3DD.0077908AE8
21	5/16/2018	M6	2370	2670	930	R2R	Mark		3DD.007790CFED
22	5/16/2018	M6	2420	2670	980	R2R	Mark		3DD.007783F9E8
23	5/16/2018	M1-4	1430	1630	600	R2R	Mark		3DD.00778F5ECD
24	5/16/2018	JUV	1410	1590	540	R2R	Recapture	L2,9	3D9.1BF10DFA1D
25	5/17/2018	JUV	840	980	350	R2R	Mark		3D9.1C2DC8A9C1
26	5/17/2018	JUV	940	1075	365	R2R	Mark		3D9.1C2DC8F682
27	5/17/2018	JUV	1030	1210	430	R2R	Recapture		3DD.007763D63A
28	5/17/2018	F3	2390	2630	1040	R2R	Mark		3DD.007790EDA5
29	5/17/2018	M5	2580	2890	1070	R2R	Mark	L9	3DD.0077905A53
30	5/17/2018	JUV	1420	1580	570	R2R	Mark		3DD.007790CD64
31	5/17/2018	JUV	1080	1260	450	R2R	Mark		3D9.1C2D66DB1C
32	5/17/2018	M6	2370	2650	1080	R2R	Mark		3DD.007790DF98
33	5/17/2018	M6	2190	2480	800	Hatchery	Mark	R2,4,6,8	3D9.1C2DF7C503
34	5/17/2018	M5	1660	1880	650	R2R	Recapture	L2,12,R9	3D9.1BF264C1C3
35	5/17/2018	M6	2100	2360	920	Hatchery	Recapture	L1-3,R11	3D9.1BF1D0EE26
36	5/17/2018	M6	1640	1820	670	R2R	Recapture	L2, R7,13	3D9.1C2CDA6205
37	5/18/2018	F5	2520	2800	1160	Hatchery	Mark		3D9.1C2DF78BF4
38	5/18/2018	M6	2330	2580	900	R2R	Mark	R6	3D9.1C2DF784D1
39	5/18/2018	F5	2530	2790	1080	R2R	Mark	L10	3D9.1C2DF7DA48
40	5/18/2018	M6	2500	2770	1000	R2R	Mark		3D9.1C2DF7DF18
41	5/18/2018	M6	2340	2610	850	Hatchery	Mark	R12,14	3D9.1C2DF7885D
42	5/18/2018	F5	2750	2990	1070	Hatchery	Mark		3D9.1C2DF7DA4A
43	5/18/2018	JUV	1540	1710	640		Recapture	L2	3DD.007763C2DA
44	5/18/2018	JUV	1010	1160	430	R2R	Mark		3D9.1C2D673EE3
45	5/18/2018	JUV	1340	1540	560	R2R	Recapture	L2	3D9.1BF264C48B
46	5/18/2018	JUV	1120	1260	440	R2R	Recapture		3DD.00775358A2
47	5/18/2018	M6	2360	2610	920	R2R	Mark	L2,7	3D9.1C2E0A6AD1
48	5/18/2018	M6	2520	2810	950	R2R	Mark	R26,27	3D9.1C2DF7ED22
49	5/19/2018	F1-2	1920	2150	770	R2R	Recapture	L2	3D9.1C2E0AAA13
50	5/19/2018	F3	2670	2960	1150	R2R	Recapture	L2	3D9.1C2DF15CCD
51	5/19/2018	M6	2290	2550	930	R2R	Mark		3D9.1C2DF7F065
52	5/19/2018	M5	2310	2570	830	R2R	Mark		3D9.1C2E0A62D3
53	5/19/2018	M6	2110	2400	740	R2R	Mark	L1,2,3,4	3D9.1C2E0AAFE4
54	5/19/2018	M5	2580	2940	1020	R2R	Mark	R20	3DD.0077915D8C
55	5/19/2018	M5	1900	2160	690	R2R	Mark	L10, R18,20	3D9.1C2DF79043
56	5/19/2018	F5	2300	2540	1000	R2R	Recapture	L2	3D9.1C2DF5E12B
57	5/19/2018	M5	2190	2400	830	R2R	Mark	R25	3D9.1C2DF7CC85
58	5/19/2018	M5	2000	2270	840		Mark		3D9.1C2DF784DC
59	5/20/2018	M5	2260	2490	840	R2R	Mark		3D9.1C2E0A5179
60	5/20/2018	F3	2550	2840	960	R2R	Recapture	L2, R17	3DD.0077536116
61	5/20/2018	M6	2300	2560	960	R2R	Mark	L2,14-15,17-19,22-26,R21	3D9.1C2E0A5E78
62	5/20/2018	M6	2030	2280	810	Hatchery	Recapture	L2,9, R8,9,10,26,27,28,29,30	3D9.1BF10D308E
63	5/20/2018	M5	2170	2480	810	R2R	Mark		3D9.1C2DF7BE76

No.	Date	Sex	Fork (mm)	Total (mm)	Girth (mm)	Fate	Event Type	Mark @ Cap	PIT Tag
64	5/20/2018	M5	1590	1780	620	R2R	Mark		3D9.1C2DF78FF7
65	5/20/2018	F5	2530	2850	1110	Hatchery	Mark		3D9.1C2DF7904F
66	5/20/2018	UNK	2390				Mark	L2	3D9.1C2E0ABAA1
67	5/20/2018	F5	2150	2450	970	R2R	Mark		3DD.00779064E0
68	5/21/2018	F3	2520	2690	1080	R2R	Mark		3D9.1C2E0A707F
69	5/21/2018	M5	1750	1970	740	R2R	Recapture	L2, R10	3D9.1BF1CA5933
70	5/21/2018	M5	1760	2000	710	R2R	Recapture	L2,L15, R12	3D9.1C2DF7E2BD
71	5/21/2018	JUV	1320	1490	480	R2R	Mark		3D9.1C2E0A7781
72	5/21/2018	UNK				R2R	Recapture		3D9.1C2DECBA0C
73	5/21/2018	M6	2520	2810	1060	R2R	Mark	L2	3D9.1C2DF7A9CC
74	5/21/2018	M5	2320	2590	950	R2R	Mark		3D9.1C2E0AAD9A
75	5/21/2018	M6	2680	3060	1080	R2R	Mark		3D9.1C2DF770E9
76	5/22/2018	M6	2330	2620	930	R2R	Recapture	L2, R11	3D9.1C2DCBD11B
77	5/22/2018	M5	2580	2890	1080	R2R	Mark		3D9.1C2DF7D5AD
78	5/22/2018	M6	2410	2670	920	R2R	Mark		3D9.1C2DF7BF82
79	5/22/2018	M5	2290	2600	950		Mark		3D9.1C2E0A4170
80	5/22/2018	M6	2470	2750	1030	R2R	Mark	R8	3D9.1C2DF796E3
81	5/22/2018	M6	2320	2590	990	R2R	Recapture	L2, R4	3D9.1C2DC9012A
82	5/22/2018	M5	2290	2480	890	R2R	Mark		3D9.1C2E0A442E
83	5/23/2018	JUV	720	840	290	R2R	Mark		3D9.1C2DC916A3
84	5/23/2018	JUV	750	850	280	R2R	Mark		3D9.1C2DC886F0
85	5/23/2018	UNK	1850	2090	720	R2R	Recapture	L2	3DD.0077527D44
86	5/23/2018	JUV	1650	1880	620	R2R	Mark	R9	3D9.1C2DF79DBE
87	5/23/2018	JUV	1840	2120	720	R2R	Recapture	L2,17,18	3DD.007763ACDC
88	5/23/2018	M5	2280	2560	1000	R2R	Mark	R3,5,6,7	3D9.1C2DF7CC7B
89	5/23/2018	JUV	1090	1160	490	R2R	Recapture	L2,10,R3	3D9.1C2D31062A
90	5/23/2018	JUV	990	1080	380	R2R	Mark		3D9.1C2D79733F
91	5/23/2018	JUV	860	1040	390	R2R	Mark		3D9.1C2D675696
92	5/23/2018	M6	2250	2490	900	R2R	Mark		3D9.1C2E0A6366
93	5/23/2018	F5	2210	2480	940		Mark		3D9.1C2E0A2D52
94	5/23/2018	M6	2300	2570	920	R2R	Mark		3D9.1C2DF7F9A0
95	5/24/2018	F5	2370	2610	970	Hatchery	Mark		3D9.1C2E0A5EBF
96	5/24/2018	M6	2070	2340	840	R2R	Recapture	L2,4,9,R2	3D9.1BF10E073C
97	5/24/2018	JUV	1120	1270	460		Recapture	R21,24,25	3DD.0077601F3E
98	5/24/2018	M6	2140	2430	810	R2R	Mark		3D9.1C2E0ABE9E
99	5/24/2018	F5	2550	2860	1230	Hatchery	Mark		3D9.1C2DF790A8
100	5/24/2018	JUV	1570	1760	650	R2R	Mark		3D9.1C2DC98B65
101	5/24/2018	M6	2130	2400	900	R2R	Mark	L1,2	3D9.1C2DF790C4
102	5/24/2018	M6	2430	2680	950	R2R	Mark		3D9.1C2DF782BA
103	5/24/2018	M5	2410	2710	940	R2R	Mark		3D9.1C2DC8A303
104	5/24/2018	M6	2300	2470	950	R2R	Recapture	L2,9	3D9.1BF10E33C1
105	5/24/2018	M5	2140	2450	840	R2R	Mark		3D9.1C2DF7F5D0
106	5/25/2018	JUV	1990	2230	720	R2R	Recapture	L2,9,R11,15	3D9.1BF1C51CAA
107	5/25/2018	F5	2350	2610	970	R2R	Mark		3D9.1C2E0A45E2
108	5/25/2018	M5	2050	2290	780	R2R	Recapture	L2,9	3D9.1BF10E1DB8
109	5/25/2018	JUV	1400	1580	545	R2R	Recapture		3D9.1BF10E13FB
110	5/25/2018	M6	1940	2200	770	R2R	Mark	L2, R2,8	3D9.1C2DF7B7DD
111	5/25/2018	F5	2600	2890	1110	Hatchery	Mark	R15,16,17	3D9.1C2DF795E7
112	5/25/2018	F5	2750	3100	1140	R2R	Mark		3D9.1C2DC90D83
113	5/26/2018	JUV	810	920		R2R	Mark		3D9.1C2DC9645F
114	5/26/2018	JUV	1590			R2R	Mark		3D9.1C2DC94FD8
115	5/26/2018	F5	2660	2910	1060	R2R	Mark		3D9.1C2DF7BBEC
116	5/26/2018	F5	2610	2910	1000	R2R	Mark		3D9.1C2DC69D6F
117	5/26/2018	M6	2330	2580	840	R2R	Recapture		3D9.1C2DEC8B54
118	5/26/2018	M6	1980	2230	830	R2R	Mark	L2,7	3D9.1C2DC95023
119	5/26/2018	M6	2420	2740	1010	R2R	Recapture	L2,R2	3D9.1C2DB99A6A
120	5/26/2018	F5	2270	2520	1030	R2R	Recapture	L2, R9	3D9.1BF1C51CB5
121	5/26/2018	M6	2280	2540	890	R2R	Mark	L2,6	3D9.1C2DC8A44E
122	5/27/2018	M6	2110	2380	920	R2R	Recapture	L2	3D9.1C2DF1B651
123	5/27/2018	F5	2210	2470	1010	R2R	Recapture	L2,9	3D9.1BF10E3279
124	5/27/2018	M6	2160	2470	840	R2R	Recapture	L2,7, R2,7,8	3D9.1C2DF1B788
125	5/27/2018	M6	2600	2870	1000	R2R	Mark		3DD.0077904E60

Appendix B
Washington Department of Ecology March 7, 2019 Approval Letter

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
1250 W Alder St • Union Gap, WA 98903-0009 • (509) 575-2490

March 7, 2019

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

RE: Request for Ecology Review and Comments – *2018 White Sturgeon Management Plan Annual Report.*
Priest Rapids Hydroelectric Project No. 2114

Dear Tom Dresser:

The Department of Ecology (Ecology) has reviewed the *2018 White Sturgeon Management Plan Annual Report* sent via email to Ecology on February 4, 2019.

Ecology has no comments for the *2018 White Sturgeon Management Plan Annual Report* as submitted. 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

cc: Chris Mott, Grant County PUD