Evaluations of White Sturgeon Supplementation and Management in the Wells Reservoir, 2015

David Robichaud¹ and Andrew Gingerich²

¹ LGL Limited, Sidney, BC, Canada
² Public Utility District No. 1 of Douglas County, East Wenatchee, WA, USA

Prepared for:

Public Utility District No. 1 of Douglas County,
East Wenatchee, WA

August 10th, 2016
EXECUTIVE SUMMARY

In 2015, Public Utility District No. 1 of Douglas County (Douglas PUD) began implementing the White Sturgeon Management Plan (WSMP). Phase I components of the WSMP include supplementation releases, an Index Monitoring Program, an Acoustic-Tracking Program, and research towards Determining Natural Reproduction Potential.

To date, supplementation has comprised a total of 10,053 hatchery-produced PIT-tagged juvenile sturgeon that were released into the Wells Reservoir. These included 5,044 ‘brood year 2013’ fish (BY2013), released in 2014; and 5,009 ‘brood year 2014’ fish (BY2014), released in 2015. Forty-nine (1%) of the BY2014 fish also bore an acoustic tag when released.

For Index Monitoring, strictly-implemented stratified-random setline sampling was conducted in the summer (July/August) and fall (September/October) of 2015. For each set, the total number of sturgeon (by brood-year-class) was recorded. All captured sturgeon were scanned for PIT tags, measured (fork length, weight), and any fish without a PIT tag or scute mark had one applied. Collectively, there were 441 capture events (acoustic tags were applied to fifty BY2013 fish when they were recaptured).

Apparent survival rates were estimated for BY2013 fish using the PIT-tag mark and recapture data. Survival from release (January to June 2014) to recapture (July to August 2015) was estimated at 17.3% (SE = 2.4%), and was probably biased low. Survival of wild-origin fish (those raised from wild-caught larvae) was 2% higher than that for those raised from broodstock eggs (direct gametes), but the difference was not statistically significant. The apparent survival rates did not account for tag loss or emigration. Modelling a 2% emigration rate and 5% tag-loss rate resulted in ~1.2% increase in survival. Growth rates appeared to be higher than those observed in other similar studies.

Acoustic-tracking was done using an array of 23 receivers deployed throughout the study area from the Chief Joseph Dam tailrace to the Wells Dam tailrace. PIT-tag detection arrays were deployed in the Methow and Okanogan rivers, and at Wells Dam fish ladders. All telemetry data were processed using LGL’s custom software, Telemetry Manager. The acoustic-tagged fish appeared to have initially spread out from the release site. Following initial movements, subsequent movements of sturgeon was not marked. Sturgeon were detected in all of the reservoir sampling zones, although some areas had significantly more sturgeon than others. The distribution of sturgeon did not vary markedly between the summer and fall sampling sessions.

In 2015, no work was done towards the goal of determining natural reproduction potential, but will be examined in subsequent monitoring years during Phase I of the WSMP.
On the cover:
An 11-month old (BY 2013) white sturgeon is released into the Wells Project in spring 2014.

Suggested Reference:
# TABLE OF CONTENTS

EXECUTIVE SUMMARY ............................................................................................................................................. 1
LIST OF TABLES ......................................................................................................................................................... IV
LIST OF FIGURES ....................................................................................................................................................... IV
1 INTRODUCTION .......................................................................................................................................................... 1
    1.1 White Sturgeon Management Plan .................................................................................................................. 1
    1.2 Previous Research ............................................................................................................................................... 2
    1.3 Broodstock and Breeding Plan .......................................................................................................................... 3
    1.4 Monitoring and Evaluation ............................................................................................................................... 3
2 METHODS ................................................................................................................................................................... 4
    2.1 Study Site ............................................................................................................................................................ 3
    2.2 PIT-tag Releases .................................................................................................................................................. 4
    2.3 Acoustic Tracking ............................................................................................................................................... 6
        2.3.1 Acoustic-tag Applications .......................................................................................................................... 6
        2.3.2 Acoustic Tracking Infrastructure ............................................................................................................. 8
        2.3.3 Telemetry Data Processing ...................................................................................................................... 8
    2.4 Emigration Rate .................................................................................................................................................. 10
    2.5 Gross-Level Habitat Use .................................................................................................................................. 10
    2.6 Index Monitoring .............................................................................................................................................. 10
        2.6.1 Standardized Fishing Effort ...................................................................................................................... 10
        2.6.2 Survival and Abundance Estimation ........................................................................................................ 11
        2.6.3 Seasonal Distribution ............................................................................................................................... 12
        2.6.4 Condition, Size and Growth .................................................................................................................... 12
        2.6.5 Sex and Maturity ....................................................................................................................................... 12
    2.7 Determining Natural Reproduction Potential ................................................................................................ 12
3 RESULTS ................................................................................................................................................................. 13
    3.1 Acoustic-Tracking Results .................................................................................................................................. 13
        3.1.1 Emigration .................................................................................................................................................. 13
        3.1.2 Movements and Habitat Use .................................................................................................................... 13
    PIT-tag Tracking Results ........................................................................................................................................ 15
    3.2 Index Monitoring Results .................................................................................................................................. 15
        3.2.1 Captures .................................................................................................................................................... 15
        3.2.2 Survival Estimation .................................................................................................................................. 15
        3.2.3 Distribution ................................................................................................................................................ 16
        3.2.4 Condition, Size and Growth .................................................................................................................... 18
4 DISCUSSION ............................................................................................................................................................ 25
    4.1 Acoustic-tracking ................................................................................................................................................ 25
        4.1.1 Sturgeon Movements .................................................................................................................................. 25
        4.1.2 Emigration .................................................................................................................................................. 25
    4.2 Index Monitoring ................................................................................................................................................ 26
        4.2.1 Capture Success .......................................................................................................................................... 26
        4.2.2 Survival Estimation .................................................................................................................................. 27
        4.2.3 Growth ....................................................................................................................................................... 28
    4.3 Determine Best Stocking Approaches ............................................................................................................... 29
5 ACKNOWLEDGEMENTS .......................................................................................................................................... 29
6 REFERENCES ............................................................................................................................................................. 29
LIST OF TABLES

Table 1. Douglas PUD’s releases of PIT-tagged sturgeon in 2015, by date, location (Washburn Island vs. Bridgeport), and rearing type (wild-caught larval fish vs. standard hatchery crosses) in 2014 and 2015.................................................................................................................. 6

Table 2. Douglas PUD’s releases of acoustic-tagged sturgeon in 2015, by tag type. Tags with longer battery life are larger, and more powerful. ................................................................................... 7

Table 3. Douglas PUD’s spring releases of PIT-tagged juvenile sturgeon by year, semiannual recapture events (indexing), and the specific survival estimates that can be generated. Note that two surveys are required to estimate any single survival value. ....................... 12

Table 4. Estimates of apparent (Φ) or true (S) survival, and detection probability (p) derived from CJS models, by release cohort, and parental origin. Apparent survival was estimated when no emigration data were considered. When a 2% emigration rate was applied, estimates of True Survival were generated. .................................................... 16

LIST OF FIGURES

Figure 1. Location map of the Well Project................................................................. 4

Figure 2. Locations and boundaries of the Sampling Zones, into which the Wells Reservoir study area was partitioned................................................................. 5

Figure 3. Biologists prepare to close incision after inserting a V13 acoustic tag into a BY 2013 white sturgeon......................................................... 7

Figure 4. Locations of receivers in Wells study area, 2015........................................ 9

Figure 5. Second left lateral scute is removed from a wild origin fish captured in 2015. The fish was given a V16 acoustic tag, and was PIT-tagged and scute marked before being released at the point of capture. ....................................................... 11

Figure 6. Proportions of the 2014 brood year acoustic-tagged White Sturgeon that were in each of the Sampling Zones, by date in 2015. Proportions calculated when n ≥ 5. Black line (plotted on right axis) shows the total number of tagged 2014 brood year fish........ 14

Figure 7. Proportions of the 2013 brood year acoustic-tagged White Sturgeon that were in each of the Sampling Zones, by date in 2015. Proportions calculated when n ≥ 10. Black line (plotted on right axis) shows the total number of tagged 2013 brood year fish........ 14

Figure 8. Catch of White Sturgeon in setlines deployed in six Sampling Zones during two seasons in 2015. Black dots show the observed catch (sturgeon per setline), jittered along the horizontal dimension (and very slightly in the vertical) to minimize the hiding of points underneath others. Red letters indicate the statistical differences among Sampling Zones (zones that share a letter are not significantly different from each other). Box plots extend from the 25th to 75th percentiles, and include a horizontal line at the median, and whiskers extend to 1.5 times the interquartile
range. Mean values are indicated by blue diamonds. * two large catches are left off the upper (Summer 2015) plot: in the Upper Reservoir, abnormally successful sets on July 29th and August 4th caught 28 and 22 fish, respectively. ............................................... 17

Figure 9. Fork length frequency distributions for fish released in 2014 (Brood Year 2013, left panels) and 2015 (Brood Year 2014, right panels). Top row: fork lengths at release (orange: fish that were recaptured in 2015; blue: all others). Orange bars are small and hard to see in the top right panel, values ranged 212-312. Bottom row: fork lengths upon recapture in 2015. ........................................................................................ 19

Figure 10. Growth (change in fork length) for fish released in 2014 (Brood Year 2013, upper panels) and 2015 (Brood Year 2014, lower panels). Left column: change in length between release and recapture. Right column: change in length, shown as a ‘per year’ rate. .......................................................................................................................... 20

Figure 11. Frequency distributions of weights of fish released in 2014 (Brood Year 2013, right panels) and 2015 (Brood Year 2014, left panels). Top row: weights at release (orange: fish that were recaptured in 2015; blue: all others). The orange bars are small and hard to see in the top right panel, values ranged from 71-210. Bottom row: weights upon recapture in 2015. ....................................................................................... 21

Figure 12. Growth (change in weight) for fish released in 2014 (Brood Year 2013, upper panels) and 2015 (Brood Year 2014, lower panels). Left column: change in weight between release and recapture. Right column: change in weight, shown as a ‘per year’ rate. 22

Figure 13. Relative weight at release (first row) and at recapture (second row) for fish released in 2014 (left column) and 2015 (right column). Also, change in relative weight (RW) is shown ‘as measured’ (third row), and scaled to show the rate of change per year (bottom row). .................................................................................................................... 23

Figure 14. Lengths and weights of seven wild-caught sturgeon, captured in the Wells Reservoir in 2015. The length-weight relationship (red line) is based on data from six fish (blue dots) that were both measured and weighed. One of the seven fish was not weighed (black triangle), hence its Y position has been plotted along the trend line. ..................... 24
1 INTRODUCTION

1.1 White Sturgeon Management Plan

The goal of the White Sturgeon Management Plan (WSMP) is to increase the White Sturgeon (*Acipenser transmontanus*) population in the Wells Reservoir to a level that can be supported by the available habitat and characterized by a diverse age structure consisting of multiple cohorts (juvenile and adult). In addition, the WSMP is intended to support spawning, rearing and migration as identified by the aquatic life designated use under WAC 173-201A in the Washington state water quality standards.

The WSMP is one of six Aquatic Resource Management Plans contained within the Aquatic Settlement Agreement (Agreement). Collectively, these six Aquatic Resource Management Plans are critical to direct implementation of Protection, Mitigation, and Enhancement measures (PMEs) during the term of the Wells Project license and, together with the Wells Anadromous Fish Agreement and Habitat Conservation Plan (HCP), will function as the Water Quality Attainment Plan (WQAP) in support of the Clean Water Act Section 401 Water Quality Certification for the Wells Hydroelectric Project (Project).

To ensure active stakeholder participation and support, the Public Utility District No. 1 of Douglas County (Douglas PUD) developed all of the resource management plans in close coordination with agency and tribal natural resource managers (i.e., the Aquatic SWG). Members of the Aquatic SWG include the U.S. Fish and Wildlife Service (USFWS), Washington Department of Ecology (Ecology), Washington State Department of Fish and Wildlife (WDFW), the Confederated Tribes of the Colville Reservation (Colville), the Confederated Tribes and Bands of the Yakama Nation (Yakama), and Douglas PUD. During the development of this plan, the Aquatic SWG focused on developing management priorities for resources potentially impacted by Project operations.

Based upon the information available as of December 2006, the Aquatic SWG determined that an assessment of Project effects on White Sturgeon was not practical given sturgeon life history characteristics and the limited number of fish estimated to exist in the Project. Therefore, the Aquatic SWG concluded that resource measures related to White Sturgeon should focus on population protection and enhancement by means of supplementation as an initial step in order to increase the number of fish within the Wells Reservoir. In addition to the initial supplementation activities, implementation of a monitoring and evaluation program was prescribed to accurately assess natural recruitment, juvenile habitat use, emigration rates, carrying capacity, and the potential for natural reproduction, so as to inform the scope of a future, longer-term supplementation strategy. All objectives were developed in order to meet the WSMP goal. The PMEs presented within the WSMP are designed to meet the following objectives:

- **Objective 1**: Supplement the White Sturgeon population in order to address Project effects, including impediments to migration and associated bottlenecks in spawning and recruitment;
- **Objective 2**: Determine the effectiveness of the supplementation activities through a monitoring and evaluation program;
- **Objective 3**: Determine the potential for natural reproduction in the Wells Reservoir in order to appropriately inform the scope of future supplementation activities;
• **Objective 4**: Adaptively manage the supplementation program as warranted by the monitoring results;
• **Objective 5**: Evaluate whether there is biological merit to providing safe and efficient adult upstream passage; and
• **Objective 6**: Identify White Sturgeon educational opportunities that coincide with WSMP activities.

1.2 Previous Research
From 2001-2003, Douglas implemented a study to examine the White Sturgeon population within the Project. Prior to the implementation of this study, little information on White Sturgeon was available for the Wells Reservoir. The primary objectives of the study were to provide basic information on the population abundance, age structure, size, and growth of Project White Sturgeon; analyze movements of White Sturgeon within the Reservoir; and compare the data collected during this study with data collected during assessments at other projects (Jerald 2007). During the summers of 2001 and 2002, setlines were deployed in the Wells Reservoir. Sturgeon captured on setlines were measured, marked with passive integrated transponder (PIT) tags and with scute markings. Additionally, a select number of captured fish were fitted with radio-transmitters to track movements, and had pectoral fin rays removed for age analysis using standard methodologies (Rien and Beamesderfer 1994). Setline sampling took place over a two-year timeframe with a total of 129 setlines deployed and retrieved from throughout the Reservoir. In total, 13 White Sturgeon were captured during the 2-year study with the majority of the fish being captured in the Columbia River within five miles of the mouth of the Okanogan River. Twelve of the captured fish were PIT tagged. Subsequently, five recapture events were recorded for a total of 18 capture events during the mark-recapture period (one fish was recaptured twice). Population abundance was estimated to be 31.35±17.51. The 95% confidence interval for sturgeon abundance was calculated to be CI (13<N<218). The results of the mark-recapture portion of the study indicated that the sturgeon population in the Wells Reservoir is small with a point estimate of 31 fish over 50 cm in length (Skalski and Townsend 2005).

The length of the 13 fish captured during the study ranged from 60-202 cm. Two of the fish were classified as juveniles (<90 cm fork length) while 11 were classified as sub-adults or adults. It is important to note that the capture methodology was not designed to provide accurate sampling of fish under 50 cm. Captured sturgeon ranged in age from 6 to 30 years old (based on 11 fish), demonstrating that all of these fish recruited to the Wells Reservoir after Wells Dam was completed in 1967, with strong year class recruitment between the years 1972 and 1978, and again between 1988 and 1996. The presence of fish within these age classes suggests that successful recruitment within or to the Wells Reservoir is occurring either through (1) spawning within the Wells Reservoir, and/or (2) immigration into the Wells Reservoir from populations upstream.

---

1 WDFW catch record card returns for 1993 and 1994 indicated that legal size White Sturgeon were present in the Wells Reservoir (Brad James, WDFW, pers. comm.). Additionally, information from previous studies in upstream and downstream reservoirs supported the existence of a population.
1.3 Broodstock and Breeding Plan
Following the November 2012 FERC license issuance, and consistent with requirements found in Section 4.1.1 of the WSMP, Douglas PUD and Aquatic SWG partners developed a Broodstock and Breeding Plan (BSBP) for the purposes of determining how Douglas PUD will meet stocking goals for White Sturgeon. Once approved by the Aquatic SWG, Douglas PUD filed the BSBP and the associated consultation record with the Federal Energy Regulatory Commission (FERC) on February 13th, 2013. The FERC subsequently approved the BSBP on May 28th, 2013. The BSBP has been used since 2013 to meet supplementation goals outlined in section 4.1.2 of the WSMP.

As identified in the WSMP, stocking targets are outlined as follows: within two years following issuance of the new license, Douglas PUD was required to release up to 5,000 yearling White Sturgeon into the Wells Reservoir annually for four consecutive years (20,000 fish total; years 2014-2017). Additional years and numbers of juvenile sturgeon to be stocked during Phase I (years 2018-2023) will be determined by the Aquatic SWG and will not exceed 15,000 juvenile sturgeon (total of 35,000 juvenile sturgeon during Phase I).

Beginning in June of 2013, broodstock (direct gamete) and larvae (wild caught larvae) sturgeon were captured to meet stocking targets designed for the first release in 2014. Under these actions, juvenile sturgeon obtained by implementing the BSBP were reared at the Wells Fish Hatchery for approximately 11 months prior to release into the Wells Reservoir. In both 2014 and in 2015 stocking targets were met.

1.4 Monitoring and Evaluation
As part of Douglas PUD’s implementation of the WSMP contained within the Agreement, Douglas PUD began implementing White Sturgeon monitoring in 2015. The ‘Phase I: White Sturgeon Management Plan Monitoring and Evaluation Study’ Plan was approved by the Aquatic SWG in December 2013 and January 2014.

Components of White Sturgeon monitoring and evaluation include:
- an Index Monitoring Program (section 4.2.1 of the WSMP),
- an Acoustic-Tracking Program (section 4.2.2 of the WSMP), and
- research towards Determining Natural Reproduction Potential (section 4.2.3 of the WSMP).

A study plan (Douglas PUD 2014), developed to meet the above areas of monitoring and evaluation, was approved by the Aquatic SWG, and field work began in the spring of 2015. This report details the progress made and results generated up to December, 2015 (i.e., Year One of a three-year M&E task).

2 METHODS

2.1 Study Site
The core study area extends from the tailrace of Chief Joseph Dam to the tailrace of Wells Dam. Wells Dam is located at river mile (RM) 515.6 on the Columbia River in the State of Washington (Figure 1). Wells Dam is located approximately 30 river miles downstream from the Chief Joseph Hydroelectric Project, owned and operated by the United States Army Corps of Engineers; and 42 miles upstream from the Rocky Reach Hydroelectric Project owned and operated by Public Utility District No. 1 of Chelan
Figure 1. Location map of the Well Project.

County (Chelan PUD). The nearest town is Pateros, Washington, which is located approximately 8 miles upstream from the Wells Dam.

The Wells Reservoir is approximately 30 miles long. The Methow and Okanogan rivers are tributaries of the Columbia River within the Wells Reservoir. The Wells Project boundary extends approximately 1.5 miles up the Methow River and approximately 15.5 miles up the Okanogan River. The surface area of the reservoir is 9,740 acres with a gross storage capacity of 331,200 acre-feet and usable storage of 97,985 acre feet at the normal maximum water surface elevation of 781 feet (Figure 1). The reservoir was divided into six Sampling Zones (Figure 2).

2.2 PIT-tag Releases

The WSMP calls for ~5000 PIT-tagged hatchery-reared juvenile sturgeon to be released into the Wells Reservoir annually from 2014-2017. In 2014, a total of 5,044 juvenile sturgeon were released (17 fish
were released on January 15th; 2,911 on April 10th; and 2,116 on June 12th). Of these, there were 2,132 sturgeon that were raised from wild-caught larval fish; and 2,912 that were raised using standard hatchery crosses (eggs and milt stripped from adult broodstock, using a variety of family crosses). In 2015, all 5,009 of the juvenile sturgeon were released between June 1st-2nd, and all were raised from wild-caught larval fish (Table 1).

In both years, >99% of the fish were released at Washburn Island (48° 5' 17.76" N, 119° 40' 34.51" W). However, a small number of fish were released in 2014 and 2015 near the town of Bridgeport, WA (48° 0' 53.21" N, 119° 40' 40.66" W) as a community outreach event where local high school and grade school students participated (Table 1). In 2015, 1% of the hatchery sturgeon were acoustic-tagged prior to release (see Section 2.3.1).

Figure 2. Locations and boundaries of the Sampling Zones, into which the Wells Reservoir study area was partitioned.
### Table 1. Douglas PUD’s releases of PIT-tagged sturgeon in 2015, by date, location (Washburn Island vs. Bridgeport), and rearing type (wild-caught larval fish vs. standard hatchery crosses) in 2014 and 2015.

<table>
<thead>
<tr>
<th>Date</th>
<th>Washburn Island</th>
<th>Near Bridgeport, WA</th>
<th>TOTAL</th>
<th>GRAND TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wild-caught</td>
<td>Broodstock crosses</td>
<td>Wild-caught</td>
<td>Broodstock crosses</td>
</tr>
<tr>
<td></td>
<td>Larvae</td>
<td></td>
<td>Larvae</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>15 Jan</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10 Apr</td>
<td>0</td>
<td>2,881</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>12 Jun</td>
<td>2,116</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2014 TOTAL</td>
<td>2,132</td>
<td>2,882</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>2015</td>
<td>1-2 Jun</td>
<td>4,985</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>2015 TOTAL</td>
<td>4,985</td>
<td>0</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>7,117</td>
<td>2,882</td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>

### 2.3 Acoustic Tracking

#### 2.3.1 Acoustic-tag Applications

In 2015, 49 (1%) of the hatchery-produced juvenile sturgeon were acoustic-tagged (in addition to being PIT-tagged) prior to their release. Active tags were also implanted into 50 Brood Year 2013 fish (fish released in 2014) that were recaptured during the *Indexing Monitoring Program*. Of these 50 Brood Year 2013 fish, 30 were originally produced at Marion Drain Hatchery (produced directly from broodstock or direct gametes), and 20 were ‘wild-caught’ during their larval phase from the Lake Roosevelt section of the Columbia River. Additionally, one Brood Year 2012 fish (a Chelan PUD Chelan Falls Release), and 7 wild-origin fish were recaptured and acoustic-tagged in 2015. These latter, larger fish are able to carry larger, more powerful tags with longer battery life (Table 2), as compared to the fish that are tagged in the hatchery prior to release. All tags were uniquely coded transmitters, manufactured by Vemco (models V9, V13 and V16 tags; Table 2), and programmed to ping once every 210-300 s (see model-specific ping rates in Table 2).

For the hatchery-produced fish released in 2015, surgical implantation of acoustic transmitters took place on May 29th, 2015 at the Wells Fish Hatchery (Azwell, WA). The fish were allowed to recover for 33 days and were released on 1 June at Washburn Island. Surgeries on all other acoustic-tagged fish took place *in situ*: upon capture in set line gear, fish designated for acoustic tagging were held in coolers on the boat until a full setline was pulled, then transported to a Douglas PUD tagging boat. On the tagging boat, fish were held (prior to and following tagging) in a 100 L livewell that constantly provided fresh river water via electric pump (temperature and DO was continually monitored using a YSI temp/DO meter). After being tagged, the fish were held for at least 10 minutes to ensure adequate post-surgery recovery, and were released from the livewell at the original capture location.

In general, the surgical process followed the most up-to-date basin-wide standards (described by Liedtke et al. 2012). Sturgeon were placed in an anesthetic bath (MS-222; 60-80 mg/L) until a loss of equilibrium was attained, at which time they were examined for markings/abnormalities and had biometrics (length, weight, scute-mark pattern) recorded. The fish were then transferred to a surgical table and administered a
maintenance dose of anesthesia (MS-222; 19 mg/L). For fish tagged in the hatchery, acoustic transmitters were implanted through an incision centered approximately between both the pectoral and pelvic fins and the lateral and ventral scute lines. Fish tagged in the field (Figure 3) were larger and therefore the incision was made ventrally between the *linea alba* and the left ventral scutes, and approximately four scutes anterior of the pelvic fin (McLellan Jason, Colville Confederated Tribes, pers. comm.). The incision was then closed with two to three sutures and the fish was transferred to a recovery bucket/livewell with fresh water and aeration and monitored until equilibrium was recovered. For in-field surgeries, wetted shop towels were placed over fish, except in the area where the tag was implanted. The towels kept the fish moist and shielded them from sun exposure. In addition, the wetted towels aided in holding the tube that delivered the maintenance dose of anesthetic in the fish’s mouth (Figure 3).

**Table 2.** Douglas PUD’s releases of acoustic-tagged sturgeon in 2015, by tag type. Tags with longer battery life are larger, and more powerful.

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Year of Hatchery Release</th>
<th>Number Tagged in 2015</th>
<th>Tag’s Estimated Battery Life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild Origin</td>
<td>na</td>
<td>7</td>
<td>487&lt;sup&gt;a&lt;/sup&gt; 904&lt;sup&gt;b&lt;/sup&gt; 1070&lt;sup&gt;c&lt;/sup&gt; 3650&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>1</td>
<td>&lt;sup&gt;1&lt;/sup&gt;†</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>50</td>
<td>25&lt;sup&gt;†&lt;/sup&gt; 24&lt;sup&gt;†&lt;/sup&gt; 1&lt;sup&gt;†&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>49</td>
<td>49 *</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>107</td>
<td>49 25 25 8</td>
</tr>
</tbody>
</table>

<sup>*</sup> tagged at the hatchery prior to release  
<sup>†</sup> tagged in situ upon recapture during indexing settling efforts  
<sup>a</sup> Vemco Model V9-2H-069k-1 (length 29 mm, diameter 9 mm, weight in air 4.7 g); pings every 150-210 s.  
<sup>b</sup> Vemco Model V13-1H-069k-1 (length 36 mm, diameter 13 mm, weight in air 11 g); pings every 150-210 s.  
<sup>c</sup> Vemco Model V13-1H-069k-1 (length 36 mm, diameter 13 mm, weight in air 11 g); pings every 150-300 s.  
<sup>d</sup> Vemco Model V16-4L-069k-1 (length 36 mm, diameter 16 mm, weight in air 25 g); pings every 150-210 s.

**Figure 3.** Biologists prepare to close incision after inserting a V13 acoustic tag into a BY 2013 white sturgeon.
2.3.2 Acoustic Tracking Infrastructure
An array of 23 acoustic receivers (Vemco Model VR2W) was deployed to monitor White Sturgeon movement in and around the Wells Project (Figure 4). Specifically, receivers were positioned in order to assess emigration of released juvenile sturgeon, assess tributary use, and to focus on areas where sturgeon were thought to concentrate in the Wells Reservoir given previous research. Receivers were fixed to docks, piers, or deployed in recoverable bottom frames. Detection ranges were tested for each receiver in April 2015, and most were found to detect fish clear across the channel, with dead zones in the areas immediately adjacent to the receivers themselves. As a result, most deployments involved a pair of receivers, one located on each river bank. In addition to the receivers owned and operated by Chelan PUD, three additional receivers were deployed downstream of Wells Dam, to maximize the probability of tag detection in the noisy environment. On July 23rd, 2015, one receiver was removed from the Wells tailrace and redeployed (on October 15th) in the Foster Creek Delta near the Chief Joseph tailrace.

All receivers were pulled to the surface, inspected, and downloaded regularly during the study period. The most recent data included in this report was downloaded on December 4th. See Appendix A for details of the data that were included in this report.

2.3.3 Telemetry Data Processing
All receiver data were downloaded to a field laptop running Vemco VUE software and then subsequently transferred to LGL’s custom processing software, Telemetry Manager. Telemetry Manager facilitates data organization, record validation and analysis through the systematic application of user-defined criteria. Temporal or spatial resolution and noise filtering criteria can be changed by the user at any time without altering the raw data (English et al. 2012). False records (e.g., non-study tags; detections before release; detections that resulted from electronic noise; single hits; and those that occurred in a sequence which was not possible) were flagged for exclusion, and the remaining records were compressed into a manageable database of sequential detections for each fish. Each record included the tag number, detection location, and the first and last date and time of any sequential detections in that location. The compressed database was used for all subsequent analyses.

For this report, acoustic telemetry detections were binned into the Sampling Zones (Figure 2) in order to simplify the picture of sturgeon distributions and movements in the Reservoir. On every date during the study period, we determined the number of sturgeon in each of the Sampling Zones, and plotted the proportions over time. During periods when fish were not detected, they were presumed to be in the vicinity of their most recent detection, and to be residing there until they were detected at another receiver.
Figure 4. Locations of receivers in Wells study area, 2015.
2.4 Emigration Rate

Emigration was defined as movement out of the Reservoir, including downstream movements through Wells Dam, and unidirectional movements into tributary areas. Two tag types provide insight into emigration rates. First, information on the emigration of acoustic tagged fish was derived from the VR2W acoustic-receiver array. Second, information on the emigration of PIT-tagged fish could be derived from fixed PIT-receiver antennas and from setline recapture events in Rocky Reach Reservoir. Acoustic-tagged fish had much higher detection probability, but there were fewer tagged fish. Conversely, nearly all fish in the Reservoir were expected to bear PIT tags, but detection probability was markedly lower. Emigration rates were estimated as a proportion of total abundance.

2.5 Gross-Level Habitat Use

Telemetry detections and physical recaptures were used to describe seasonal and overall patterns of distribution, and to describe gross-scale habitat use (i.e., the relative use of each of the Sampling Zones). Generalized Linear Models (GLM) were used to test for CPUE (Catch per unit effort) differences among Sampling Zones. Models were initially run with a Poisson-distributed error structure, but if residual deviances were large relative to the degrees of freedom (suggesting over dispersion), then alternative (quasipoisson) models were used. Catch rates were plotted (along with a boxplot showing the first and third quartiles, and with vertical bars extending to the highest value that was within 1.5 times the distance between the first and third quartiles) to reveal patterns.

In addition, tributary-use was documented by querying the acoustic tracking data and the within-tributary fixed PIT arrays.

2.6 Index Monitoring

Index monitoring was designed to determine size structure, survival rates, abundance, density, condition factor, growth rates, and to identify distribution and habitat selection of juvenile sturgeon.

2.6.1 Standardized Fishing Effort

In the summer (July/August) and again in autumn (September/October) of 2015, strictly-implemented stratified-random setline sampling was conducted. The reservoir was divided into six Sampling Zones (Figure 2), and random fishing locations were generated within each zone, with elevated effort allocated to zones in which sturgeon catches were expected to be more productive (34% of sets were in Erlandsen; 20% in the Lower Reservoir; ~15% in each of Bathtub, Upper Reservoir and Chief Joseph Tailrace; and 1% in Okanogan). The length of the lines (91.4 m, or 300 ft), the number (80) and size (VMC 2/0 & 4/0 sure set circle) of hooks per line, and the bait (mix of worms, crickets and squid in the summer; squid only in the fall) were constant across all sets. In the summer session, 207 setlines were deployed over 26 days between July 6th and August 4th. In the autumn session, 212 setlines were deployed over 27 days between September 8th and October 8th.

For each set, the location, depth, temperature and soak time were recorded, along with the total number of sturgeon (by size-class) caught. All captured sturgeon were scanned for PIT tags, measured (fork length, weight), and checked for scute marks; and any fish without a PIT tag or scute mark had one applied. The scute marks applied in situ were different (‘second left’ for wild origin fish; Figure 5) from those used for the hatchery-produced fish (‘first three scutes anterior to dorsal on right’ for fish raised from wild-caught

---

2 Bait was changed to only use squid on advice from the Aquatic SWG in August 2015.
larvae; and ‘first three scutes anterior to dorsal on left side’ for fish of direct gamete origin). During these setline sessions, some of the captured large-size sturgeon (either of wild origin, or from release years prior to 2015) were acoustic-tagged prior to release (see the ‘Acoustic-tag Applications’ section, above).

Figure 5. Second left lateral scute is removed from a wild origin fish captured in 2015. The fish was given a V16 acoustic tag, and was PIT-tagged and scute marked before being released at the point of capture.

2.6.2 Survival and Abundance Estimation
PIT-tag mark and recapture data were used to estimate survival rates of each of the hatchery-reared juvenile sturgeon cohorts. Survival was assessed using a Cormack-Jolly-Seber (CJS) model (Lebreton et al. 1992). The CJS method allows the simultaneous estimation of the probability of detection during survey events (p) and the apparent survival between events (Φ), but requires at least one additional sampling event to occur after the period of interest, and requires that some individual fish be captured in more than one sampling session. Based on the schedule of annual releases and twice-annual surveys (Table 3), it will be possible to get several independent estimates survival over the three year study. Currently, two survival estimates are possible at this stage:

- survival (Φrls - 1¼y) of the 2014 release group from release in spring 2014 until the first survey in summer 2015 (1.25 years at large); and
- survival (Φrls - ¼y) of the 2015 release group from release in spring 2015 until the first survey in summer 2015 (0.25 years at large).

Note that the survival models described above do not explicitly allow for emigration or tag loss. Emigration rates were estimated using PIT and acoustic telemetry data (see ‘Emigration Rate’ section, above). PIT tag loss/failure rates were calculated using the proportions of scute-marked fish that were caught without PIT tags. Once tag loss and emigration are accounted for (by ‘reducing’ the total number of fish being modelled), ‘True’ survival rates (S) were calculated using modelling methods described above.
Table 3. Douglas PUD’s spring releases of PIT-tagged juvenile sturgeon by year, semiannual recapture events (indexing), and the specific survival estimates that can be generated. Note that two surveys are required to estimate any single survival value.

<table>
<thead>
<tr>
<th>PIT Tag</th>
<th>Release Year</th>
<th>n</th>
<th>Recapture Survey</th>
<th>Summer 2015</th>
<th>Fall 2015</th>
<th>Spring 2016</th>
<th>Fall 2016</th>
<th>Spring 2017</th>
<th>Fall 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>5,044</td>
<td></td>
<td></td>
<td>∅ rls - 1½ y</td>
<td>∅ 1½ - 1⅔ y</td>
<td>∅ 1½ - 2 y</td>
<td>∅ 2 – 2½ y</td>
<td>∅ 2½ – 3 y</td>
<td>req’d to est. ∅ 2½ – 3 y</td>
</tr>
<tr>
<td>2015</td>
<td>5,009</td>
<td></td>
<td></td>
<td>∅ rls - ¾ y</td>
<td>∅ ¾ - ⅔ y</td>
<td>∅ ⅔ - 1 y</td>
<td>∅ 1 - 1½ y</td>
<td>∅ 1½ - 2 y</td>
<td>req’d to est. ∅ 1½ – 2 y</td>
</tr>
<tr>
<td>2016</td>
<td>~5,000</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2017</td>
<td>~5,000</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

All survival models were fit using the R (R Core Team 2014) package called ‘RMark’ (Laake 2013), which allows models to be constructed and fed to the program ‘MARK’ (White and Burnham 1999) for analysis.

2.6.3 Seasonal Distribution
CPUE was calculated from the randomized indexing sessions for each Sampling Zone, and compared among zones and between seasons using GLMs. A significant interaction term (Zone x Season) would be evidence for a change in distribution between seasons.

In addition, tributary-use was documented by querying the acoustic tracking data and the within-tributary fixed PIT arrays.

2.6.4 Condition, Size and Growth
Condition of the recaptured sturgeon was assessed using the relative weight index (Beamesderfer 1993). Growth rates of recaptured sturgeon were computed in mm/yr and g/yr for each of the hatchery-reared juvenile sturgeon cohorts. The size structures of the recaptured fish were plotted using length frequency distributions.

2.6.5 Sex and Maturity
No fish were sexed in 2015.

2.7 Determining Natural Reproduction Potential
No work was done towards the goal of determining natural reproduction potential in 2015. This work is planned to begin once more of the survival and distribution results have been collected.
3 RESULTS

3.1 Acoustic-Tracking Results

3.1.1 Emigration

To date, we have record of two acoustic-tagged fish that emigrated from the study area. One fish (tag A69-1601-34139), measuring 271 mm (123 g), was part of the 2014 hatchery brood year (it was given an acoustic tag prior to release from the hatchery), and was released on June 1st 2015. After release, it moved downstream as follows: it was detected in the Erlandsen Zone (opposite Pelican Point) from June 17th to July 6th, in the Bathtub (Brewster) on July 6th, and in the Lower Reservoir (on Pateros, Starr and Wells forebay arrays) on July 7th. It was first detected in the Wells Dam tailrace on July 13th, where it has been detected periodically right up until the most recent downloads (December 4th).

The second fish (tag A69-1601-57125) was part of the 2013 hatchery brood year. It was recaptured on September 14th 2015 in the Lower Reservoir, where it was measured (577 mm) and weighed (1.37 kg), given an acoustic tag, and released. It was detected in the Wells Forebay from September 14th to 23rd. After that, it was detected in the Wells Tailrace, past Gallagher Flats, and near Beebe Bridge on September 23rd, and has not been detected since that date (most recent Rocky Reach downloads from areas beyond the Wells tailrace were on November 4th).

From these data, we can make a preliminary estimation that the minimum emigration rate of the 2014 hatchery brood year is 1/49 (2%), and that of the 2013 hatchery brood year is 1/50 (2%).

3.1.2 Movements and Habitat Use

Binning the acoustic telemetry detections into the Sampling Zones allowed a more simplified picture of sturgeon distributions and movements to emerge (Figures 6 to 7).

For the 2014 brood year, 49 tagged fish were released in the Upper Reservoir (i.e., at Washburn Island) on June 1st, 2015. By mid-June, less than half of these fish remained in this Zone (Figure 6). Initial movements (i.e., the first observed movements, made within 1 month of release) were largely (83%) in the upstream direction. Yet by July 1st, approximately one third of the fish were in each of three upper zones (Chief Joseph Tailrace, Upper Reservoir, and Erlandsen), and a few fish had moved into the Bathtub or the Lower Reservoir (Figure 6). In fact, 40% of all observed movements occurred in the first month of tracking. By August 1st, a few fish had repositioned themselves, as 22 fish (45%) were in the Chief Joseph Tailrace, 13 fish (27%) were in the Upper Reservoir, 9 fish (18%) were in Erlandsen, and the remainder were in the Bathtub (n=3, 6%), the Lower Reservoir (n=1, 2%) or in the Wells Tailrace (n=1, 2%). After August, few fish movements were detected, and the distribution pattern (Figure 6) appeared to be stable until the end of the data available for this update report (early December 2015). As of the end of data collection (early December 2015) it appeared that 90% of fish (n=44) were in the three highest zones (Erlandsen or above) and 96% (n=47) were in the four highest zones (Bathtub or above), with only 4% in the Lower Reservoir (n=1) or in the Wells Tailrace (n=1).

The 2013 brood year fish were tagged over the course of the summer (Figure 7) and released at various locations throughout the Reservoir. Initial movements (i.e., the first observed movements, made within 1 month of release) were largely (91%) in the upstream direction. Since tagging was not evenly distributed across zones, interpreting proportion of fish per zone is a little misleading. However, over time, a portion
Figure 6. Proportions of the 2014 brood year acoustic-tagged White Sturgeon that were in each of the Sampling Zones, by date in 2015. Proportions calculated when n ≥ 5. Black line (plotted on right axis) shows the total number of tagged 2014 brood year fish.

Figure 7. Proportions of the 2013 brood year acoustic-tagged White Sturgeon that were in each of the Sampling Zones, by date in 2015. Proportions calculated when n ≥ 10. Black line (plotted on right axis) shows the total number of tagged 2013 brood year fish.
of the fish moved away from the Chief Joseph Tailrace and from Erlandsen, and into the Bathtub and the Lower Reservoir (Figure 7). The number of fish in the Lower Reservoir peaked at the end of September and declined thereafter (one fish passed into the Wells Tailrace in mid-September), generally moving back upstream. The apparent mid-November movement of fish out of Erlandsen (Figure 7) may have been an artifact of download dates (the Erlandsen receiver opposite Pelican Point was downloaded on November 13th, whereas other local receivers were downloaded in early December).

**PIT-tag Tracking Results**

Emigration rates, estimated from PIT tag data were considerably lower than those from acoustic tracking data. Since release, 6 PIT tags from BY2013 (0.1% of the group), and 1 PIT tag from BY2014 (0.02% of the group) have been detected at the PIT detector in the Rocky Reach Bypass Surface Collector. The low emigration rate derived from these results are not surprising, given the suspected difference in detection efficiency between acoustic and PIT tags.

Several of the PIT tagged sturgeon were detected in tributaries. One BY2013 fish was detected in Foster Creek in mid-April 2014, about a week after release. Also, 75 BY2013 fish were detected in the lower Okanogan River: 72 were detected in 2014 (in all months from June to December), 2 fish in 2015 (one in May, and one in October), and one fish was detected in both years (September 2014 and July 2015). Five of the fish that were detected in the Okanogan River in 2014 were caught in mainstem setlines in 2015 (1 in the Bathtub, 3 in Erlandsen, and 1 in the Upper Reservoir), including two that were then acoustic tagged.

Four BY2014 fish were detected on the Lower Okanogan PIT detection array (one each in June, July, September).

### 3.2  Index Monitoring Results

#### 3.2.1  Captures

In 2015, there were 441 White Sturgeon capture events (including some individuals that were caught multiple times) within the Wells Project area. Of these, 242 captures were made during 26 days of sampling in July through August; and 199 captures were made over 27 days of sampling from September through October. These capture events involved 384 unique individuals, including one fish released in 2013 (by Chelan PUD near Beebe Bridge), 317 fish released in 2014, 42 fish released in 2015, and seven fish of wild origin. In addition, 17 fish were of hatchery origin, but their PIT tag was not functional, hence the brood year was unknown. In cases where hatchery reared fish (identified by scute pattern) were observed to not have a functioning PIT tag, one was applied. The new PIT-tag ID codes were recorded and all data and metadata were uploaded to PTAGiS.

#### 3.2.2  Survival Estimation

Of the fish released in 2014, 317 unique individuals were recaptured in 2015. In the Summer Session 195 unique individuals were recaptured, and in the Fall Session 157 unique individuals were recaptured (35 unique individuals were caught in both sessions). Based on these recapture histories, apparent survival from release (January to June 2014) to recapture (July to August 2015) was estimated to be 17.3% (SE = 2.4%; Table 4).
Since many fish of both wild larval origin and direct gamete fish were captured, it was possible to estimate survival specific to origin. For wild larval origin fish released in 2014, 111 unique individuals were recaptured in the Summer Session, and 80 in the Fall Session (22 in both sessions). Based on these recapture histories, apparent survival from release to recapture was estimated to be 18.9% (SE = 3.2%). For direct gamete origin fish released in 2014 (those raised from broodstock eggs), 83 unique individuals were recaptured in the Summer Session, and 77 in the Fall Session (13 in both sessions). Apparent survival from release to recapture was estimated to be 16.9% (SE = 6.9%; Table 4). Although it was possible to estimate survival specific to fish origin, the differences between the wild larval origin and direct gamete origin were not statistically significant.

Table 4. Estimates of apparent (Φ) or true (S) survival, and detection probability (p) derived from CJS models, by release cohort, and parental origin. Apparent survival was estimated when no emigration data were considered. When a 2% emigration rate was applied, estimates of True Survival were generated.

<table>
<thead>
<tr>
<th>Test</th>
<th>Emigration ignored</th>
<th>Emigration 2%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apparent Surv, Φ</td>
<td>True Surv, S</td>
</tr>
<tr>
<td></td>
<td>Estimate SE</td>
<td>Estimate SE</td>
</tr>
<tr>
<td>All 2014</td>
<td>17.3% 2.4%</td>
<td>18.5% 2.6%</td>
</tr>
<tr>
<td>Wild Larvae 2014</td>
<td>18.9% 3.2%</td>
<td>20.2% 3.4%</td>
</tr>
<tr>
<td>Direct Gamete 2014</td>
<td>16.9% 6.9%</td>
<td>18.1% 6.9%</td>
</tr>
<tr>
<td>All 2015</td>
<td>NA NA</td>
<td>NA NA</td>
</tr>
</tbody>
</table>

Of the fish released in 2015, 42 unique individuals were recaptured in 2015. In the Summer Session, 25 unique individuals were recaptured, and in the Fall Session 17 fish were recaptured. None of the fish were caught in both sessions, thus the model could not resolve the difference between detection and survival, and hence no estimates could be generated (Table 4).

The survival models described above do not explicitly allow for emigration or tag loss. Minimum emigration rates were estimated using acoustic telemetry data at 2% (see above). PIT tag loss/failure rates were estimated at 5.0%, since 17 scute-marked fish were caught without PIT tags (of 434 scute-marked fish examined). We accounted for tag loss and emigration by ‘reducing’ the total number of fish being modelled. ‘True’ survival rates (S) were about 1.2 points higher than apparent rates (Table 4).

3.2.3 Distribution

There were clear differences in the catch rates among the Sampling Zones. General linearized models showed that the among-zone differences in CPUE were statistically significant in both Summer (Dev = 230.4; df = 5, F = 11.3, P < 0.0001) and Fall (Dev = 66.9; df = 4, F = 4.7, P = 0.0012). Despite considerable variability within the data, post hoc tests revealed a few statistically significant pairwise differences for Summer 2015: CPUE estimates from Erlandsen and Upper Reservoir were significantly higher than those recorded in the Lower Reservoir (Figure 8).

There was no obvious seasonal effect on sturgeon distribution in 2015 (Figure 8). Using the relative CPUE among Sampling Zones as a measure of distribution, we found that the Sampling Zones followed the identical rank-order in Summer as in Fall. Specifically, CPUE was highest in Erlandsen, Upper...
Figure 8. Catch of White Sturgeon in setlines deployed in six Sampling Zones during two seasons in 2015. Black dots show the observed catch (sturgeon per setline), jittered along the horizontal dimension (and very slightly in the vertical) to minimize the hiding of points underneath others. Red letters indicate the statistical differences among Sampling Zones (zones that share a letter are not significantly different from each other). Box plots extend from the 25th to 75th percentiles, and include a horizontal line at the median, and whiskers extend to 1.5 times the interquartile range. Mean values are indicated by blue diamonds. * two large catches are left off the upper (Summer 2015) plot: in the Upper Reservoir, abnormally successful sets on July 29th and August 4th caught 28 and 22 fish, respectively.
Reservoir was second, Bathtub was third, Lower Reservoir was fourth, and Chief Joseph Tailrace was fifth (very few samples were collected from the Okanogan Zone). Moreover, two-way GLM showed no significant interaction between Sampling Zone and Season, indicating that the among-zone distribution pattern (i.e., the CPUE pattern) did not vary significantly between seasons (Dev = 19.7; df = 4, F = 1.3, P = 0.27).

The acoustic-tracking data confirmed that there was not a large difference in sturgeon distribution between the summer (July/August) and fall (September/October) periods in 2015 (Figures 6 to 7). Finer-scale examinations of the acoustic tracking data suggest that some upstream redistribution may have begun at the end of November (Figure 7). Further collection and processing of the sturgeon telemetry data will reveal if this trend continues into the winter. As data collection continues into 2016, we will get our first insights into springtime movements and continued tracking into 2017 may reveal whether any repeated seasonal behaviors can be detected.

### 3.2.4 Condition, Size and Growth

#### 3.2.4.1 Brood Year 2013

At the time of release in 2014, the BY2013 fish ranged in length from 98 to 413 mm (mean 281.9 mm), with 95% of the lengths falling between 207 and 355 mm (Figure 9). In 2015, 391 to 547 days after release, we recorded 373 recaptures of these fish, of which 370 were measured. Upon recapture in 2015, the BY2013 fish measured between 357 and 739 mm (Figure 9), having grown between 38 and 446 mm (mean = 197.0 mm; 95% of length increases were between 62 and 345 mm; Figure 10), which scaled to 34-314 mm per year (mean = 152.3 mm; 95% of growth rates were between 56 and 253 mm per year; Figure 10).

At the time of release in 2014, the BY2013 fish universally weighed less than 500 g (mean 166.5 g; 95% of the weights falling between 67 and 306 g; Figure 11). After 391 to 547 days, recaptured fish weighed 787 g on average (95% of the weights falling between 311 g and 1.5 kg; Figure 11), having grown 592 g on average (95% of weight increases were between 87 g and 1.3 kg; Figure 12). These weight increases scaled to an average of 454.3 g per year (95% of growth rates were 75-957 g per year; Figure 12).

The recaptured BY2013 fish had relative weights averaging 1.18 at the time of their release in 2014 (Figure 13); and relative weights averaged 0.92 at the time of recapture in 2015 (391 to 547 days later). The average change in relative weight was -0.27 (95% of the relative weight changes were between -0.69 and +0.02), which scaled to an annual change of -0.21 per year (95% of annual changes were between -0.52 and +0.01; Figure 13).

#### 3.2.4.2 Brood Year 2014

At the time of release in 2015, the BY2014 fish ranged in length from 97 to 373 mm (mean 234.2 mm), with 95% of the lengths falling between 165 and 294 mm (Figure 9). In 2015, 38 to 130 days after release, we recorded 43 recaptures of these fish. Upon recapture in 2015, the BY2014 fish measured between 290 and 429 mm (Figure 9), having grown between 45 and 162 mm (mean = 82.6 mm; Figure 10), which scaled to 222-644 mm per year (mean = 389.8 mm; Figure 10).

At the time of release in 2014, the BY2014 fish universally weighed less than 300 g (mean 97.6 g; 95% of the weights falling between 34.7 and 182.6 g (Figure 11). After 38 to 130 days, recaptured fish weighed
Figure 9. Fork length frequency distributions for fish released in 2014 (Brood Year 2013, left panels) and 2015 (Brood Year 2014, right panels). Top row: fork lengths at release (orange: fish that were recaptured in 2015; blue: all others). Orange bars are small and hard to see in the top right panel, values ranged 212-312. Bottom row: fork lengths upon recapture in 2015.
Figure 10. Growth (change in fork length) for fish released in 2014 (Brood Year 2013, upper panels) and 2015 (Brood Year 2014, lower panels). Left column: change in length between release and recapture. Right column: change in length, shown as a ‘per year’ rate.
Figure 11. Frequency distributions of weights of fish released in 2014 (Brood Year 2013, right panels) and 2015 (Brood Year 2014, left panels). Top row: weights at release (orange: fish that were recaptured in 2015; blue: all others). The orange bars are small and hard to see in the top right panel, values ranged from 71-210. Bottom row: weights upon recapture in 2015.
Figure 12. Growth (change in weight) for fish released in 2014 (Brood Year 2013, upper panels) and 2015 (Brood Year 2014, lower panels). Left column: change in weight between release and recapture. Right column: change in weight, shown as a ‘per year’ rate.
Figure 13. Relative weight at release (first row) and at recapture (second row) for fish released in 2014 (left column) and 2015 (right column). Also, change in relative weight (RW) is shown ‘as measured’ (third row), and scaled to show the rate of change per year (bottom row).
Figure 14. Lengths and weights of seven wild-caught sturgeon, captured in the Wells Reservoir in 2015. The length-weight relationship (red line) is based on data from six fish (blue dots) that were both measured and weighed. One of the seven fish was not weighed (black triangle), hence its Y position has been plotted along the trend line.

236 g on average (95% of the weights falling between 101 and 541 g; Figure 11), having grown 101 g on average (95% of weight increases were between 26 and 400 g; Figure 12). These weight increases scaled to an average of 452.0 g per year (95% of growth rates were between 149 g and 1.2 kg per year; Figure 12).

The recaptured BY2014 fish had relative weights averaging 1.25 at the time of their release in 2015 (Figure 13); and relative weights averaged 0.90 at the time of recapture in 2015 (38 to 130 days later). The average change in relative weight was -0.35, which scaled to an annual change of -1.76 per year (Figure 13).

In 2015, seven wild origin fish were caught. These measured between 696 and 905 mm, and weighed between 2.4 and ~6 kg. The weights of the wild-caught sturgeon fit tightly ($r^2 = 0.995$) to a third-power function of length (Figure 14; $F = 748.4$, $P < 0.0001$). Ages of the wild-caught sturgeon are not known.
4 DISCUSSION

4.1 Acoustic-tracking

4.1.1 Sturgeon Movements
Only a few months of acoustic telemetry were available when this report was prepared. To date, it appears that the tagged fish have initially spread themselves throughout the study area, although fewer fish appear to occupy the lower half of the Reservoir. Subsequent movement of animals among the Reservoir zones was not marked, and there was little difference in the overall distribution of fish during summer versus autumn. This pattern of movements is consistent with that seen in other juvenile sturgeon studies – an initial period of rapid redistribution, followed by settling behavior (e.g., Howell and McLellan 2007, Golder 2010, Golder 2014, Wright and Robichaud 2015). And the preferential distribution of fish in the upper reaches of the Reservoir is a pattern that has also been observed in the Rocky Reach Reservoir (Wright and Robichaud 2015).

The observed juvenile sturgeon distribution in Wells Reservoir was markedly different from that of adult-sized fish, as documented in 2002-2003 using radio-telemetry. Specifically, Jerald (2007) fitted six large-sized sturgeon with radio tags, and found them to congregate near the Okanogan River confluence, with none detected upstream of Park Island (RM 538) or downstream of Brewster (RM 530). By contrast, our acoustic-tagged juveniles were found throughout the Reservoir, whereas the Okanogan Confluence (part of the Bathtub Sampling Zone) was an area of relatively little use. However, direct comparisons between adult radio tagged fish and <3 year old fish carrying acoustic tags are difficult, since differences between movements may be associated with variables that include but are not limited to life stage, point of capture and tracking methodology. For example, radio tracking detection probabilities are reduced when fish occupy deeper habitats, like those found in the upper and lower reservoir.

Jerald (2007) observed three individuals (one fish in 2002 and two fish in 2003) – all mature-sized fish – moving upstream into the Okanogan River. To date, we have detected no acoustic tagged fish, and a small proportion of the PIT-tagged fish (79 of the ~10,000 fish at large) in the Okanogan River, suggesting that use of this tributary may increase as the sturgeon grow or mature, or environmental conditions in the Okanogan were unfavorable for sturgeon compared to historical norms (e.g., flows and turbidity were below average and water temperatures were above average in 2015). Evidence for the latter is supported by far fewer PIT-tag detections of sturgeon in the Okanogan in 2015 compared to 2014 (see section 3.2). A direct comparison between 2002/2003 radio tagged adult fish and PIT tagged hatchery fish is admittedly difficult because methodologies of detection are dissimilar. For example, the PIT-detection array is located approximately 20 river km up the Okanogan, thus PIT-tagged fish could be using the lower Okanogan River without detection. In addition, detection efficiency of the PIT-detection array has not been empirically evaluated and would be expected to change with river flows, thus fish could pass the array undetected.

4.1.2 Emigration
There appears to have been a small (2%) amount of emigration from Wells Reservoir. Since acoustic tracking began, there have been two emigration events. Both events occurred within a few weeks of acoustic tagging, and may have been the result of handling stresses. To confirm that emigration is a natural process, it would be preferable to detect emigration events after the initial post-tagging period.
Our emigration rate is low relative to that estimated for the Rocky Reach Reservoir (4.7%; Wright and Robichaud 2015), and may be biased as a result of the short duration over which we have been tracking. Yet Wright and Robichaud (2015) reported that many of their departures were recorded in the autumn (with very little movement recorded over the winter), thus our observation period (June to December – which included the autumn months) may have been adequate to capture the majority of the emigration events. Additional years of monitoring should improve our estimate of emigration.

Besides moving downstream of Wells Reservoir, it is also possible for fish to move out of our core study area into the Methow or Okanogan rivers. We have acoustic arrays deployed in both these systems, as well as PIT-tag detection equipment. To date, no acoustic-tagged fish has been detected in either tributary. However, PIT-tag scanners in the Okanogan River have detected 75 BY2014 or BY2015 sturgeon (0.75%). If these sturgeon eventually move back into the Wells Reservoir, they cannot be considered to have emigrated. Yet, temporary departures from the core area could bias our survival estimates (see Fujiwara and Caswell 2002). When more detection data are available (within both the reservoir and the tributaries), it may be possible to estimate survival using multi-state models that take into account temporary periods of emigration (e.g., Schaub et al. 2004).

At this stage, our preliminary estimates of emigration have not been seriously implemented into our survival models – we have simply made an adjustment to the ‘available population’ in order to coarsely estimate ‘true’ (rather than ‘apparent’) survival. Once more data are available, finer-scale analyses of emigration rate will occur, accounting for the differing sample sizes and battery life spans of the various tag models deployed. Once emigration and tag-loss rates are parametrized, they can be woven into the structure of the survival models in order to better reconstruct the age-structured population within Wells Reservoir.

The emigration to the Okanogan, or temporary use of this habitat, is an interesting observation since we are unaware of other studies that have tracked sturgeon into Columbia River tributaries. Specific to the Wells Project, no sturgeon were detected using the Methow River in either 2014 or 2015, suggesting that the Okanogan may provide preferred habitat at certain times of the year compared to the Methow River.

4.2 Index Monitoring

4.2.1 Capture Success

In 2015, we captured 441 White Sturgeon in the summer and fall sessions, combined. In all, 373 fish (83%) were from BY2013, and 43 (10%) were from BY2014. Approximately equal numbers of fish were released from each brood year. It follows that, having been exposed to dangers in the Reservoir for one year longer, there should have been fewer BY2013 fish at large than BY2014 fish. Thus, it is interesting that we captured 8.6× more BY2013 fish than BY2014 fish in 2015. Two explanations can account for this pattern. First, it is possible that the survival of BY2014 was, for some reason, very poor compared to that of BY2013. Because so few BY2014 fish were captured, it was not possible to estimate their post-release survival for this report. Perhaps after collecting more data in 2016-2017, we will be able to estimate survival and address this possibility. Nevertheless, it should be noted that other studies have observed marked variability in survival rates among brood years (e.g., Justice et al. 2009, Wright and Robichaud 2015). The second possibility is that gear selectivity negatively affected our ability to catch the one-year-old (BY2014) fish, as compared to the larger two-year-old (BY2013) fish. It would be surprising that the range of hook sizes used (2/0 - 4/0) would preclude the capture of the one-year old fish,
given these hooks are successfully used in nearby reservoirs (e.g., Wright and Robichaud 2015). Although similar capture gear has been used in other sturgeon studies, there are nevertheless reports of vastly different capture probabilities among cohorts (e.g., in 2013, Wright and Robichaud (2015) reported capture probabilities of 7% for BY2012 and 28% for BY2010, where the fish from different brood years differ noticeably in size, as expected). A combination of the two possibilities for differences in capture rates among brood years is also possible. However we suspect that capture efficiency was the leading cause of differences in catch rates, as it has been demonstrated in the Upper Columbia White Sturgeon Initiative Monitoring Program (Jason McLellan, pers. comm.). We expect to tease these factors apart when subsequent years of monitoring occur.

4.2.2 Survival Estimation

The apparent survival rates estimated in this report, 17-19% depending on the group in question, are likely underestimated. To calculate survival ‘from release to the Summer 2015 survey’, we needed to tease apart the effects of survival and detection probability. The number of fish caught in the Summer 2015 survey was the product of three parameters: the number of fish released × the survival rate × the capture probability during the Summer 2015 survey. The value of the first parameter (number of fish released) is known. But to calculate the value of the second parameter (survival), requires that we know (or have an estimate of) the third parameter (capture probability during the Summer 2015 survey). The Fall 2015 survey provided the data needed to independently estimate the capture probability of the Summer 2015 survey. And, with two known (or estimated) parameter values, we can calculate the third parameter: survival. Here, we note that only a single pair of surveys has been conducted to date, and this study will continue for two more years, including four more surveys. Moving forward, every additional fish that is captured will downwardly-adjust the Summer 2015 capture probability and produce a concomitant increase in our initial post-release survival estimates. And there is room for improvement: post-release survival in other studies is considerably higher than that reported here. A recent survival estimate from the Rocky Reach Reservoir was 35.7% (Wright and Robichaud 2015). In the Upper Columbia River, the published survival rates, ranging from 27% to 29% (Golder Associates 2009), were likely underestimated. Recent data from the Upper Columbia White Sturgeon Recovery Initiative M&E Program have shown that after 16 years of stocking, the growing/ageing fish are becoming more effective at recruiting to the sampling gear. Specifically, BC Hydro and Golder Associates have revised the annual survival estimates (i.e., survival adjusted to a 1-year period), which were heavily influenced by release weight, from 0.476 (95% CI of 0.382-0.574) at 100 g, to 0.863 (95% CI of 0.744-0.933) at 200 g, and 0.981 (95% CI of 0.938-0.994) at 300 g (Golder Associates in prep.). For comparison, in 2014 we released larval origin fish at a mean size of 227 g, and estimated 18.9% survival in their first year. If fish recruit to gear better as they grow it is possible that our survival estimates will improve through time as observed in the Upper Columbia White Sturgeon Recovery Initiative program.

It is possible that the Wells Reservoir survival could be improved by releasing sturgeon of a larger size. Justice et al. (2009) found evidence of size-dependent mortality for supplementation releases of juvenile sturgeon into the Kootenai River. Examination of their survival-at-length curves shows that fish the size of Douglas’ 2013 Brood Year (average 281.9 mm) would have had lower-than-average survival rates. In

---

3 Any fish caught in the Fall survey was, logically, known to be alive during the Summer survey. Thus, we have a set of fish that are known to have been alive during the Summer survey, and we know the portion of them that were actually caught during the Summer survey, thus we have an estimate of the capture probability of the Summer survey.
the Upper Columbia White Sturgeon Recovery Initiative, the 20th, 50th, 75th, and 90th percentiles of all release weights (2002-2014) were 35, 55, 93, and 181 g, respectively, which corresponded to annual survival estimates of 0.238, 0.293, 0.444, and 0.811 (Golder Associates in prep.).

Our initial results indicated a 2% survival difference between 2013 brood year fish reared from larvae versus those produced from direct gametes. The difference was not large, and not statistically significant, but was in the ‘preferred’ direction (i.e., larval fish survived better), given that Aquatic SWG members had already decided (starting with the 2014 brood year, released in 2015) to release only larval-reared fish moving forward. It makes sense that wild-caught fish might be better adapted for in-river survival than hatchery produced individuals (Tringali and Bert 1998, Leberg 1990, Hughes and Sawby 2004). Moreover, wild animals may be so well adapted, that their advantages may be detected in the survival estimates of the next generation: progeny of wild-caught adults survived better than progeny of captive broodstock in the Rocky Reach Reservoir (Wright and Robichaud 2015).

4.2.3 Growth

Growth rates for BY2014 sturgeon in the Wells Reservoir were notably greater than some other published growth rates. In their first 1-4 months in the Reservoir, BY2014 fish grew between 45 and 162 mm, and averaged 389.8 mm/year (rates extrapolated to 365 days). This rate is quite high when compared to the growth rates reported for one-year old sturgeon in other similar studies. For example, average annual growth of age-one sturgeon averaged 153 to 176 mm/year in the Rocky Reach Reservoir (Wright and Robichaud 2015), 280 mm/year in the Keenleyside and Roosevelt reaches (Golder Associates 2009) and 120 mm/year in the Kootenai River (Neufeld and Spence 2002). It is not surprising, however, that our growth rate is biased, given that it was based on measurements that were extrapolated from relatively short at-large periods.

When measured over longer at-large periods, the Wells Reservoir sturgeon appeared to grow at rates that were similar to other recent studies. Averaged over 1-1.5 years in the Wells Reservoir, the BY2013 fish grew on average 152.3 mm/year; and age 2 sturgeon in the Keenleyside and Roosevelt reaches grew on average 160 mm/year (Golder Associates 2009). By contrast, lower growth rates were observed in the Rocky Reach Reservoir, where age 2 sturgeon averaged growth rates between 62 and 93 mm/year (Wright and Robichaud 2015). The only other sturgeon growth rates data from the Wells Reservoir comes from two fish tagged in 2001: one 65 cm fish grew 22 cm in 14 months (189 mm/year; Jerald 2007); and a 197 cm adult grew 31.5 cm in about 5 years (6.1 cm/year; unpublished data).

In terms of weight gain, both BY2013 and BY2014 fish averaged ~450 g/year in the Wells Reservoir. This is similar to the growth rate of Rocky Reach BY2010 when recaptured in 2015 (457 g/year ; Wright and Robichaud 2015), but exceeds the rates observed for this brood year in 2012 or 2013 (96 or 272 g/year, respectively), or those of any other Rocky Reach brood year (BY2012 recaptured in 2013 or 2014 gained 143 and 157 g/year, respectively; BY2013 recaptured after ~0.5 years gained 141 g/year). Moreover, Golder Associates reported growth of 389 g/year for age 2 hatchery-released sturgeon in the Keenleyside and Roosevelt reaches (Golder Associates 2009), and only 37 g/year in Canada’s middle-Columbia River (Golder Associates 2010). Slower growth rates observed in these more northern sections of the Columbia River might, however, be attributed to colder water temperatures and relatively low productivity. Low conspecific competition, warmer water temperatures, and higher productivity may all contribute to the observed higher growth rates in the Wells Reservoir for hatchery released fish.
4.3 **Determine Best Stocking Approaches**

LGL analysts and Douglas PUD biologists will work with the Aquatic SWG to determine preferred stocking techniques. Throughout the 3-year study period, Douglas PUD will experiment with size of the sturgeon at release, holding periods, and release locations, and we will use these independent variables when examining relative survival rates.

5 **ACKNOWLEDGEMENTS**

Douglas PUD’s White Sturgeon Management Plan implementation program has benefited from many individual and agency supporters. The Washington Department of Fish and Wildlife’s Scott Moore, Jayson Wahls, and Chad Jackson participated in rearing, release and various program review topics. The Colville Confederated Tribes and Bands of the Yakama Nation fish biologists provided valuable program oversight and fish delivery. Jason McLellan, Matt Howell, and Donella Miller and their respective staffs were instrumental in helping support this program. Columbia Research Specialists, Tyson Jerald and staff are thanked for countless long rain-or-shine hours making indexing possible. Many Douglas PUD staff participated in various components of the program including but not limited to Chas Kyger, Karl Shulke, Barb Wolfe, and Mary Mayo. We thank Lucia Ferreira (LGL Limited) for surgical tagging and instruction. LGL administrative staff kept various technical, financial and logistical aspects of the project running smoothly. Chelan and Grant PUD, Blue Leaf Environmental, Golder Associates, and members of the Upper Columbia White Sturgeon Recovery team have provided valuable regional coordination and data sharing. Agencies that contributed to PIT tag and receiver maintenance are also thanked, including Colville OBMEP staff, specifically Jenny Miller. Private residents around the Wells Reservoir, including but not limited to Roger Erlandsen, are thanked for providing receiver mounting locations and access. The Colville Tribes and the U.S Army Corps of Engineers provided receiver and Project access near Chief Joseph Dam.

6 **REFERENCES**


Appendix A. Dates for which fixed-station data were included in this report, by receiver. Receiver numbers with decimal points have been deployed in multiple locations, where the digit after the decimal indicates the deployment sequence.

<table>
<thead>
<tr>
<th>Receiver</th>
<th>Location Code</th>
<th>Site Name</th>
<th>First Included Data</th>
<th>Last Included Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR2W-126887</td>
<td>V1</td>
<td>CJ Tailrace West</td>
<td>Apr 16\textsuperscript{th}, 2015</td>
<td>Dec 1\textsuperscript{st}, 2015</td>
</tr>
<tr>
<td>VR2W-126891</td>
<td>V2</td>
<td>CJ Tailrace Hatchery</td>
<td>Apr 16\textsuperscript{th}, 2015</td>
<td>Dec 1\textsuperscript{st}, 2015</td>
</tr>
<tr>
<td>VR2W-126892.2</td>
<td>V15</td>
<td>CJD Foster Creek Delta</td>
<td>Oct 15\textsuperscript{th}, 2015</td>
<td>Dec 1\textsuperscript{st}, 2015</td>
</tr>
<tr>
<td>VR2W-126885</td>
<td>V3</td>
<td>CJ St. Pk East</td>
<td>Apr 16\textsuperscript{th}, 2015</td>
<td>Dec 1\textsuperscript{st}, 2015</td>
</tr>
<tr>
<td>VR2W-126888</td>
<td>V4</td>
<td>CJ St. Pk Gate 2</td>
<td>Apr 16\textsuperscript{th}, 2015</td>
<td>Dec 1\textsuperscript{st}, 2015</td>
</tr>
<tr>
<td>VR2W-126897</td>
<td>V0</td>
<td>Release Location</td>
<td>May 21\textsuperscript{st}, 2015</td>
<td>Dec 1\textsuperscript{st}, 2015</td>
</tr>
<tr>
<td>VR2W-105360</td>
<td>CCT3</td>
<td>Erlandsen's Dock</td>
<td>Apr 16\textsuperscript{th}, 2015</td>
<td>Nov 13\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-126884</td>
<td>V5</td>
<td>Okanogan Mouth</td>
<td>Apr 16\textsuperscript{th}, 2015</td>
<td>Dec 2\textsuperscript{nd}, 2015</td>
</tr>
<tr>
<td>VR2W-110454</td>
<td>CCT4</td>
<td>Monse LB</td>
<td>Jun 9\textsuperscript{th}, 2015</td>
<td>Nov 13\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-110446</td>
<td>CCT5</td>
<td>Monse RB</td>
<td>Jun 9\textsuperscript{th}, 2015</td>
<td>Nov 13\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-105558</td>
<td>CCT2</td>
<td>Brewster Dock</td>
<td>Apr 16\textsuperscript{th}, 2015</td>
<td>Nov 13\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-126890</td>
<td>V6</td>
<td>Brewster Bridge</td>
<td>Apr 16\textsuperscript{th}, 2015</td>
<td>Dec 2\textsuperscript{nd}, 2015</td>
</tr>
<tr>
<td>VR2W-105559</td>
<td>CCT1</td>
<td>Pateros Dock</td>
<td>Apr 12\textsuperscript{nd}, 2015</td>
<td>Sep 22\textsuperscript{nd}, 2015</td>
</tr>
<tr>
<td>VR2W-126901.1</td>
<td>V7</td>
<td>Methow Mouth</td>
<td>May 2\textsuperscript{nd}, 2015</td>
<td>Dec 4\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-126894</td>
<td>V8</td>
<td>Starr Access</td>
<td>May 2\textsuperscript{nd}, 2015</td>
<td>Dec 2\textsuperscript{nd}, 2015</td>
</tr>
<tr>
<td>VR2W-126900</td>
<td>V9</td>
<td>Starr Access</td>
<td>May 2\textsuperscript{nd}, 2015</td>
<td>Dec 2\textsuperscript{nd}, 2015</td>
</tr>
<tr>
<td>VR2W-126886</td>
<td>V10</td>
<td>Wells Forebay East</td>
<td>Apr 17\textsuperscript{th}, 2015</td>
<td>Dec 4\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-126896</td>
<td>V11</td>
<td>Wells Forebay West</td>
<td>Apr 17\textsuperscript{th}, 2015</td>
<td>Dec 4\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-126889</td>
<td>V12</td>
<td>Wells Tailrace Hatchery</td>
<td>Apr 17\textsuperscript{th}, 2015</td>
<td>Dec 4\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-126892.1</td>
<td>V13</td>
<td>Wells Tailrace East</td>
<td>Apr 17\textsuperscript{th}, 2015</td>
<td>Jul 23\textsuperscript{rd}, 2015</td>
</tr>
<tr>
<td>VR2W-126893</td>
<td>V14</td>
<td>Wells Tailrace West</td>
<td>Apr 17\textsuperscript{th}, 2015</td>
<td>Dec 4\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-119939</td>
<td>R829_01</td>
<td>CPUD Top Res Receiver</td>
<td>Apr 11\textsuperscript{th}, 2015</td>
<td>Nov 4\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-119940</td>
<td>R826_71</td>
<td>Wells Tailrace Left Bank</td>
<td>Apr 11\textsuperscript{th}, 2015</td>
<td>Nov 4\textsuperscript{th}, 2015</td>
</tr>
<tr>
<td>VR2W-119942</td>
<td>R826_81</td>
<td>Wells Tailrace Right Bank</td>
<td>Apr 11\textsuperscript{th}, 2015</td>
<td>Nov 4\textsuperscript{th}, 2015</td>
</tr>
</tbody>
</table>