2016 Nechako Juvenile White Sturgeon Sampling; 2016AFSAR-2861 (Year 1) Juvenile Recruitment Indexing

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Executive Summary

The 2016 Nechako Juvenile White Sturgeon Juvenile index program is a continuation of efforts to monitor juvenile white sturgeon in the Nechako River. The juvenile index program has been standardized since 2009 to provide annual comparable data related to hatchery and wild-origin juvenile white sturgeon abundance, growth and distribution/habitat use. The Nechako White Sturgeon hatchery located in Vanderhoof, BC has been increasing release capacity. In 2015 1,250 one-year-old juveniles were released into Nechako River, and in 2016 9,175 one-year-old juveniles were released into Nechako River. It is important to monitor the dispersion and survival of these hatchery-released juveniles to ensure appropriate adjustments are made to the hatchery production and release strategies.

The Nechako River's juvenile index region was sampled using setlines between August 31 and October 4, 2016. A total of 93 setlines, or 36,284 hook-hours were applied during this period. One hundred and ten (110) juvenile sturgeon (< 100cm Total Length) were captured, resulting in catch per unit effort (CPUE) of 0.3032 juvenile white sturgeon per 100 hook-hours. Of the 110 captures, 105 were unique individuals (5 were juveniles were captured twice within the 2016 sampling period). Of the 105 unique individuals 74 were 2016 hatchery-releases, 14 were 2015 hatchery-releases, 2 were 2009 hatchery-releases, and the remaining 15 were wild-origin juveniles. Of the 15 wild-origin juveniles, 12 were first-time captures and 3 were recaptures from previous years. The total lengths of captured juveniles ranged from 39.9 cm to 92.4 cm.

The capture rate of pre-2016 releases, and wild origin fish was comparable to previous years. Many 2016 releases were captured, but this was expected because of the large number of 1-year-olds released in June 2016. Distribution of juvenile captures was like previous years; the habitat unit surrounding and including rkm 117 provided the greatest number of captures (55), followed by habitats near rkm 110, rkm 120, and rkm 125. By-catch data show Northern pike-minnow, sculpin, and rainbow trout and bull trout also occupy juvenile sturgeon habitats.

Introduction

White sturgeon in Canada have been considered Endangered by COSEWIC since 2003. The Nechako River population has been federally protected under Schedule 1 of the Species at Risk Act since 2006. More recently COSEWIC amalgamated genetically distinct populations (Upper Fraser, Mid-Fraser, and Nechako River) into one "Upper Fraser" designate-able unit (DU). As of November 2016 this DU is currently undergoing a Recovery Potential Assessment, which could result in re-listing or de-listing from SARA's Schedule 1.

The population dynamics of white sturgeon within the Nechako River has been examined in several investigations over the past three decades (Dixon 1986; RL&L 1996, 1997, 1998, 1999 & 2000a). Work by Dixon (1986) and subsequent investigations into the Nechako white sturgeon populations by RL&L Environmental Services (*now* Golder Associates Ltd.) between 1995 and 1999 identified a number of issues with regards to this population, the most notable of which was the negligible level of juvenile recruitment that appeared to be occurring (RL&L 2000b).

Following the conclusion of assessment activities in 1999, BC's Ministry of Water, Land and Air Protection (MoWLAP) initiated a recovery planning process for the Nechako River white sturgeon stock. This *Nechako White Sturgeon Recovery Initiative* (NWSRI) parallels recovery planning processes implemented on the Columbia and Kootenay rivers, where sturgeon populations have also experienced recruitment failures (Golder 2003). This involved the creation of a Recovery Team in 2000 (now termed the Technical Working Group – TWG), comprised of government and non-government technical personnel assembled to recommend technical directions for recovery actions. The Nechako White Sturgeon TWG, through the development of a Recovery Plan, indicated that a focused juvenile sampling program should be carried out on the Nechako River (Golder 2003). The intent of the juvenile sampling program is to monitor recruitment, and factors controlling recruitment. Additional objectives of such a program would include routine assessment of juvenile sturgeon habitat within Nechako River, assessment of the effects of habitat restoration activities undertaken, and monitoring the growth and survival of hatchery-reared juvenile white sturgeon released into the wild.

A standardized sampling program has been implemented since 2009 to monitor juvenile sturgeon recruitment into the Nechako River population, and document the distribution, health and survival of hatchery-reared juveniles. In 2015 1,250 one-year-old juveniles were released into Nechako River, and in 2016 9,175 one-year-old juveniles were released into Nechako River. It is important to monitor the dispersion and survival of these hatchery-released juveniles to ensure appropriate adjustments are made to the hatchery production and release strategies.

Purpose

The 2016 juvenile sampling program is a continuation of the sampling efforts conducted annually since 2004. From 2004 to 2008 gillnet sampling was conducted. From 2009 – 2016 setlines have been used in order to increase juvenile sturgeon catch and reduce bycatch. The primary purposes of 2016 sampling included gaining insight on hatchery-origin juvenile survival and growth rates, monitoring the presence of wild-spawned juvenile sturgeon, as well refining knowledge on juvenile sturgeon habitat in Nechako River.

Objectives

The technical objectives of this project were stated as follows:

1. Conduct sampling within known juvenile habitat using methods similar to previous years.
2. Collect detailed biological and morphological information from any sturgeon captured.
3. Apply identifying tags (PIT) and marks (scute markings) to unmarked juvenile sturgeon.

Methodology

Sampling methodologies used in 2016 reflected those used from 2009 through 2015.

Setlining

Setlines were rigged with 4 sizes (4, 2, 1, 1/0) of circle hooks (Gamakatsu Circle Octopus Hooks - NS Black) on 8-12" leaders of braided line. 40m to 60m setlines were deployed with 20 hooks per line (~2.5m spacing). Five of each hook size were placed randomized along the setline. Sockeye flesh and worms were used for bait. Setlines were set, soaked overnight and retrieved the following day.

A crew of 3-7 people completed sampling. Sampling was generally conducted in a downstream direction within the study area, usually in areas previously identified as sturgeon "hotspots" with a high sturgeon capture rate. These heavily sampled zones are located between rkm 110.0 and rkm 132.7. Setlines were also deployed outside of these key habitat units, but sturgeon capture rate was usually low and bycatch capture rate was usually high in these lower-use habitats. Lines were checked daily and moved, re-baited and re-deployed or re-set in the same location with fresh bait. When personnel were available two boats/crews were used; one boat-crew would pull setlines and process catch, and the other boat crew would re-bait and re-set setlines.

Physical Conditions

Water temperatures were obtained at the start of every set (when the setline was placed in the water) using either a digital thermometer or the sampling vessel's fish finder. Water depth at

the site of gear deployment was measured utilizing the fish finder, which was tested for accuracy using a known length of rope with weight attached. Water clarity was estimated utilizing a standard size Secchi Disc deployed and interpreted in a standardized manner. Nechako River temperature and discharge information collected at the Vanderhoof Hydrometric station was retrieved from Environment Canada's Water Survey of Canada website for the duration of sampling activities.

Age Structure Analysis

An approximately 1.5 cm section of leading finray was excised from the right pectoral fin and sent to Coastal Ecology Lab at Acadia University, Nova Scotia, Canada for aging analysis. Finray samples were sectioned at least three times using an isomet saw with a diamond cutting edge. Each section was mounted on a dissecting scope and annular growth rings were counted. Ages were verified by a second reader with 100% inter-reader precision. A representative digital photo of a section from each finray sample was also provided to CSTC.

Results

Sampling was conducted between August 31 and October 4, 2016. A total of 93 setlines were deployed during this period. One hundred and five (105) unique juvenile sturgeon captures were recorded in 2016; 5 of those individuals were captured twice during the 2016 sampling period, resulting in 110 total captures recorded in 2016. Sampling was conducted between rkm 110.0 and rkm 132.7 (the index region). River discharge (50 – 90 m^3/sec) and water temperature (10°C – 15°C) were within ranges that have proven ideal for sampling juvenile white sturgeon.

Physical Conditions of the Nechako River at time of Sampling

Figures 1 and 2 below show river discharge and water temperature measured at Burrard Bridge (rkm137.7) respectively. River discharge was near 90 m^3/s at the start of the sampling period and declined to approximately 50 m^3/s by the end of the sampling period. A relatively sharp decrease in discharge occurred around the beginning of September, and then the rate of decrease became gradual near the second week of September. Water temperature was approximately 15.0°C at the beginning of the sampling period and declined to approximately 10.0 °C at the end of the sampling period. Water temperature decline was gradual with small temperature increases between Sept. 05 – 07, Sept. 13 – 15, and Sept. 19 – 20. The measurements recorded at Burrard Bridge by the Environment Canada hydrometric station closely matched average daily temperatures recorded at setline locations (Figure 2).

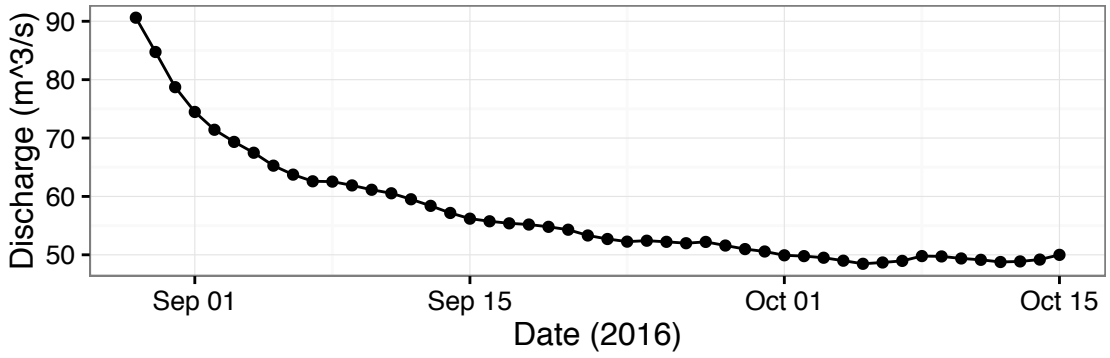

Figure 1. Daily average discharge (m^3/s) for the Nechako River at Vanderhoof Environment Canada hydrometric station 08JC001 from August 29 to October 15, 2016.

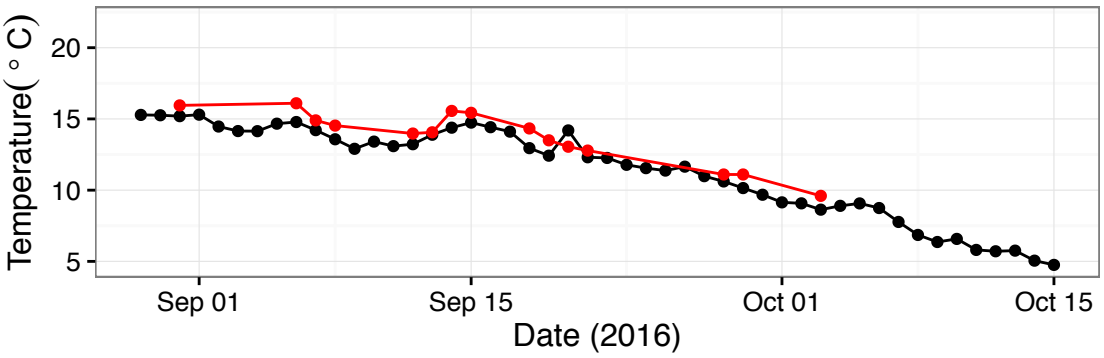

Figure 2. Daily average water temperature (centigrade) for Nechako River at Vanderhoof Environment Canada hydrometric station 08JC001 from August 29 to October 15, 2016 in black, and daily average water temperature for Nechako River at setline locations measured using the boat temperature sensor, in red.

Water clarity was measured once at the beginning of the day. All days were estimated (via Secchi disc measurements) to be 2m throughout the duration of the sampling program.

Sampling Effort

Ninety-three (93) setlines were deployed mostly during September 2016 (Figure 3) between rkm 110.0 and rkm 132.7, resulting in a total of 2,180.27 setline soak hours. Average soak time for setlines was 23.44 hours. Each setline was deployed with 20 hooks but some hooks were recovered fouled, bent, broken, or bait-less. On average a setline had 17 hooks fishing for the entire deployment. The minimum number of hooks fishing upon retrieval was 2, and the maximum was 20. Only hooks that were fishing for the entire deployment were counted towards total hook-hours. In 2016 a total of 36,284.13 hook-hours were applied. A summary of 2016 sampling effort is provided in Table 1 below. All setlines were deployed within areas that have been annually sampled for juvenile sturgeon, and most setlines were deployed in known juvenile sturgeon habitat at rkm 116-117, rkm 125, and rkm 110 (Figure 4).

Table 1. Summary information for sampling effort deployed in 2016.

Juv. WSG Captures	Setline Deployments	Effort (Hook-Hours)	CPUE (# WSG/100 hook-hours effort)	Distribution of Sampling
110	93	36,284.13	0.3032	All identified habitat units found from rkm110.0 – 132.7

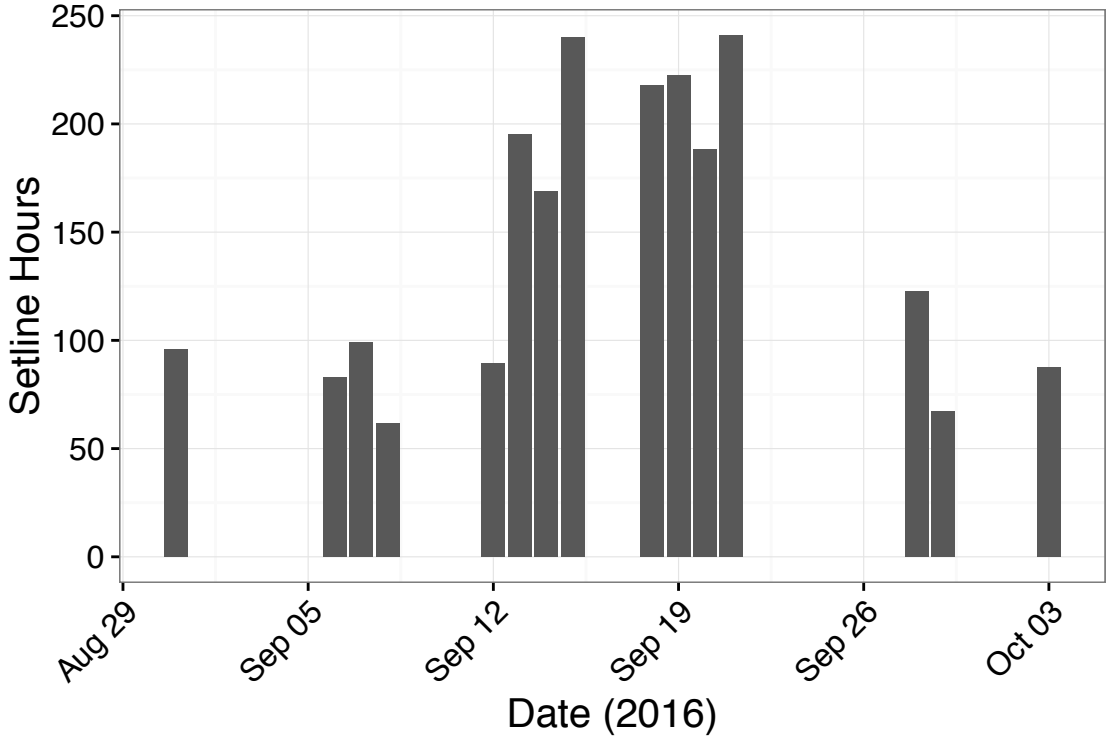

Figure 3. 2016 effort (setline hours) summarized by date.

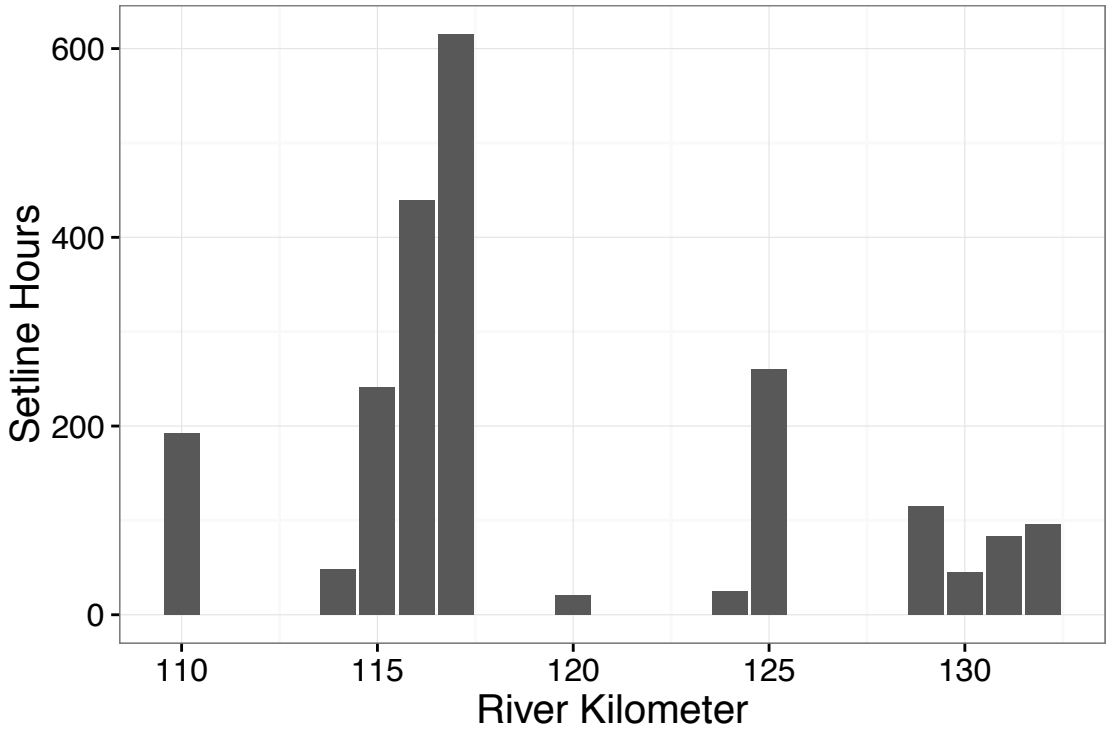

Figure 4. 2016 effort (setline hours) summarized by river kilometer.

Juvenile White Sturgeon CPUE and Habitat Distribution

One hundred and ten (110) juvenile white sturgeon were captured during 2016 sampling efforts. Five juveniles were captured twice within the 2016 program (1 hatchery capture, 4 wild-origin captures), so 105 unique juvenile sturgeon were captured in 2016. As anticipated given recent hatchery-reared juvenile releases (in 2015 – 1,250 and 2016 – 9,175), 2016 represents the largest number of juvenile sturgeon captured in any year of juvenile monitoring efforts dating back to 2004.

Figures 5 and 6 display the distribution of white sturgeon captures and CPUE across all of the river kilometers within the index region. River kilometer 117 produced the greatest number of juveniles (55). This area received disproportionately high effort (Fig. 4) and CPUE was high, but similar to other high-use habitats within the index region. The habitat unit around rkm 117 is a known overwintering area for juvenile and adult sturgeon. River kilometer 114, rkm 120, and rkm 124-125 also had relatively high CPUE but lower capture numbers; these areas are known juvenile sturgeon aggregation sites. Data from 2016 supports the hypothesis that the habitat unit contained within rkm 114 through to rkm 117 has high juvenile sturgeon abundance and is Critical Habitat for the Nechako River population.

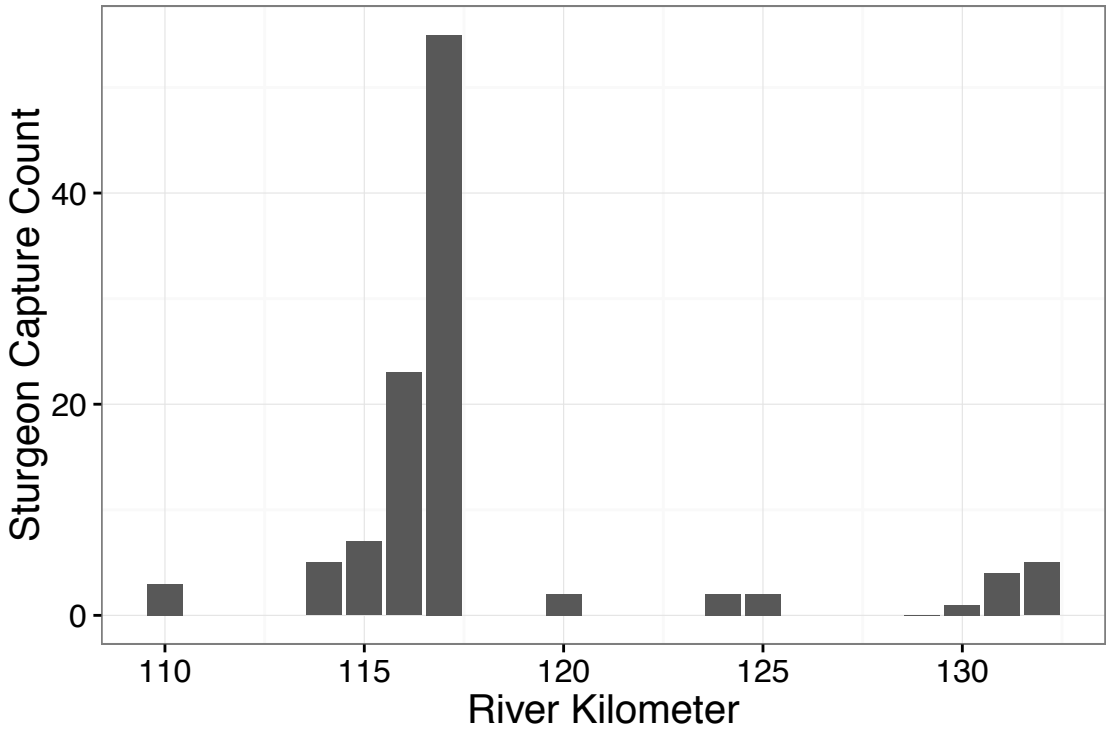

Figure 5. Capture counts of juvenile white sturgeon summarized by capture river kilometer

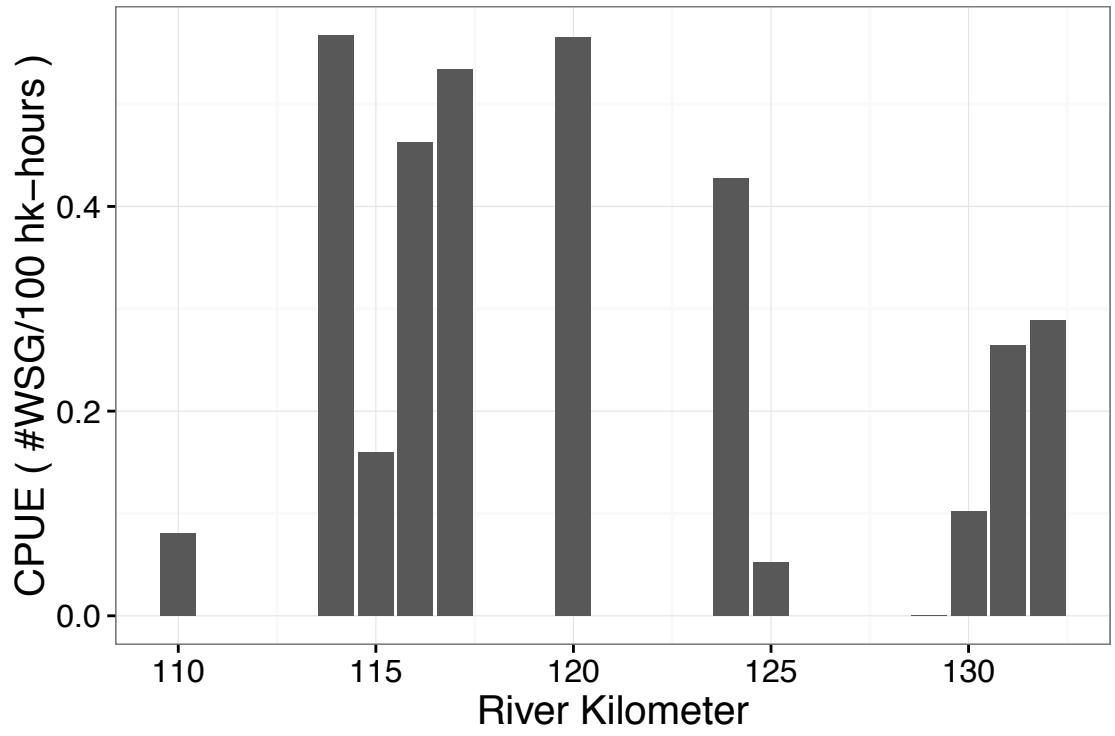

Figure 6. Catch-per-unit-effort for each river kilometer within the index region.

Of the 105 unique juvenile WSG captured in 2016, 15 were wild-origin juvenile sturgeon, and 90 were hatchery-origin juvenile sturgeon. Of the 15 wild-origin juveniles, 12 were first-time captures, and 3 were captured, sampled and marked prior to 2016 (recaptures from previous years). The range of total length (47.9 cm to 92.4 cm) amongst the 12 fish suggests several year classes are included in the new wild-origin sample.

Figure 7 displays the distribution of total lengths of the 2016 hatchery-origin sample including juveniles released in 2009, 2015, and 2016. The distributions of total length show 2016 juveniles are heavily represented in the short-length classes (35 – 55 cm), 2015 juveniles are predominately in the mid-size classes (50 – 70 cm), and 2009 releases are the longest size classes captured in 2016.

Figure 8 displays the distribution of total lengths of the 2016 wild-origin sample. Interestingly the 2016 wild-origin sample formed a relatively normal distribution across all catchable size classes.

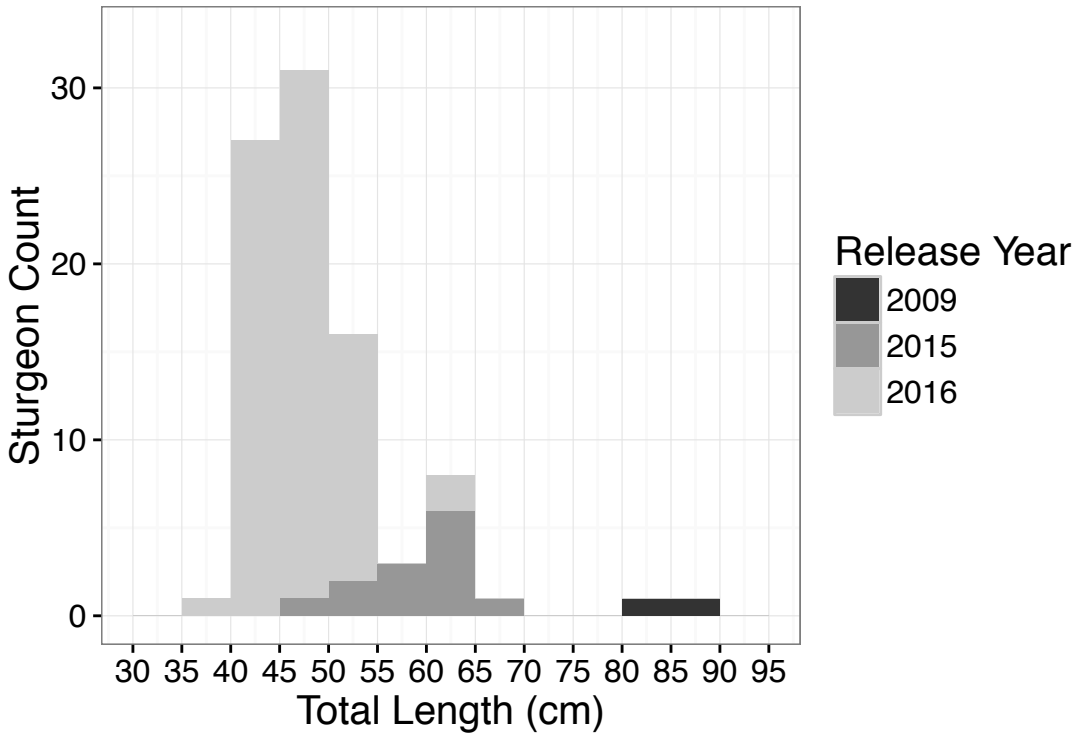

Figure 7. Length (TL) frequency distribution of 90 hatchery-origin WSG captured during 2016.

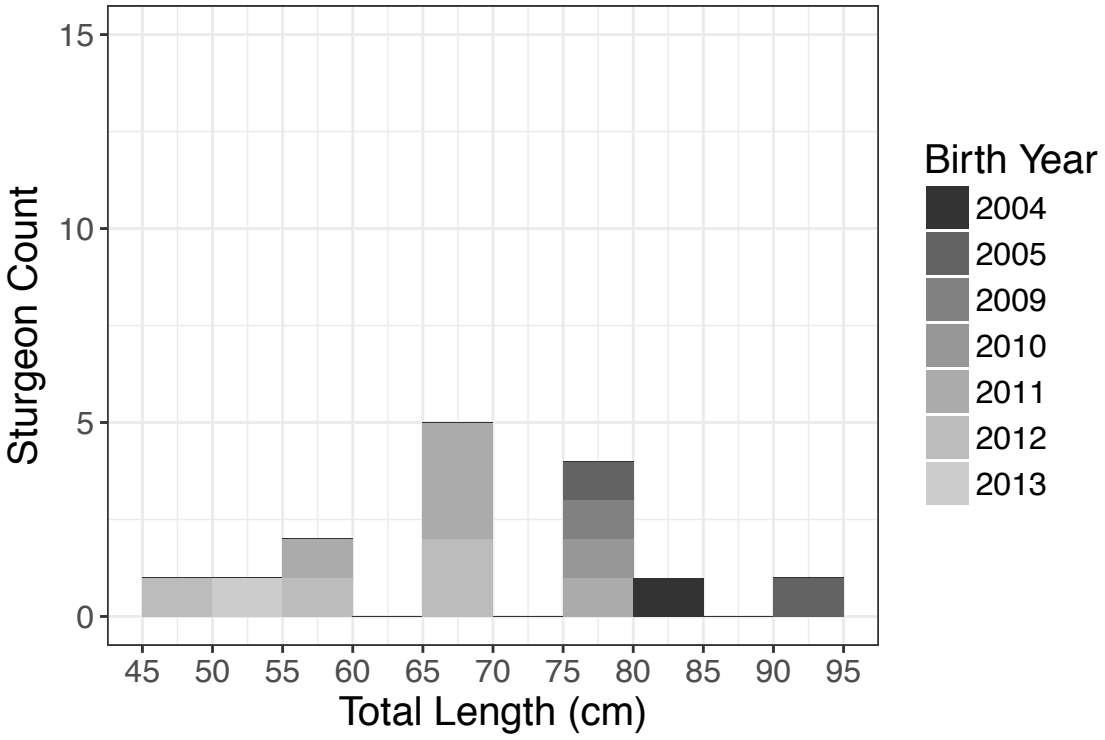

Figure 8. Length (TL) frequency distribution of the 15 wild-origin WSG captured during 2016.

The first major hatchery release (9,175 fish) year was in May-June 2016 (1,250 juveniles were released in 2015) thus 2016 is the first year that the juvenile index captures have demonstrated a ~10-fold greater abundance of hatchery-origin juveniles relative to wild-origin juveniles. Of the 90 hatchery-origin juveniles captured, 74 were 2016 releases, 14 were 2015 releases, and 2 juveniles were 2009 hatchery releases. The 2016-releases of course do not have a capture history and therefore their life history (recorded prior to release) can only provide information based on approximately 5 months in Nechako River. Juveniles with capture histories dating 2015 or earlier can offer insight on longer-term juvenile growth and survival, and habitat occupancy during September-October. Biological and life history details of juveniles recaptured in 2016 are provided in Table 2.

Figure 9 is a map displaying the capture locations of all juvenile white sturgeon captured in 2016. The hatchery juvenile captures were dispersed throughout the index region, whereas the wild-origin juvenile captures were between ~rkm 117 and rkm 110. Figure 9 also demonstrates the relative concentration of captures (hatchery and wild-origin juveniles) between rkm 117 and rkm 115.

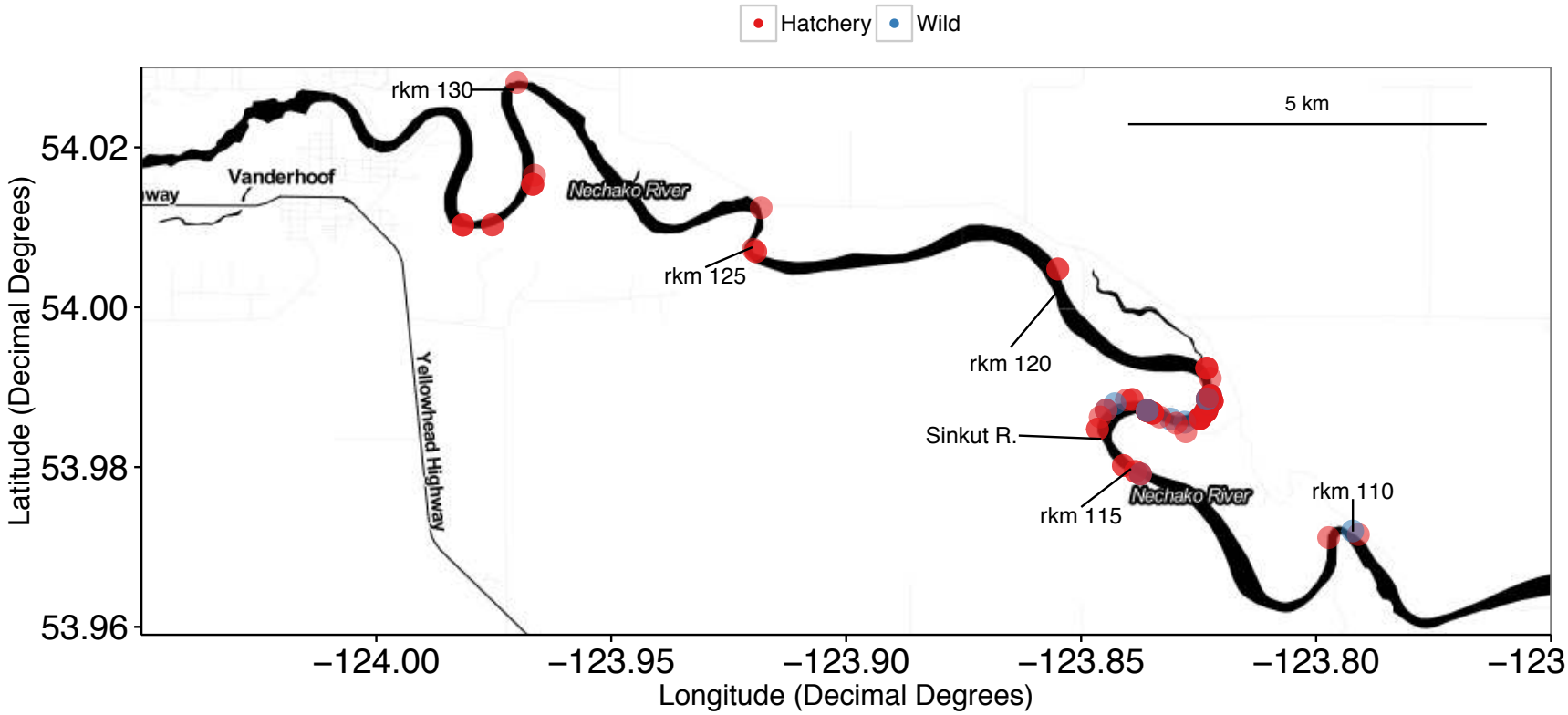

Figure 9. Map of Nechako River study area depicting distribution of juvenile WSG captured in 2016 (red dots – hatchery origin fish; blue dots wild-origin fish).

Life History Characteristics of Recaptured Hatchery White Sturgeon

Sixteen hatchery-origin juveniles (2 from 2009, 14 from 2015) that had been captured and sampled in previous years were recaptured in 2016, and one of those juveniles were captured more than once in 2016. ID 4A0D3C3446 (ID446) has the largest recapture history since being released in 2009 and has been recaptured six times including in 2016. ID446 was released at rkm 116.8 and has been recaptured twice near rkm 110, twice near rkm 117, and twice near rkm 125 (Table 2).

Table 2. Summary of the origins and recapture histories of hatchery-origin juvenile white sturgeon captured in 2016[1].

Capture Year	Capture rkm	PIT	Capture Date (YY-MM-DD)	TL (cm)	Mass (kg)	Release Date from Hatchery (YY-MM-DD)	Release rkm	FL at Release (cm)	Mass at Release (kg)
2016	132.7	152211107A	2016-09-01	60.1	0.708	2015-05-04	136.9	47	0.696
2015	117.6	152212794A	2015-09-30	60.6	0.746	2015-05-04	136.9	47.6	0.796
2016	114.9	152212794A	2016-09-21	64.3	0.928	2015-05-04	136.9	47.6	0.796
2015	117.5	152213787A	2015-09-29	59.4	0.609	2015-05-04	136.9	44.3	0.615
2016	115.6	152213787A	2016-09-20	63.1	0.835	2015-05-04	136.9	44.3	0.615
2016	116.1	152215756A	2016-09-20	51.9	0.519	2015-04-13	136.4	36.5	0.372
2016	116.8	152217687A	2016-09-19	56.9	0.775	2015-04-13	136.4	41.2	0.565
2015	125.1	152218005A	2015-09-25	45.4	0.345	2015-04-13	136.4	47.1	0.364
2016	115.8	152218005A	2016-09-20	49.0	0.431	2015-04-13	136.4	47.1	0.364
2016	116.4	152218071A	2016-09-16	61.5	0.851	2015-05-04	136.9	45.0	0.754
2016	117.4	152218071A	2016-09-30	60.3	0.833	2015-05-04	136.9	45.0	0.754
2016	117.2	152218402A	2016-09-19	65.4	0.840	2015-04-13	136.4	47.1	0.777
2016	115.6	152218686A	2016-09-20	63.5	0.861	2015-04-13	136.4	45.0	0.656
2016	131.2	152220301A	2016-09-07	57.7	0.630	2015-05-04	136.9	43.7	0.527
2016	120.5	152220390A	2016-09-15	65.5	0.946	2015-05-04	136.9	47.6	0.791
2016	117.3	152221151A	2016-09-22	54.8	0.590	2015-05-04	136.9	43.0	0.510
2016	116.6	152221326A	2016-09-19	55.9	0.713	2015-05-04	136.9	42.0	0.614
2016	110.7	152221345A	2016-09-22	60.2	0.720	2015-04-13	136.4	45.4	0.568
2010	125.3	4A0D3C3446	2010-10-01	54.6	0.570	2009-06-26	116.8	23.5	0.080
2011	117.7	4A0D3C3446	2011-09-23	57.9	0.790	2009-06-26	116.8	23.5	0.080
2012	110.4	4A0D3C3446	2012-09-25	64.6	0.960	2009-06-26	116.8	23.5	0.080
2013	110.7	4A0D3C3446	2013-09-18	71.3	1.375	2009-06-26	116.8	23.5	0.080
2015	117.6	4A0D3C3446	2015-10-06	81.5	1.954	2009-06-26	116.8	23.5	0.080

[1] Table 2 data demonstrates a degree of measuring error when sampling length and weight of recaptured fish (ID07A). Although measuring error is inherent in field data, attempts can be made to reduce this. For juvenile length measurement, it may be more accurate to use a flat surface with a measuring tape attached rather than using an unattached measuring tape. It may also be more accurate to compare fork length instead of total length because the top lobe of the heterocercal caudal fin can be damaged or missing, especially in older fish.

2016	124.9	4A0D3C3446	2016-09-14	80.0	1.918	2009-06-26	116.8	23.5	0.080
2016	117.3	4A0D3F5F1E	2016-09-16	88.4	2.193	2009-06-26	137.3	23.5	0.081

The survival rate of hatchery-origin juveniles in the Nechako River (to date) is still indeterminable. We know from other sturgeon stocking programs that survival can be very high (e.g. Columbia River) or very low (e.g. Kootenay River). Since larger-scale juvenile stocking in the Nechako River has only been recently been undertaken, we need to continue gathering data to assess relative abundance of individuals from different release years. This sampling will continue to provide valuable details on possible "pulse" years for wild recruitment

Age Structure Analysis

Twelve finrays from wild sturgeon not previously captured were aged by sectioning and counting annular growth rings. Aging results are displayed in Table 3. Five of the 12 (42%) new wild juveniles were 5 years old ("born" in 2011), four of the 12 (33%) were born in 2012. Two juveniles (17%) were born prior to 2011, and one juvenile (8%) was born 2013. Wild juveniles born after 2013 probably have not grown to target size of sampling gear. The majority of new wild juveniles being born in 2011 and 2012 is significant because 2011 was the first year of having remediated spawning habitat installed for spawning season, and then any years after are also important for evaluating the remediation effort.

Table 3. Summary of "new" wild sturgeon ages from 2016 sampling organized by descending age.

PIT	Age	Spawn Year
486A606827	11	2005
4875523B48	6	2010
491A4E6212	5	2011
486A387A37	5	2011
491B41540d	5	2011
4875414844	5	2011
487516677E	5	2011
48767d1A44	4	2012
486B2A1569	4	2012
484913114F	4	2012
49172B0234	4	2012
486A320B20	3	2013

By-Catch Summary

Northern pike-minnow are the most abundant bycatch species (CPUE 0.739/ 100 hook-hours), followed by sculpin, bull trout, and rainbow trout (Table 4). Burbot and "long nose sucker" are also present in the Nechako River system, but are much rarer than the previously mentioned species. One freshwater clam was also captured.

Table 4. Number of bycatch species encountered during 2016 juvenile white sturgeon indexing.

Northern Pike-minnow	Sculpin	Rainbow Trout	Bull Trout	Sucker	Freshwater Clam	Burbot	Whitefish
268	13	4	3	1	1	1	0

General Conclusions

General comments and conclusions on 2016 juvenile white sturgeon index program are provided below.

Catch, CPUE and Sampling Methods

110 juvenile white sturgeon were captured during 2016 sampling efforts (105 individual juveniles, and 5 juveniles were captured twice within the 2016 sampling), which is the highest number of juveniles captured in any year of the juvenile index project. This was an anticipated result due to the large release of hatchery juveniles (9,175) in 2016. Seventy-one percent (71%) of the 2016 captures were 1-year old hatchery juveniles released in 2016, 13% of the 2016 captures were 2-year old hatchery juveniles released as 1-year olds in 2015, 9% were 5-year and 4-year old wild juveniles captured for their first time, 4% were 6 years or older (oldest being 12-year old wild juvenile), and 1% of the sample (one wild juvenile) was 3 years old. The relatively large proportion of 4 and 5-year old wild juveniles could represent a recruitment pulse related to remediation efforts (2011), and one might expect that pulse to grow as those fish grow into catchable size.

Juvenile white sturgeon CPUE was 0.3032 juvenile WSG / 100 hook-hours, which is relatively high compared to previous years. The high CPUE was expected due to the large hatchery release. In 2015 CPUE was lower than expected despite a hatchery release of approximately 1,250 juveniles. In 2015 76 setlines and ~60,000 hook-hours were recorded, versus 93 setlines and ~36,000 hook hours in 2016. The difference in CPUE may have been related to the setline methods between the two years; in 2015 a fewer number of lines were set but each setline had 40 hooks, and in 2016 a greater number of lines were set but each setline had 20 hooks.

Juvenile Distribution & Habitat Use/Preference

The distribution of juvenile white sturgeon captures in 2016 shows the habitat unit surrounding and including rkm 117 is the most heavily occupied area within the index region. This habitat unit has consistently provided the greatest number of juvenile white sturgeon captures throughout the index region.

Habitat units near rkm 110, rkm 120, rkm 125, and rkm 130 are also areas that juvenile white sturgeon occupy. These locations are typically associated with river bends and relatively deep benthic conditions. In general, these areas are also locations adult sturgeon occupy as well.

Status of Juvenile Recruitment

Results from 2016 sampling indicated similar catch rates for 2015-hatchery releases and wild-origin juveniles, suggesting 2015-releases are approximately equally abundant as wild-origin juveniles within the index region. It is important to remember that this comparison is between one year class (2015-releases) and a range of year classes (the wild-origin juveniles). None-the-less it is favourable to know the release of 1,250, or even 9,175 had not diluted the wild-origin stock to undetectable levels. On the other hand, catching a similar number of wild-origin fish and 2015-releases may indicate after one year in the wild the 2015-releases are experiencing the same recruitment bottleneck as wild-origin juveniles.

Wild juvenile recruitment appears to have been relatively successful in 2011 and 2012 spawn years. Wild juvenile ages from new captures in 2016 suggest 2011 recruits are 5x more abundant than 2010 or 2006 recruits. This is significant because 2011 was the first year spawning habitat remediation was installed for spawning season. These results suggest the remediation effort may have had a positive effect on recruitment. However, it is too early to estimate the number or relative proportion of 2011 recruits (and recruits born after 2011) as these wild fish are probably still growing into target size of the sampling gear. A comprehensive analysis taking all juvenile sampling years into consideration will provide a clearer picture of wild juvenile recruitment.

Juveniles from 2006-08 release years were released as 6-month olds, and are not reflected in 2016 catch, or other recent samples. It is assumed that small juveniles (e.g. 6 months old) experience high predation pressure and are unable to recruit into the population. This assumes predation pressures from other fish species (e.g. northern pike-minnow, bull trout, rainbow trout) and other riverine predators (e.g. river otter, bald eagle) are likely a major cause of juvenile mortality. Efforts to understand these pressures must be put forth to ensure recruitment of both hatchery and wild juvenile sturgeon into the Nechako River population.

Preliminary information from the index program (since 2015 and 2016 hatchery releases) suggests that 1-yearold hatchery releases are experiencing higher rates of mortality in the river than anticipated.

Recommendations

Based on results from 2016 and the objectives of the juvenile sampling/monitoring program, the following recommendations are provided to guide future work of this nature.

1) Juvenile focused setlining should continue to be employed as the primary sampling method used for work of this nature.
2) Juvenile length measurements should be taken using a measuring device attached to a flat surface.
3) Sampling should continue annually for the purposes of assessing and monitoring the status of wild recruitment and the survival rates of hatchery-origin white sturgeon. This is particularly important given the initial release of 1-year old juveniles in the springs of 2015 and 2016 and anticipated annual releases thereafter. Understanding growth and survival will be fundamentally important to adaptively managing release strategies.
4) Sampling should continue annually for the purposes of monitoring juvenile survival, distribution and habitat use.
5) Sampling should be targeted to occur in September to align with falling temperature and discharge, among other seasonal factors such as photoperiod. Results in 2016 re-affirmed the importance of the September period.
6) DNA analysis of wild-recruited individuals originating from 2011 should be considered to determine their parentage.
7) There are now several years of juvenile-focused sampling data. The cumulative data should be summarized and analyzed.
8) Future reports on Nechako River juveniles should use fork length instead of total length, including the comprehensive report mentioned in recommendation 7.
9) Sampling outside of the core area should be considered, including downstream to the first major bend after the Nechako-Stuart confluence and in key areas upstream of Vanderhoof to the mouth of the Nautley River.
10) Sampling using 20 hooks on a juvenile setline is preferable to 40 hooks. Data suggests the number of setlines deployed has a greater impact on capture success than increasing hook hours.

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Appendix 1 - Biophysical data for juvenile white sturgeon captured in 2016.

Pull Date	River Kilometre	PIT	Origin	TL	Girth	WT
2016-09-01	132.7	0A181C3F08	Hatchery	42.2	13.9	0.246
2016-09-01	132.7	152211107A	Hatchery	60.1	19.2	0.708
2016-09-01	132.7	0A181C2A01	Hatchery	45.7	15.0	0.301
2016-09-01	132.4	0A181C2111	Hatchery	46.0	15.1	0.298
2016-09-01	132.4	0A181C2B3F	Hatchery		15.9	0.347
2016-09-07	131.4	0A181C4834	Hatchery	42.7	13.3	0.256
2016-09-07	131.4	0A181C3F5B	Hatchery	42.1	13.3	0.244
2016-09-07	131.4	0A181B7A06	Hatchery	49.3	15.2	0.382
2016-09-07	131.2	152220301A	Hatchery	57.7	17.8	0.630
2016-09-08	130.0	0A181C2771	Hatchery	43.3	13.0	0.241
2016-09-13	125.6	0A181C1211	Hatchery	50.7	15.3	0.402
2016-09-14	125.0	0A181C0B54	Hatchery	44.5	14.0	0.305
2016-09-14	124.9	0A181C107A	Hatchery	45.0	14.2	0.320
2016-09-14	124.9	4A0D3C3446	Hatchery	80.0	24.5	1.918
2016-09-15	120.5	0A181C2A78	Hatchery	42.0	15.0	0.287
2016-09-15	120.5	152220390A	Hatchery	65.5	19.5	0.946
2016-09-15	117.6	0A181C442A	Hatchery	42.2	14.3	0.268
2016-09-15	117.4	0A181C4B0F	Hatchery	47.8	14.2	0.308
2016-09-15	117.4	0A181B7430	Hatchery	54.4	16.6	0.406
2016-09-15	117.4	486B2A1569	Wild	67.5	20.8	1.170
2016-09-15	117.7	0A181C1A70	Hatchery	48.9	14.7	0.342
2016-09-15	117.7	0A181C0A18	Hatchery	45.6	14.4	0.300
2016-09-15	117.7	0A181C0B4F	Hatchery	49.6	15.4	0.426
2016-09-15	117.3	0A181C217C	Hatchery	49.7	14.5	0.348
2016-09-15	117.3	0A181C2A2F	Hatchery	52.9	15.6	0.419
2016-09-15	117.3	0A181C4932	Hatchery	39.9	13.0	0.218
2016-09-15	117.3	0A181C4D08	Hatchery	45.9	14.5	0.308
2016-09-15	117.3	484913114F	Wild	56.0	18.0	0.654
2016-09-15	117.2	0A181C4748	Hatchery	41.0	13.0	0.250
2016-09-15	117.2	0A181C445D	Hatchery	47.7	14.3	0.347
2016-09-15	117.2	0A181C4859	Hatchery	45.2	15.0	0.338
2016-09-15	117.1	0A181C0E06	Hatchery	49.9	16.0	0.393
2016-09-15	117.1	0A181C2B35	Hatchery	51.2	15.5	0.447
2016-09-15	117.1	0A181B7D76	Hatchery	46.1	15.4	0.318
2016-09-15	117.1	0A181B7116	Hatchery	43.5	14.2	0.268
2016-09-16	116.7	49172B0234	Wild	69.0	21.5	1.080
2016-09-16	116.5	0A181C264C	Hatchery	41.1	13.1	0.217
2016-09-16	116.5	0A181C0E24	Hatchery	51.4	15.6	0.409
2016-09-16	116.5	0A181C287C	Hatchery	51.7	16.3	0.420

2016-09-16	116.4	6C00073009	Wild	75.7	35.3	1.798
2016-09-16	116.4	152215765A	Hatchery	63.5	20.0	0.860
2016-09-16	116.4	152218071A	Hatchery	61.5	20.0	0.851
2016-09-16	116.4	0A181C201A	Hatchery	45.5	14.7	0.288
2016-09-16	116.4	0A181C2A6B	Hatchery	45.4	14.5	0.299
2016-09-16	116.4	0A181C0927	Hatchery	41.5	14.4	0.247
2016-09-16	117.4	0A181B7822	Hatchery	40.6	13.2	0.238
2016-09-16	117.4	0A181C3F23	Hatchery	44.6	13.8	0.259
2016-09-16	117.3	0A181C212C	Hatchery	44.9	14.0	0.297
2016-09-16	117.3	4A0D3F5F1E	Hatchery	88.4	26.3	2.193
2016-09-16	117.3	0A181C4C10	Hatchery	46.8	14.1	0.285
2016-09-16	117.3	0A181C1A14	Hatchery	52.8	15.8	0.417
2016-09-16	117.2	486A320B20	Wild	50.6	16.5	0.480
2016-09-19	117.3	0A181C1D33	Hatchery	43.7	14.0	0.265
2016-09-19	117.3	0A181C0B7A	Hatchery	44.5	13.6	0.276
2016-09-19	117.3	0A181C1870	Hatchery	47.7	15.0	0.328
2016-09-19	117.3	0A181C1A35	Hatchery	51.2	17.6	0.460
2016-09-19	117.2	0A181C445D	Hatchery	47.9	14.6	0.339
2016-09-19	117.2	0A181C0F6B	Hatchery	44.5	13.0	0.251
2016-09-19	117.2	0A181B7270	Hatchery	49.4	14.9	0.370
2016-09-19	117.2	152218402A	Hatchery	65.4	19.0	0.840
2016-09-19	116.9	487516677E	Wild	59.7	18.2	0.712
2016-09-19	116.8	152217687A	Hatchery	56.9	20.1	0.775
2016-09-19	116.6	152221326A	Hatchery	55.9	19.5	0.713
2016-09-19	116.5	0A181C1549	Hatchery	44.4	13.5	0.272
2016-09-19	116.2	0A181C2B00	Hatchery	46.2	15.1	0.334
2016-09-19	116.2	0A181B746B	Hatchery	45.3	14.0	0.278
2016-09-16	116.9	0A181B7D2A	Hatchery	48.8	15.1	0.362
2016-09-19	116.4	48752A0F62	Wild	83.3	26.2	1.925
2016-09-19	116.4	0A181C232C	Hatchery	51.4	15.6	0.360
2016-09-19	116.4	0A181C4141	Hatchery	40.2	13.3	0.209
2016-09-19	116.4	491A4E6212	Wild	69.5	20.6	1.060
2016-09-20	117.4	0A181C242C	Hatchery	54.6	16.9	0.465
2016-09-20	117.4	0A181C4B50	Hatchery	44.2	14.1	0.261
2016-09-20	117.4	0A181C1B2E	Hatchery	48.8	14.6	0.329
2016-09-20	117.3	0A181C1409	Hatchery	48.6	15.5	0.326
2016-09-20	117.2	48767D1A44	Wild	47.9	15.0	0.397
2016-09-20	116.1	152215756A	Hatchery	51.9	16.6	0.519
2016-09-20	116.0	486A387A37	Wild	76.0	23.0	1.356
2016-09-20	115.8	4875523B48	Wild	76.0	24.8	1.610
2016-09-20	115.8	152218005A	Hatchery	49.0	16.1	0.431
2016-09-20	115.7	0A181B7D22	Hatchery	40.7	13.0	0.236
2016-09-20	115.6	152218686A	Hatchery	63.5	19.9	0.861

2016-09-20	115.6	152213787A	Hatchery	63.1	19.5	0.835
2016-09-21	115.1	0A181C1960	Hatchery	49.5	15.0	0.358
2016-09-21	115.1	0A181C3219	Hatchery	43.8	12.5	0.244
2016-09-21	114.9	152212794A	Hatchery	64.3	20.5	0.928
2016-09-21	114.9	0A181C0470	Hatchery	54.4	16.4	0.458
2016-09-21	114.8	0A181C4804	Hatchery	43.4	13.0	0.241
2016-09-21	114.8	487519543C	Wild	77.6	24.0	1.700
2016-09-21	114.8	0A181C4C02	Hatchery	47.8	14.1	0.316
2016-09-22	110.2	0A181C4745	Hatchery	50.2	15.5	0.365
2016-09-22	110.3	491B41540D	Wild	66.5	20.4	1.064
2016-09-22	110.7	152221345A	Hatchery	60.2	18.7	0.720
2016-09-22	117.3	152221151A	Hatchery	54.8	17.1	0.590
2016-09-22	117.3	4875414844	Wild	65.2	19.5	0.898
2016-09-29	117.3	0A181C0B7A	Hatchery	43.0	15.0	0.285
2016-09-29	117.3	0A181C2161	Hatchery	43.9	14.5	0.254
2016-09-29	117.2	0A181C1870	Hatchery	46.5	16.3	0.333
2016-09-29	117.2	0A181B7D40	Hatchery	42.1	14.9	0.274
2016-09-29	117.2	0A181C2B39	Hatchery	49.8	16.0	0.442
2016-09-29	117.1	0A181C2B1C	Hatchery	48.6	15.7	0.392
2016-09-29	117.1	0A181C3366	Hatchery	43.6	15.2	0.350
2016-09-30	117.4	152218071A	Hatchery	60.3	21.0	0.833
2016-09-30	117.4	0A181C0F45	Hatchery	50.1	16.6	0.392
2016-09-30	117.3	0A181C0A71	Hatchery	45.2	14.9	0.321
2016-09-30	117.3	487516677F	Wild	59.7	18.2	0.712
2016-09-30	117.3	4875296214	Hatchery	47.5	15.3	0.325
2016-09-30	117.3	0A181C0431	Hatchery	42.3	15.4	0.276
2016-09-30	117.3	486A606827	Wild	92.4	29.6	3.207
2016-10-04	117.4	0A181C1974	Hatchery	50.4	16.2	0.355