SUMMARY REPORT

STATUS OF WHITE STURGEON IN THE LOWER FRASER RIVER

REPORT ON THE FINDINGS OF THE LOWER FRASER RIVER WHITE STURGEON MONITORING AND ASSESSMENT PROGRAM

2016

BY

TROY C. NELSON[1]

DAVID ROBICHAUD[2]

TONY MOCHIZUKI[2]

JIM RISSLING[2]

KARL K. ENGLISH[2]

WILLIAM J. GAZEY[3]

FRASER RIVER STURGEON CONSERVATION SOCIETY

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[1] TCNelson Consulting, Sheldon, Queensland 4157 Australia (*troyaustralia@bigpond.com*)
[2] LGL Limited environmental research associates, 9768 Second Street, Sidney, BC V8L 3Y8
[3] W. J. Gazey Research, 1214 Camas Court, Victoria, BC V8X 4R1

EXECUTIVE SUMMARY

The Fraser River Sturgeon Conservation Society (FRSCS), a not-for-profit charitable organization founded in 1997, has a mandate to conserve and restore wild Fraser River White Sturgeon, raise public awareness of Fraser River White Sturgeon and their ecosystem, and produce reliable information regarding the status of Fraser River White Sturgeon and their habitat. This summary report provides abundance and status assessments (as of January 2016) derived from the FRSCS' Lower Fraser River White Sturgeon Monitoring and Assessment Program.

Originally developed in 1999, this program uses a true "stewardship" approach to address objectives and generate field data. Since April 2000, the program has relied on the volunteer contributions of angling guides, recreational, commercial, and Aboriginal fishermen, test fishery and enforcement personnel, and various fishery monitors. Volunteers from these sectors were trained to sample and tag White Sturgeon, and record and transfer data. By January 2017, volunteers had conducted 142,789 sampling events (7,882 in 2016), tagged and released 66,904 sturgeon (2,170 in 2016), and documented 69,667 recapture events of tags applied by FRSCS volunteers within the general study area in the lower Fraser River (5,610 in 2016).

Abundance estimates presented in this report were derived from a Bayesian mark-recapture model, which has been used since 2000. The mark-recapture inputs were limited to sturgeon of 60-279 cm fork length (FL), a rolling temporal period of 24 months, and four spatial sampling regions (the combination of which comprised the core assessment area in the lower Fraser River). The model incorporates information of tag distribution, seasonal mixing, growth, and estimates of mortality, emigration, and observer error. The Bayesian model produces our best estimates of the abundance of 60-279 cm FL White Sturgeon in the core assessment area of the lower Fraser River during each 24-month period.

The core assessment area includes 187 km of the lower Fraser River mainstem downstream of Lady Franklin Rock (near Yale), the lower sections of the Pitt and Stave rivers, and the Harrison River. Although White Sturgeon are captured and sampled by FRSCS volunteers throughout the general study area, over 98.4% of all samples collected since 2000 have been taken within the core assessment area. By consistently imposing this spatial limitation from 2000 to the present, abundance estimates can be compared among assessment years.

Importantly, the 2016 assessment year is the first for which the analytical model used the size range of 60-279 cm FL to produce abundance estimates. Prior to 2016, the size range used was 40-279 cm FL, but because of lower sample sizes and associated confidence, it was decided to exclude the 40-59 cm size group from the abundance analyses. The high levels of confidence associated with reported abundance estimates for 60-279 cm FL Lower Fraser River White Sturgeon provide corresponding levels of utility for conservation assessment and management of that population. We have rerun the assessment models back to 2000 using the new size range, thus all abundance estimates presented in this report differ from previously published values.

Abundance Estimates and Trends

As of January 2016 (the mid-point of the 24-month data window that ran from January 2015 to December 2016) the mean abundance estimate for White Sturgeon from 60-279 cm FL in the core assessment area of the lower Fraser River was 43,196 (95% CLs ± 8.5% of the estimate). The average abundance of White Sturgeon in 2016 in the section of the core assessment area downstream of the Mission Railway Bridge was 20,277 (46.9% of the total abundance estimate). In the section of the core assessment area upstream of the Mission Railway Bridge (to Lady Franklin Rock near Yale), the average abundance was 22,919 (53.1% of the total abundance estimate). The total abundance estimate for the entire core assessment area for the 2016 assessment year was

4.1% lower than the respective 2015 estimate, and 23.4% lower than the program's peak abundance estimate in 2003.

The observed decline in the total abundance of White Sturgeon in the lower Fraser River since 2003 was likely driven mostly by declines in juvenile recruitment into the population, as during this same time period increases in abundance have occurred for larger-sized sturgeon (in most size groups above 140 cm FL). While an increasing number of larger-sized sturgeon provides potential security for population rebuilding and recovery, this can only be realized if juvenile recruitment occurs at a level sufficient to maintain and grow the population over time.

Recruitment Decline – Comparisons of annual abundance estimates of White Sturgeon generated by the Bayesian mark-recapture model indicate that since 2004 significant reductions have occurred in the smallest size groups (60-79 cm FL, and 80-99 cm FL), which suggests there have been declining levels of juvenile recruitment into the population (at those sizes) as compared to respective recruitment levels prior to 2004. The 2016 program has documented three lines of evidence to suggest that juvenile recruitment is currently a primary concern for the long-term sustainability of the Lower Fraser River population of White Sturgeon:

- Results of the mark-recapture modelling indicated that since 2004 there has been a 69% decline in the estimated abundance of 60-99 cm FL juvenile sturgeon in the core assessment area of the lower Fraser River.
- The proportion of juvenile White Sturgeon less than 100 cm FL in the total measured sample captured by angling decreased 55% between 2000 and 2016.
- The proportion of juvenile White Sturgeon less than 100 cm FL in the total measured sample captured by the Albion Test Fishery decreased 66% between 2000 and 2016.

Growth

Average annual growth rates for most size groups of 60-179 cm FL White Sturgeon were greater before versus after 2005. The average growth rate for all size groups in 2016 (3.6 cm/year) was the lowest annual growth rate observed since the beginning of the program, and was well below the highest average annual growth rate of 5.7 cm/year observed in 2002.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Given conservation concerns for White Sturgeon (*Acipenser transmontanus*) in the lower Fraser River (e.g., COSEWIC 2012) there is a need for long-term monitoring of the population, including comprehensive and scientifically rigorous estimates of abundance. To that end, the Lower Fraser River White Sturgeon Monitoring and Assessment Program was initiated by the Fraser River Sturgeon Conservation Society (FRSCS) in April 2000, and has continued into 2017. The primary objectives of the program are to: 1) obtain abundance estimates of White Sturgeon in the lower Fraser River; 2) produce reliable information regarding seasonal abundance of White Sturgeon, by location, in the lower Fraser River; 3) ascertain seasonal migration and movement patterns of White Sturgeon in the lower Fraser River; and 4) increase public awareness regarding the conservation and preservation of White Sturgeon in British Columbia. The program uses a volunteer-based “stewardship” approach, initially developed in 1999, to address objectives and generate field data. Since 2000, the program has relied on the contributions of volunteers from several sectors, including recreational anglers, angling guides (including licensed, unlicensed, and assistant guides), First Nations and commercial fishers, test fishery staff (including the Albion and Pacific Salmon Commission test fisheries), fishery monitors (First Nation and federal), enforcement officers (First Nation, provincial, and federal), students, academic researchers, and provincial staff from the BC Ministry of Forests, Land and Natural Resource Operations (MFLNRO) and the BC Ministry of Environment (MOE).

This summary report presents the findings of the Lower Fraser River White Sturgeon Monitoring and Assessment Program for the 2016 assessment year. For additional information regarding the biology of White Sturgeon and history of Fraser River White Sturgeon, see Hildebrand et al. (2016) and Nelson et al. (2013a).

FIELD AND ANALYTICAL METHODS

Study Area

The general study area for the Lower Fraser River White Sturgeon Monitoring and Assessment Program is the Fraser River watershed downstream of Hell’s Gate, which is located at river kilometer (rkm) 212 on the mainstem Fraser River (Figure 1). The general study area is essentially the extent of known and observed White Sturgeon distribution in both the mainstem Fraser River and all tributaries and lakes connected to the lower Fraser River, downstream of Hell’s Gate. For the purpose of abundance estimation associated with this project, we have defined a “core assessment area” within the general study area; this area includes 187 km of the lower Fraser River mainstem downstream of Lady Franklin Rock (near Yale), the lower sections of major tributaries (Pitt and Stave rivers), and the Harrison River (Figure 1). The core assessment area is a subset of the general study area; it excludes areas of known White Sturgeon distribution, including all marine waters, the entire North Arm and adjacent Middle Arm of the Fraser River, the lower Pitt River upstream of the Highway 7 Bridge, Pitt Lake, Harrison Lake, and the section of the upper Fraser Canyon between Lady Franklin Rock and Hell’s Gate. Although White Sturgeon are captured and sampled by FRSCS volunteers throughout the general study area, over 98.4% of all samples collected since 2000 have been taken within the core assessment area. Since the beginning of the program in 2000, sampling data used for abundance modelling have been limited to those samples collected within the boundaries of the core assessment area, thus allowing direct comparison of annual abundance estimates among assessment years.

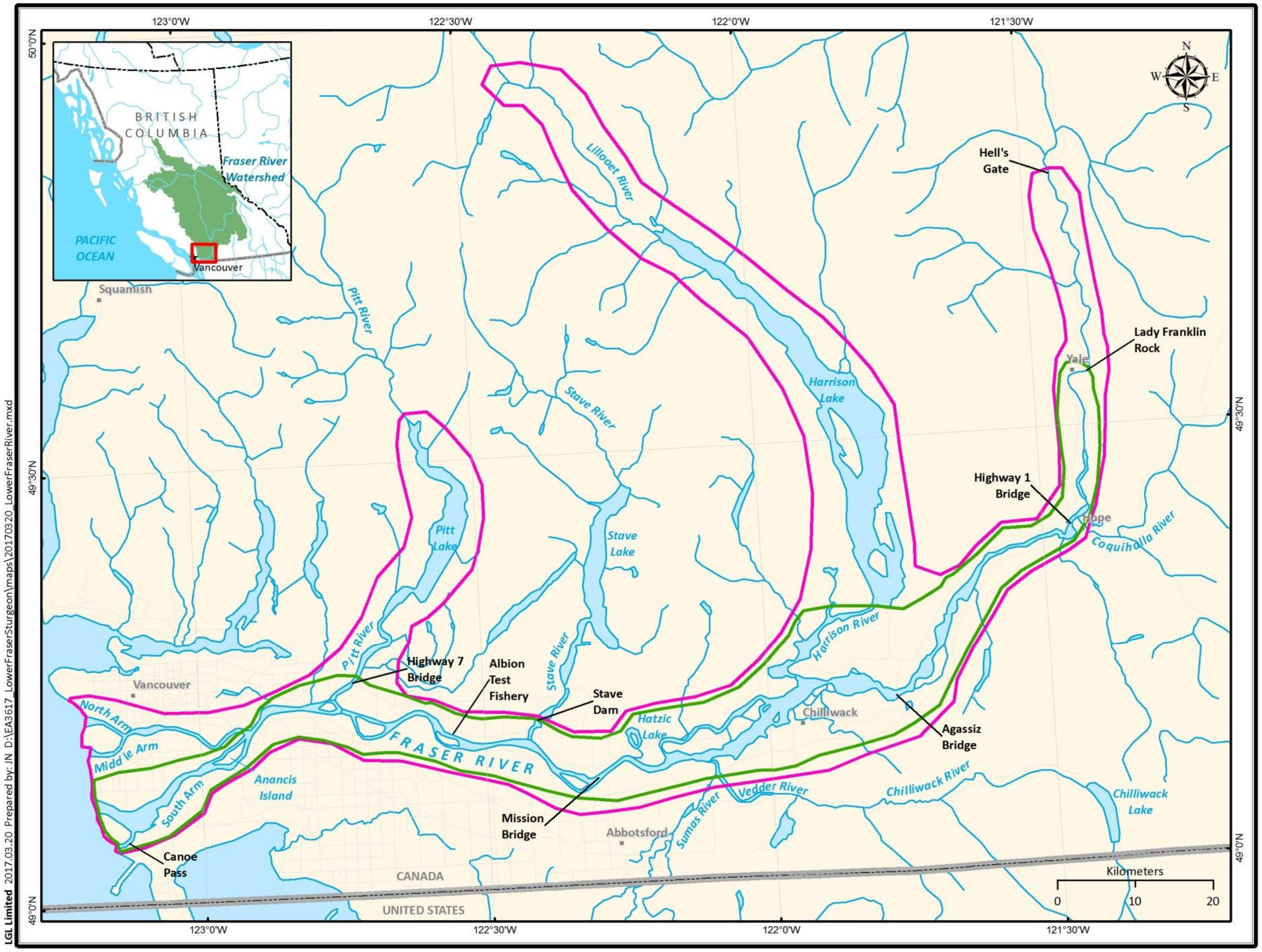

Figure 1. General study area (area within red line), and the core assessment area (area within green line; used for the production of White Sturgeon abundance estimates presented in this report). The general study area as illustrated presents the extent of known/observed White Sturgeon distribution in the lower Fraser River watershed downstream of Hell's Gate.

Sturgeon Capture and Handling Procedures

Program staff trained all volunteers that contributed to the tag and recapture database. Volunteers were trained in the field, typically on their own boat. Sturgeon capture, handling, and sampling procedures, designed to minimize stress and injury (McLean et al. 2016), were developed in partnership with provincial fishery managers. Scientific sampling permits, issued by both provincial and federal regulatory authorities, included the specified handling procedures as conditions of the respective permits. Accordingly, program volunteers were trained to use specific handling procedures when sampling live sturgeon. The sampling and tagging of at least one sturgeon was required to fulfill the training requirements, but in most cases several sturgeon were captured and tagged during training exercises.

Volunteers were trained to scan captured sturgeon for the presence of a “PIT” (passive integrated transponder) tag, record all tag recapture data (from any PIT tag or external tag), apply new PIT tags, take fork length (FL) and girth measurements, complete a standard sampling data sheet (Appendix A), and secure and transfer data. Although volunteers were trained to sample all sturgeon captured, some sturgeon were not sampled due to time constraints and conflicting priorities (e.g., safety concerns). Volunteers who captured sturgeon by angling were required to use adequate fishing equipment (strong rods and reels, line test of at least 130-pound breaking strength), and to keep all sturgeon over 150 cm FL in the water while sampling. Sturgeon less than 150 cm FL were placed in a custom "sturgeon sling" (much like a stretcher) that contained water and supported the fish being sampled. For volunteers involved with commercial and First Nations net fisheries, emphasis was placed on exercising extra care when extricating sturgeon from gill nets (including the cutting of net, if needed) to reduce capture impacts and increase the rate of post-release survival. From 2000-2005, field data collections included sturgeon sampled as part of the FRSCS’ Lower Fraser River First Nations White Sturgeon Stewardship Program; those sturgeon, intercepted in salmon gill nets, were placed in floating enclosures (provided by the FRSCS and anchored in close proximity to the fishing locations) and were removed, sampled, and released by program personnel on a daily basis (Nelson et al. 2008).

Documentation of Capture Location

A simple mapping system was established to facilitate the documentation of capture locations to the nearest 0.5 rkm. Waterproof maps, delineated with rkms, were provided to all volunteers as part of the tagging equipment kit. Documentation of sturgeon capture location at this scale (closest 0.5 rkm) was important to confirm sturgeon presence at specific locations and habitat types, by season.

In order to document the general location of applied angler effort and catch, a series of sampling zones (adjacent sections of the river) was established within the core assessment area (Table 1). Zone boundaries were established based mainly on stationary geographical elements such as channel intersections, bridge crossings, and tributary confluences. Each sampling zone comprised a unique set of rkms, and was assigned to a specific sampling region (A, B, C, and D; Table 2, Figure 2). Two of the sampling regions (A and B; Figure 2) were in the designated “tidal” waters downstream of the Mission Railway Bridge, where recreational fisheries are managed by Fisheries and Oceans Canada. The remaining two sampling regions (C and D; Figure 2) were in the designated “non-tidal” waters upstream of the Mission Railway Bridge, where MFLNRO manages the recreational fisheries.

Table 1. Sampling zones used for abundance estimation of White Sturgeon, 2015-2016.

Zone	River Km	From	To
S*	0-25	Georgia Strait	Eastern Annacis Island
3, 5**	26-56.5 & P0-P4	Eastern Annacis Island	McMillan Island (Glover Road)
6, 7***	57-78	McMillan Island (Glover Road)	Mission Railway Bridge
8	79-93	Mission Railway Bridge	Mouth of Sumas River
10	H0-H21	Confluence Fraser River	Outlet of Harrison Lake
12	94-122	Mouth of Sumas River	Agassiz Bridge
13	123-158	Agassiz Bridge	Hwy 1 Bridge (Hope)
14	159-187	Hwy 1 Bridge (Hope)	Lady Franklin Rock (Yale)

* Zone S is the Main (South) Arm including Canoe Pass
** Zone 5 includes the lower 4 kms of the Pitt River, from the Fraser mainstem to the Hwy 7 Bridge (rkm P0-P4)
*** Zone 7 is the lower 2 kms of the Stave River, downstream of the dam (rkm ST0-ST2)

Table 2. Sampling regions (A, B, C and D) used for abundance estimation of White Sturgeon, 2015-2016. Individual sampling regions are comprised of unique sampling zones (Table 1). The core assessment area is comprised of all four sampling regions (Figure 2), and includes the Harrison River and portions of the lower Pitt and lower Stave rivers (Figure 1).

Region	Zones	Description
A	S	Georgia Strait to Eastern Annacis Island (South Arm of Fraser)
B	3, 5, 6, 7	E. Annacis Is. to Mission Railway Bridge; lower 4 km of Pitt River (below Hyw 7 bridge); lower Stave River (below dam)
C	8, 10, 12, 13	Mission Railway Bridge to Hope including the Harrison River
D	14	Hwy 1 Bridge (Hope) to Lady Franklin Rock (Yale)

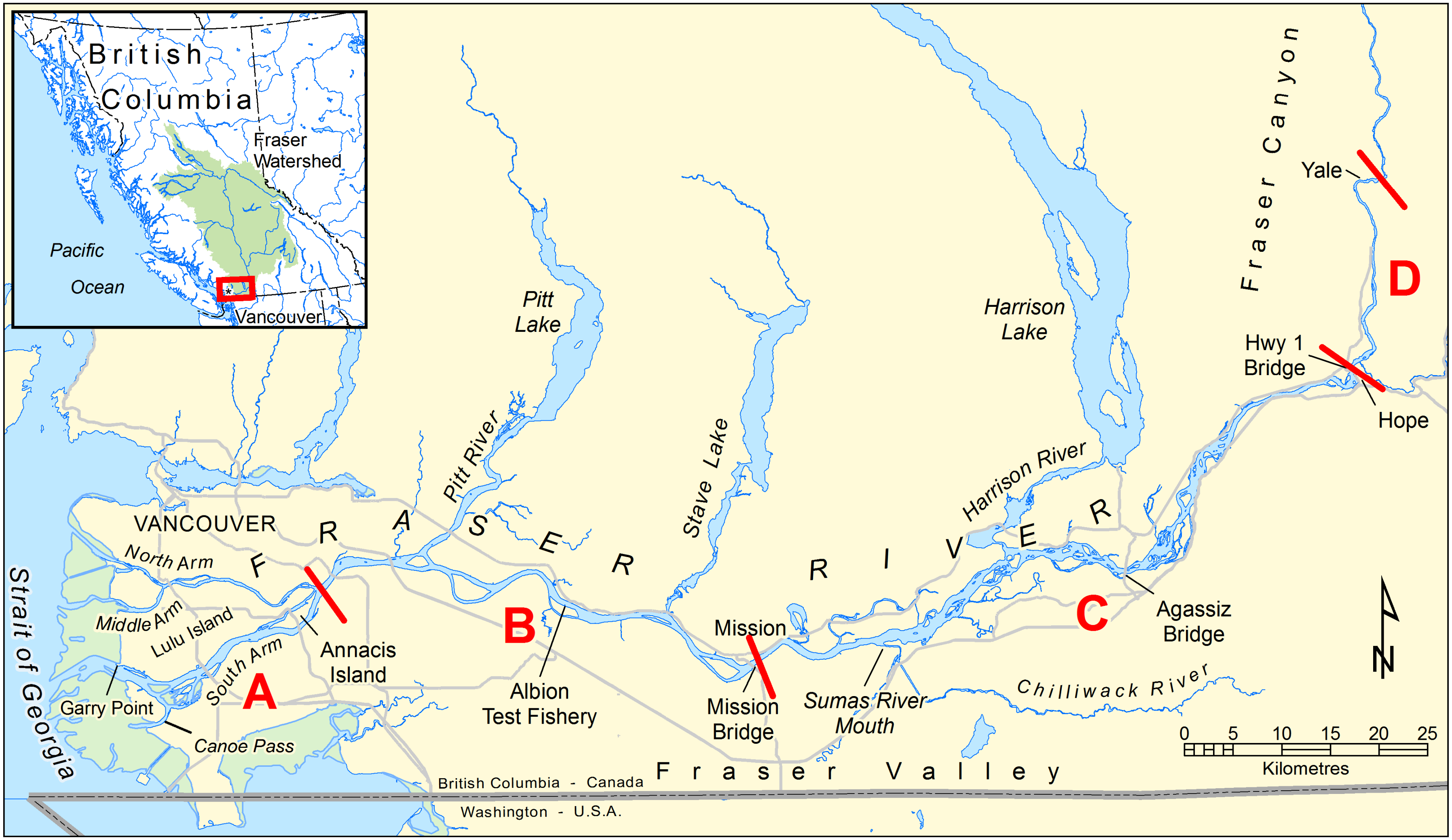

Figure 2. Boundaries of the four sampling regions (A, B, C, and D) that comprise the core assessment area used to generate abundance estimates of White Sturgeon presented in this report. Each sampling region is made up of individual sampling zones used in the analytical model to stratify tag release and recapture data; see Table 1 for a description of sampling zone locations. See Table 2 for a description of the boundaries for each sampling region. See Figure 1 for an illustration of the core assessment area.

Tagging

The marking of White Sturgeon with PIT tags has been used for movement and abundance analyses by researchers and resource managers since the early 1990s (Rein et al. 1994, Nelson et al. 2013b). PIT tags used in the study (distributed by Biomark Inc., Boise, Idaho) were injected beneath the skin of sturgeon with a specialized hand-held syringe and hypodermic needle. PIT tag models used in this study were TX1400L and BIO12.A.02 (both 12 mm long), and TX1405L (14 mm long); all tag types were 2 mm in diameter. When scanned with a tag reader, these glass-bodied tags emit a unique 10-digit alphanumeric code at a frequency of 125 kHz. PIT tags were kept in small glass or plastic jars that contained ethyl alcohol for sterilization purposes. Hypodermic needles, used to apply the tags, were also kept in small jars that contained ethyl alcohol.

PIT tags were injected just posterior to the sturgeon's bony head plate, left of the dorsal line, near the first dorsal scute. This PIT tag insertion location, referred to as the "head" location, has been used by sturgeon researchers in both Oregon and Washington, and measured tag retention has been close to 100% (Tom Rien, Oregon Dept. of Fish and Game, pers. comm.). Not all West Coast sturgeon tagging studies have applied PIT tags to the head location; other tag locations include the dorsolateral area, or body cavity near the dorsal fin. Volunteers were trained to scan all alternative areas, and sturgeon recaptured during this study that had a PIT tag in a non-standard location received a new tag in the head location. Tag-recapture data for all tags, regardless of tag type or body location, were recorded and entered in the recapture database.

The tag readers (scanners) used for the program were the hand-held models MPR (125 kHz) and GPR Plus (dual-frequency 125 kHz and 134.2 kHz) distributed by Biomark Inc., and the AVID Power Tracker (125 kHz) from AVID Canada, distributed by PETIDCO, Calgary, Alberta. The tag readers were battery-powered and displayed the tag numbers on a small screen. PIT tags were detected by the reader at a maximum distance of approximately 15 cm; an audible beep was emitted by the reader when a tag was detected. When a captured sturgeon was ready for sampling, a reader was activated and slowly passed over the length of the sturgeon, close to the body. If a tag was detected in the head location, the tag number was recorded on a data sheet as a "head" recapture. If a PIT tag was detected in any other location on the sturgeon, the number was recorded and a comment was made regarding the physical location of the tag, and a new PIT tag was applied in the head location. The readers were also used to scan PIT tags prior to tag application (so that the tag number could be recorded), and, once inserted into the sturgeon, to confirm the active status and number of the applied tag.

Tag Recoveries

An essential element of the abundance model used in this program was the positive identification and documentation of both tagged and non-tagged sturgeon in the sample. PIT tag readers were used exclusively to determine the presence of a PIT tag. The only sturgeon used in the mark-recapture analyses were sturgeon that had been properly scanned for the presence of a PIT tag. In addition, the only recaptures used in the analyses were tags applied in the head location by this program. Other sturgeon tagging projects in the Fraser River, the Columbia River, and elsewhere have applied both PIT and various types of external tags to sturgeon. Volunteers were trained to record all PIT tag and external tag information observed; for external tags, they recorded the tag type, color, attachment location, and all legible text/numbers. Recapture data from tags outside this program were entered into the core program database, and in many cases original release data were obtained from respective research programs.

Biosampling

All sturgeon included in the sampling program were measured with a flexible measuring tape for:

1) fork length to the nearest 0.5 cm, measured from tip of snout to fork in tail, measured along the side (lateral line); and
2) girth to the nearest 0.5 cm, measured around the body with the tape placed posterior to the pectoral fins at a point just posterior to their insertion point.

The general condition of each sturgeon was assessed prior to tagging, and a record was made of the condition of each fish at the time of release (ranking of 1 to 5: 1 = "vigorous, no bleeding;" 2 = "vigorous, bleeding;" 3 = "lethargic, no bleeding;" 4 = "lethargic, bleeding;" and 5 = "dead"). In addition, all visible wounds, scars, and physical deformities were identified on the data form, and comments were provided to document uncommon or unique observations regarding individual fish (specific morphological features, deformities, injuries, parasites, markings, etc.). A small number of captured sturgeon that exhibited serious wounds or deformities, or were assessed to be in some state of poor condition that could be potentially fatal or affect their normal movement and behavior, were scanned and measured, but released without a tag. When dead sturgeon were encountered by program volunteers, MFLNRO staff were contacted to conduct necropsies. When MFLNRO staff were unavailable, volunteers followed a sampling protocol that was developed in coordination with MFLNRO: sturgeon were scanned for the presence of a PIT tag, measured, and often sexed, assessed for level of maturity, and examined for stomach contents. Comments were provided regarding the state of the mortality (e.g., approximate number of days since death, any obvious wounds or cause of death) prior to "marking" the mortality carcass as having been properly sampled by removing the tail and opening of body cavity (the latter enables the carcass to more easily sink). PIT tag numbers of recaptured mortalities recovered were excluded from subsequent abundance analyses.

Data Management

Volunteers were trained to secure data sheets at the end of each sampling day. The original data were transferred to the field program manager for review; copies of data sheets were retained by the respective volunteer for filing. It was important that all volunteers retained a copy of the data that they provided, not only as a data security measure but also for future reference. The original (paper) data were reviewed by the field program coordinator and transferred to a data management technician for electronic entry. The electronic data were backed up on a secure hard drive; database updates were transferred back to the program manager on a regular basis for review. Annually, a complete (updated) database was provided to the provincial data managers at MOE, typically in February, as per the partnership and program permitting conditions.

Abundance Estimation

We adapted a Bayesian mark-recapture model for closed populations (Gazey and Staley 1986) to accommodate growth, movement, mortality of marked sturgeon, non-detection of marks, and sparse recaptures on any given day or area. Detailed data assembly procedures and mathematical description of the mark-recapture model and model assumptions are provided in Nelson et al. (2004, 2013a, 2016); in the text that follows we present a brief overview of the methodology:

Abundance estimates were bounded by 60-279 cm FL, a rolling data window of two years (e.g., the 2016 estimate consists of data extracted from January 2015 to December 2016), and four spatial sampling regions (Table 2, Figure 2). Note that a sturgeon had to be encountered at least twice in the two-year window to be deemed a recapture; valid recaptures were thus defined as either of the following occurring within a defined 24-month sampling period: 1) an initial tag application/release

Table 3. Parameter estimates for linear and non-linear sturgeon growth models from 2008-2009.

Parameter	Estimate	Std Error	R^2
Linear			
Daily Increment	8.212E-03	4.100E-04	0.158
Non-Linear von-Bertalanffy			
L_∞	532.6	15.8	
g	2.076E-05	1.003E-06	

and one (or more) subsequent recapture(s) of that tag, or; 2) two (or more) separate recapture events for the same tag.

As described in Nelson et al. (2004), estimates of the number of sturgeon sampled, tagged sturgeon available for capture, and recaptures by sampling zone (see Table 1) and day were based on deterministic (assumed known) representations of growth, movement, mortality, and non-detection of marked sturgeon. As is standard practice, we assumed that growth followed the von Bertalanffy curve (see Fabens 1965; Table 3). Growth parameters were estimated from the mark-recapture data (length-at-release, length-at-recapture, and time-at-large). The estimated growth parameters were used to define an increasing size criterion for sampled sturgeon over the two-year window. Movement was defined by the distribution of recaptured tags, weighted by number of sturgeon examined, in eight sets of sampling zones over the two-year window.

Abundance estimates for each sampling region have been produced annually since 2001 (the first year that a complete set of 24 months of sampling data was available). Prior to the 2016 assessment year, the size range used in the abundance model was 40-279 cm FL. In 2016, this size range was changed to 60-279 cm FL as a result of a review of confidence levels associated with estimates of fish smaller than 60 cm FL. For comparative purposes, we have recalculated (and document herein) abundance estimates for assessment years prior to 2016 using the new (60-279 cm FL) size range.

Abundance estimates for 60-279 cm FL White Sturgeon in the core assessment area of the lower Fraser River are presented in this report as follows:

1) “regional estimates”: abundance estimates for each of the four sampling regions A, B, C, and D (2016 only);
2) “total abundance estimates”: total abundance for the core assessment area. The regional estimates were summed to calculate the total abundance for the core assessment area. Confidence intervals for total abundance estimates were calculated by invoking a normal distribution under the central limit theorem with a variance equal to the sum of the variances of the regional estimates. Estimates were produced for each year from 2001 onwards;
3) “size-specific regional estimates”: because sample sizes were large, we were able to subdivide the dataset, and produce abundance estimates for each of three size groups (60-99 cm FL, 100-159 cm FL, and 160-279 cm FL) within each sampling region. Within each region in each year, the three size-specific relative abundances were scaled such that they

summed to the "regional estimate" for the given region in the given year. Estimates were produced for each year from 2004 onwards; and

4) "size-binned estimates": abundance estimates by 20-cm size group. When the dataset was divided into such small bins, sample sizes were insufficient for spatial stratification, hence the sampling regions were disregarded for this analysis. Within each year, the relative abundances of the size-binned estimates were scaled such that they summed to the total abundance estimate for the given year. Estimates were produced for each year from 2004 onwards.

Because the core assessment area included four sampling regions (A-D; see Table 2 and Figure 2), two of which were located downstream of the "tidal" boundary at the Mission Railway Bridge (sampling regions A and B), the program also produced separate abundance estimates of White Sturgeon for the "tidal" and "non-tidal" sections of the lower Fraser River.

Growth Analyses

Fork length data for individual recaptured (tagged) sturgeon were analyzed to determine daily growth rates, based on the number of days-at-large between release and subsequent recapture events. Daily growth rates were expanded to provide estimates of annual growth, and these estimates were pooled and averaged by size group for comparative purposes. Exploratory analyses determined how the years of growth data would be pooled: by minimizing least squares, we determined when the breaks between groupings would occur, and whether three or four groupings would be used.

RESULTS

Sampling Effort for Mark-Recapture Abundance Estimates

From October 1999 through December 2016, program volunteers working in the general study area of the Lower Fraser River White Sturgeon Monitoring and Assessment Program (Figure 1) performed a total of 142,789 unique sturgeon sampling events that included the inspection of sturgeon for the presence of a PIT tag (Appendix B). Of this total sample, 66,904 sturgeon were tagged with a PIT tag (in the head location) and released. The total sample also includes 69,667 recapture events, 46.4% of which were repeat recapture events (recaptures of tagged sturgeon that had been previously recaptured). In addition, the total sample includes 6,195 sturgeon that were sampled (examined for the presence of a PIT tag and measured), but were either: 1) not tagged due to a shortage of available PIT tags, 2) not released (i.e., a mortality) or, 3) not tagged prior to release due to poor physical condition of the fish (the bulk of these cases were for sturgeon removed from gill nets; Appendix B).

The annual number of White Sturgeon sampled was fairly consistent from 2000-2016 (average of 8,372 sturgeon examined per year, with a range from 4,385 to 12,155 (Appendix B). The relative monthly contribution to respective annual total samples has remained relatively consistent throughout all years (2000-2016; Figure 3). The variability of sample size between months is the result of variability in three main factors: fishing effort applied, catch-per-effort, and sturgeon catchability.

Three sources provided over 98% of samples over the term of the program through 2016: angling (91.5%), Albion Test Fishery (3.8%), and First Nations gill nets (3.5%). An additional 0.6% of the total sample was provided through dedicated sampling efforts using tangle nets associated with both the MFLNRO Lower Fraser Juvenile White Sturgeon Habitat Indexing Program, and the FRSCS Lower Fraser River Juvenile White Sturgeon Habitat Program (Glova et al. 2008). Approximately

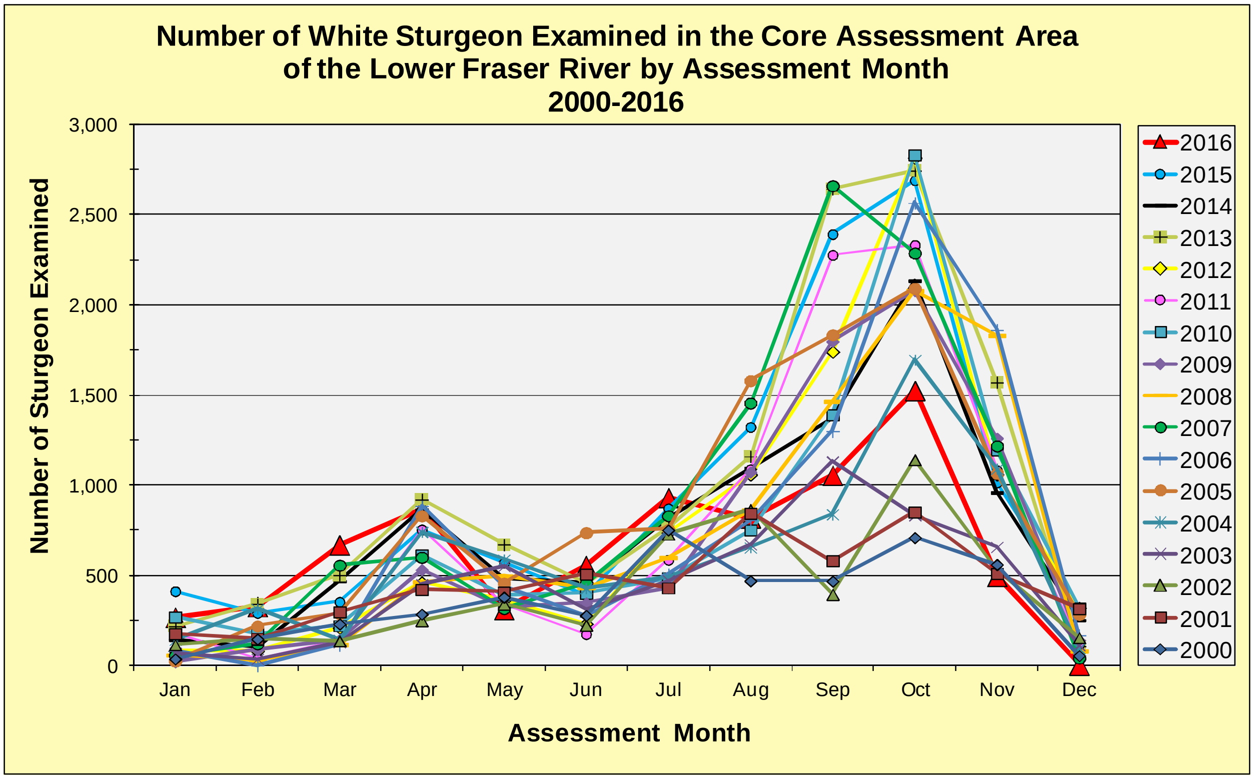

Figure 3. **Number of White Sturgeon examined for the presence of a PIT tag in the core assessment area of the lower Fraser River, by assessment month, 2000-2016.**

0.7% of samples were provided by a mix of commercial net fisheries, enforcement (illegal retention/poaching) incidents, and both sourced and unsourced mortalities.

Recaptures of Tagged Sturgeon

Recapture data provided positive determination of both direction and distance of movements for individual tagged sturgeon. In many cases, multiple recapture events over years provided patterns of movement and migration. Movements in relation to size group and time of year (season) were explored and incorporated in the analytical processes of the program, as were the spatial distribution of samples over time. Recaptures of tagged sturgeon during this study confirmed that movements and migrations occur throughout the entire lower Fraser general study area. Recapture locations of any given individual varied, and were sometimes several kilometers apart, even when the fish was at large for relatively short time periods. Many individual tagged sturgeon have been recaptured and sampled numerous times. For example, by 2016, 4,787 individual fish had been sampled five times, 393 fish had been sampled 10 times, and 13 fish had been sampled 20 times. Several individual tagged sturgeon have been sampled multiple times (up to five times) during the same assessment year.

Mark Rates

An illustration of the annual numbers of tags applied, and reported number of tag recaptures, within the core assessment area, is provided in Figure 4. The proportion of recaptures recorded in a given 12-month sampling period (i.e., the annual mark rate) has steadily increased each year over the 17 years of monitoring (Figure 4). Conversely, the proportion of newly released tags has declined over time, as the pool of marked fish available for recapture has increased. Over 86% of the samples

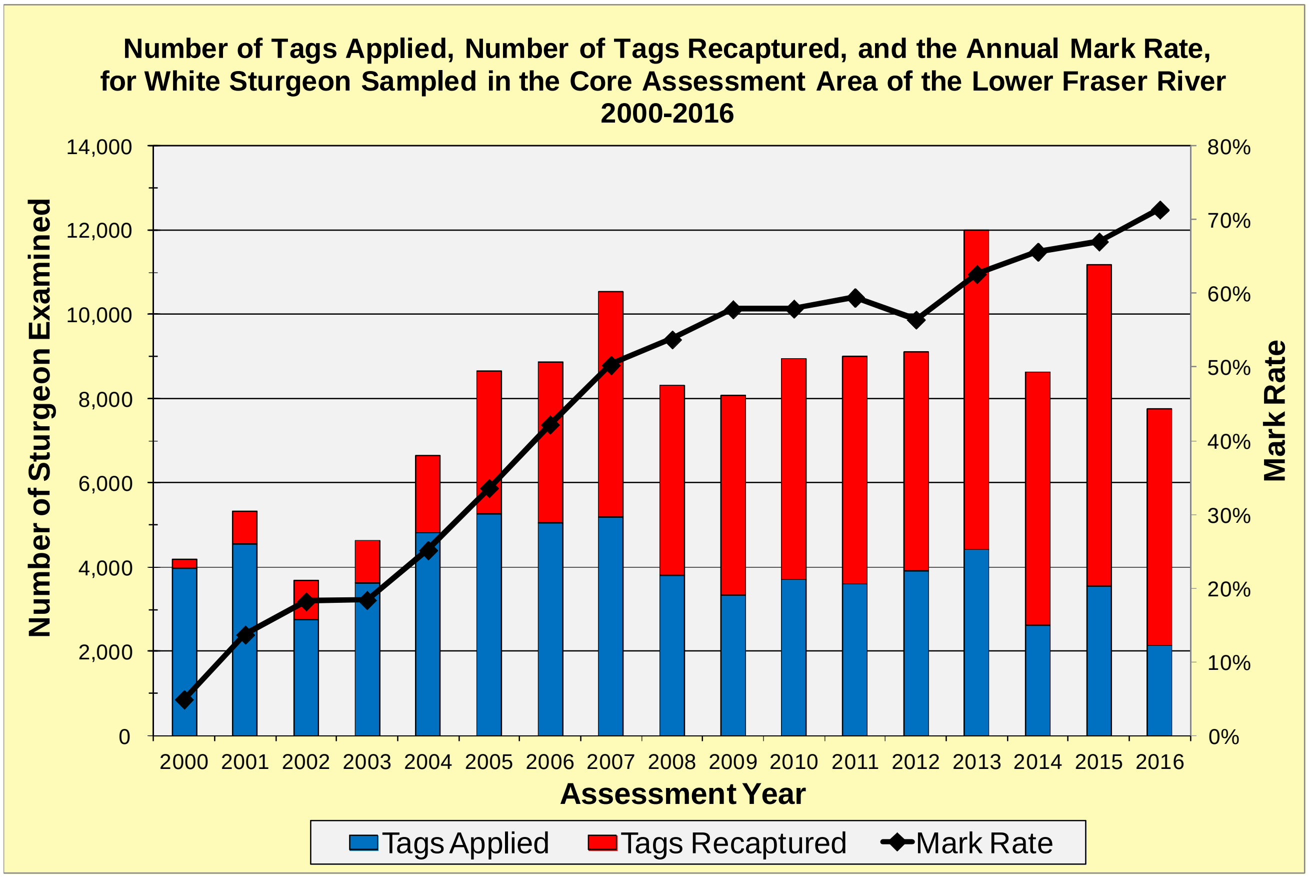

Figure 4. **Number of tags applied, reported number of tags recaptured, and the annual mark rate, for White Sturgeon sampled in the core assessment area of the lower Fraser River, by assessment year, 2000-2016.**

included in the 2001 abundance model calculations (samples from 2000 and 2001) were new tags applied, whereas only 30% of the samples used to produce the 2016 abundance estimates (samples from 2015 and 2016; Figure 4) were new tags applied.

In 2016, FRSCS volunteers applied 2,170 PIT tags and recaptured 5,610 tagged sturgeon in the general study area (Appendix B, Figure 4). The overall mark rate for the general study area in 2016 was 71.2% (Figure 4). Mark rates for sub-locations within the general study area differed from the respective overall mark rate; for example, the mark rate for sturgeon sampled from the Harrison River in 2016 was 89.6% (Figure 5).

Monthly variation in White Sturgeon mark rates within the core assessment area was evident for each of the assessment years (Figure 6), and patterns have emerged that suggest an influence of season on mark rates. The most striking of these is the lower mark rates observed during winter months. For example, winter mark rates (December-February) after 2009 have in some years been 10-20% lower than summer mark rates (July-September; Figure 6). The mark rate for the general study area in 2016 varied from a low of 60.2% in January[1] to a high of 75.8% in July (Appendix B, Figure 6). This seasonal variation could be linked to varying use of habitats by sturgeon as well as changes in angling effort by program volunteers during winter months.

[1] Data for December 2016 (50% mark rate) excluded due to limited sample size (*n*=4).

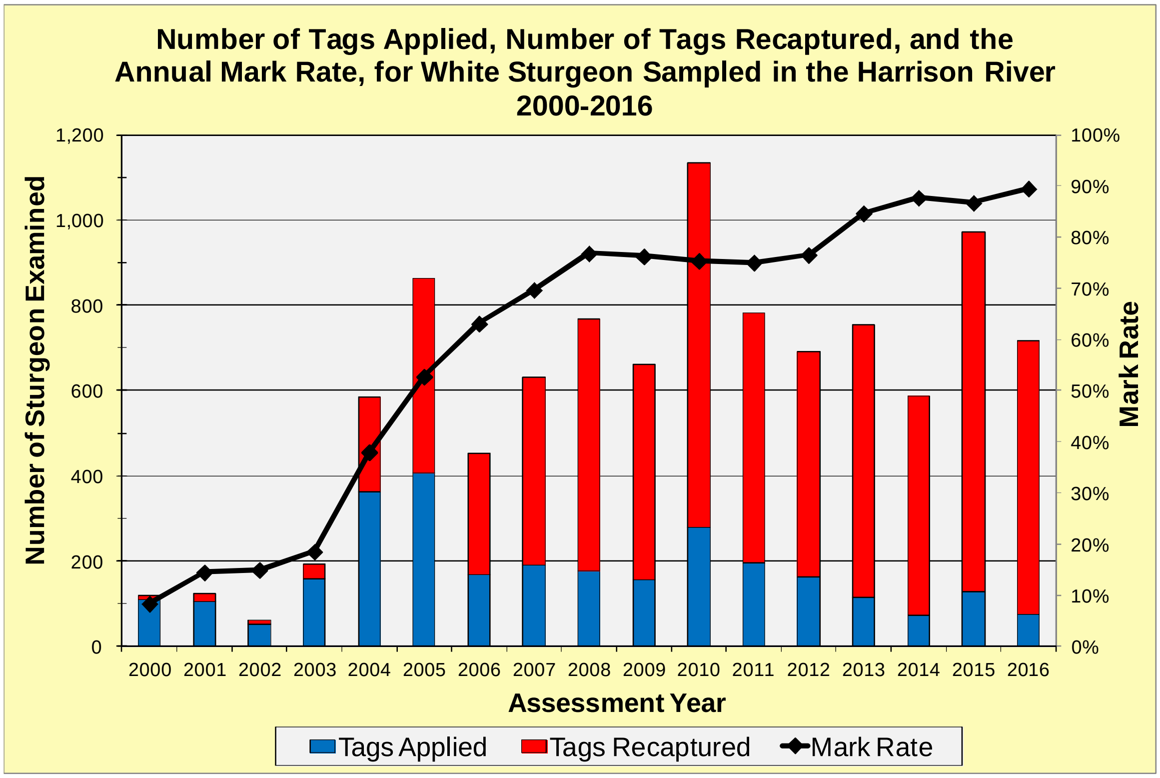

Figure 5. Number of tags applied, reported number of tags recaptured, and the annual mark rate, for White Sturgeon sampled in the Harrison River, by assessment year, 2000-2016.

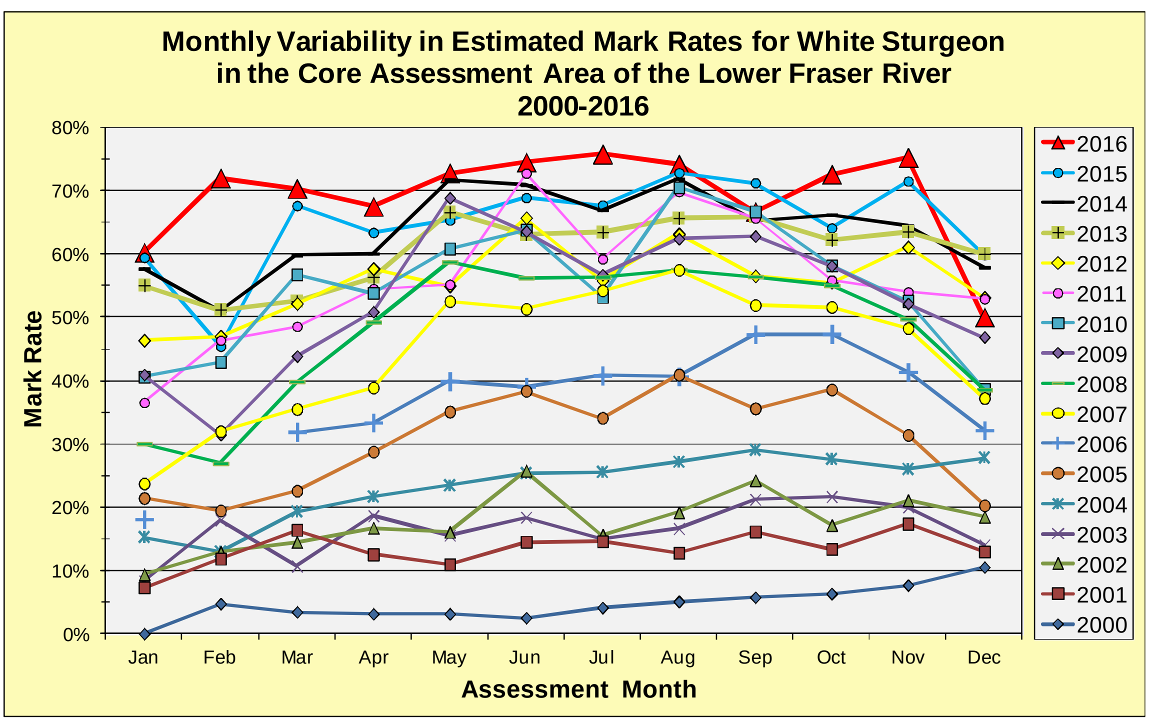

Figure 6. Monthly variability in estimated mark rates for White Sturgeon in the core assessment area of the lower Fraser River, 2000-2016. Only four sturgeon were sampled in December 2016.

Abundance Estimates

The 2016 total abundance estimate (as of January 2016) for White Sturgeon from 60-279 cm FL in the core assessment area of the lower Fraser River was 43,196 fish (95% CLs ± 8.5% of the estimate; Table 4). The estimated abundance of White Sturgeon within the core assessment area downstream of the Mission Railway Bridge (sampling regions A and B; see Figure 2) was 20,277 fish (46.9% of the total abundance estimate; Table 4, Figure 7). In the core assessment area upstream of the Mission Railway Bridge (to Lady Franklin Rock near Yale; sampling regions C and D; see Figure 2), the abundance estimate was 22,919 fish (53.1% of the total abundance estimate; Table 4, Figure 7).

Table 4. Abundance estimates of 60-279 cm FL White Sturgeon in the lower Fraser River, by sampling region, 2016.

Sampling Region			Zone			95% HPD[2]		
	From	To	Codes[1]	Mean	Mode	Low	High	Std. Dev
A	Georgia Strait	East Annacis Island	S	6,825	6,063	3,947	10,274	1,718
B	East Annacis Island	Mission Bridge	3, 5, 6, 7	13,452	13,392	12,242	14,700	625
C	Mission Bridge	Hwy 1 Bridge (Hope)	8, 10, 12, 13	20,973	20,960	20,250	21,700	368
D	Hwy 1 Bridge (Hope)	Yale	14	1,946	1,942	1,834	2,061	58
			Total	43,196		39,539	46,853	1,866

[1] See Table 1

[2] HPD - Highest Probability Density. See Nelson et al. 2004 for explanation of this statistic.

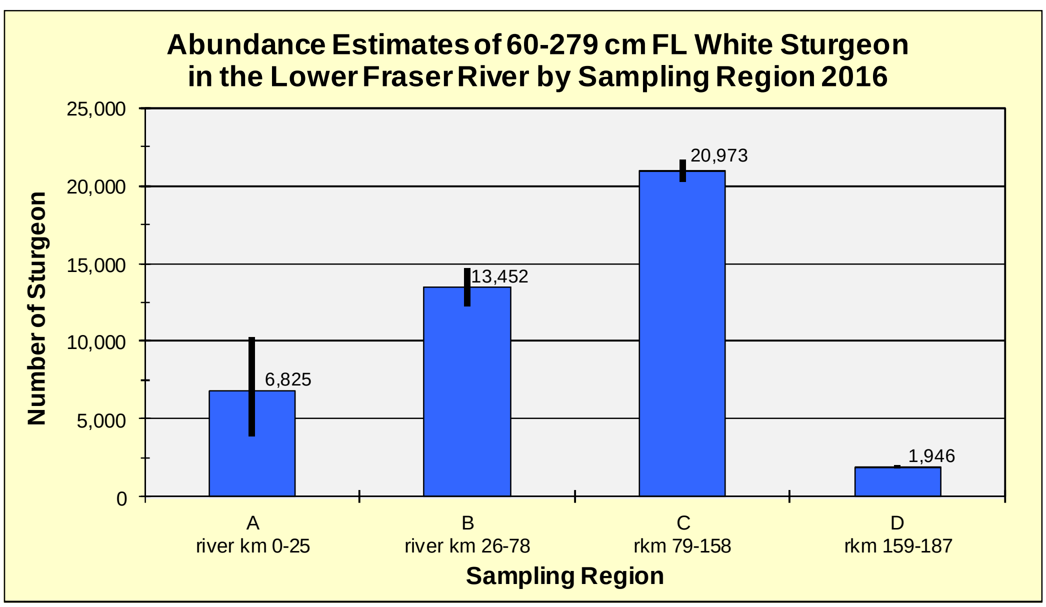

Figure 7. Abundance estimates of White Sturgeon (60-279 cm FL) in the lower Fraser River, by sampling region (A, B, C, and D; see Table 4 and Figure 2), 2016. Error bars show the 95% Highest Probability Density. Sturgeon movement and migration within the core assessment area results in a proportional redistribution of these mean abundance estimates, by season.

The 2016 total abundance estimate was 23.4% lower than the respective 2003 estimate (significant decrease, as indicated by non-overlapping confidence bounds; Table 5, Figure 8). Annual abundance estimates for the first two years of the study were similar to each other (close to 45,000 fish), and were followed in 2003 by an increase to 56,384 fish (Figure 8). Since 2003, total annual abundance estimates indicated a general population decrease, with significant decreases in 2005 and again in 2009 (Table 5; Figure 8).

Table 5. Abundance estimates of 60-279 cm FL White Sturgeon in the core assessment area of the lower Fraser River, 2001-2016. See Figure 8.

Sampling Period	Assessment Year	Abundance Estimate	95% HPD[1] Low	95% HPD[1] High	Bounds as % of Abundance Estimate	CV (%)[2]	Annual % Change
2000-2001	2001	44,341	41,127	47,555	7.2%	3.70%	
2001-2002	2002	46,139	42,809	49,469	7.2%	3.68%	4.1%
2002-2003	2003	56,384	51,778	60,990	8.2%	4.17%	22.2%
2003-2004	2004	53,969	50,597	57,341	6.2%	3.19%	-4.3%
2004-2005	2005	48,730	46,450	51,010	4.7%	2.39%	-9.7%
2005-2006	2006	47,118	44,783	49,453	5.0%	2.53%	-3.3%
2006-2007	2007	44,769	42,631	46,907	4.8%	2.44%	-5.0%
2007-2008	2008	43,638	41,456	45,820	5.0%	2.55%	-2.5%
2008-2009	2009	41,938	39,508	44,368	5.8%	2.96%	-3.9%
2009-2010	2010	44,093	41,193	46,993	6.6%	3.36%	5.1%
2010-2011	2011	43,630	41,672	45,588	4.5%	2.29%	-1.1%
2011-2012	2012	47,354	45,036	49,672	4.9%	2.50%	8.5%
2012-2013	2013	47,925	45,662	50,188	4.7%	2.41%	1.2%
2013-2014	2014	44,004	41,956	46,052	4.7%	2.37%	-8.2%
2014-2015	2015	45,038	41,181	48,895	8.6%	4.37%	-6.0%
2015-2016	2016	43,196	39,539	46,853	8.5%	4.32%	-1.8%

[1] HPD - Highest Probability Density

[2] CV - Coefficient of Variation

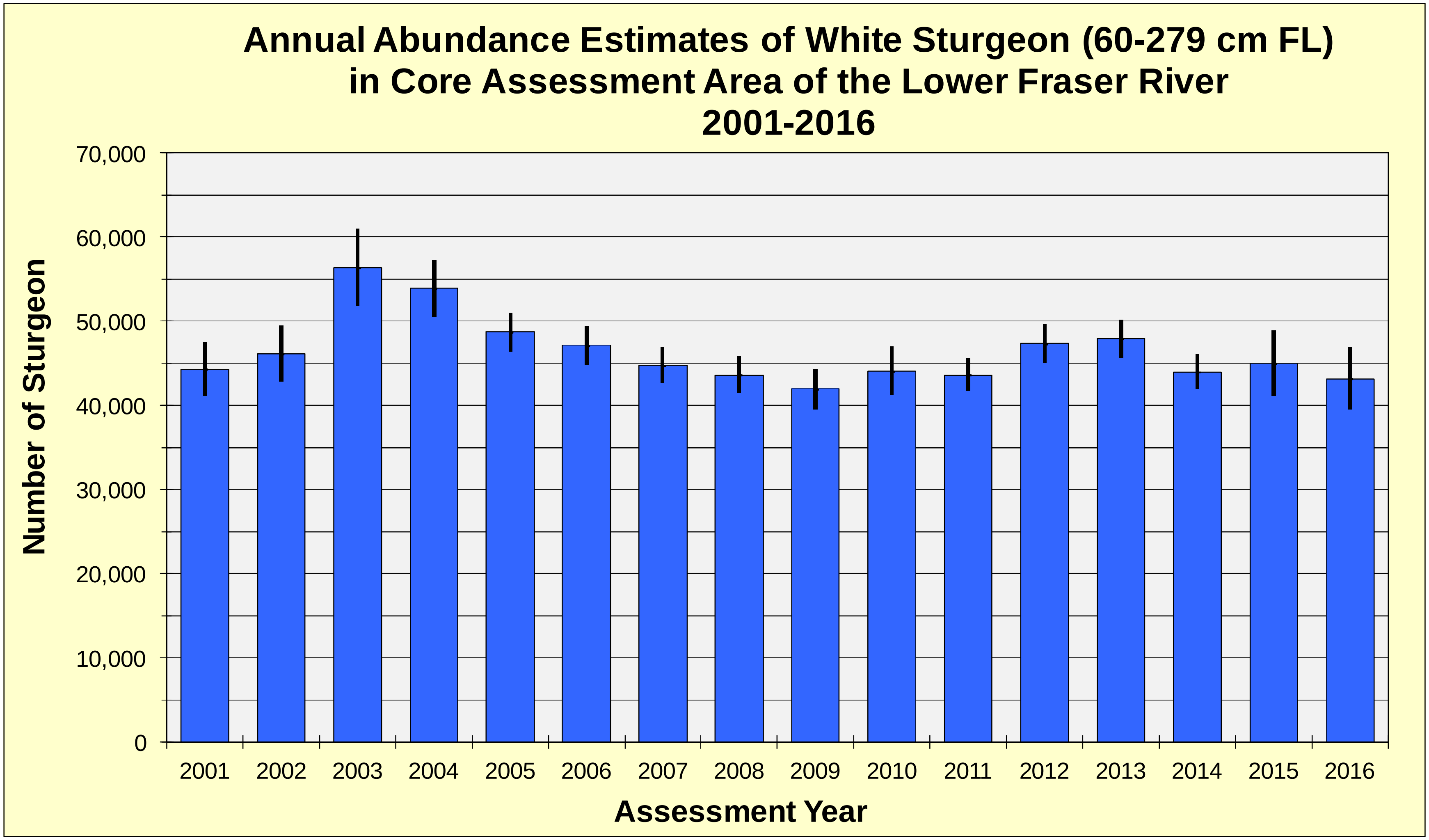

Figure 8. **Annual abundance estimates of White Sturgeon (60-279 cm FL) in the core assessment area of the lower Fraser River, 2001-2016. Error bars show the 95% Highest Probability Density. The value shown for each year is the sum of abundance estimates for the four sampling regions. The 2016 abundance estimate is 23.4% lower than the peak abundance estimate generated for 2003.**

In 2016 the estimated abundance of 60-99 cm FL juvenile White Sturgeon was 7,352 fish (Table 6), which represented a 22.2% decline from the respective estimate in 2015 (9,488 fish; Figure 9). In 2016, we estimated abundances of 20,559 fish in the 100-159 cm FL range, and 15,285 fish in the 160-279 cm FL range (Table 6). Since 2004 there has been a significant decline (68.8%) in the abundance of 60-99 cm FL White Sturgeon, concurrent with a significant increase in the abundance of larger-sized fish (Figure 9). It should be noted that lower sampling rates (fewer fish examined) in sampling region A (see Table 2 and Figure 2) resulted in relatively large CVs for all size groups in this region (Table 6).

Abundances for 2016 by 20-cm (FL) size group are presented in Table 7 and Figure 10. Figure 11 displays the temporal trends for each 20-cm size bin from 2004-2016.

Table 6. Abundance estimates for three White Sturgeon size groups in four sampling regions in the core assessment area of the lower Fraser River, 2016. Within each region, MLE values were scaled so that they summed to the mean regional estimate (Table 4).

Size Group (cm)	Sampling Region	Scaled MLE[1]	HPD[2]		CV(%)[3]
			Low	High	
60-99	A	1,471	182	3,082	58.6
	B	2,737	2,279	3,224	8.8
	C	2,827	2,607	3,053	4.0
	D	316	288	346	4.6
	Total	7,352	5,582	9,122	12.3
100-159	A	3,718	1,717	6,317	35.3
	B	7,031	6,159	7,936	6.4
	C	9,320	8,851	9,802	2.6
	D	490	450	530	4.2
	Total	20,559	17,794	23,324	6.9
160-279	A	1,636	563	3,253	51.1
	B	3,683	2,898	4,534	11.4
	C	8,826	8,298	9,366	3.1
	D	1,140	993	1,293	6.7
	Total	15,285	13,371	17,198	6.4

[1] MLE - Maximum Likelihood Estimate
[2] HPD - Highest Probability Density
[3] CV - Coefficienct of Variation

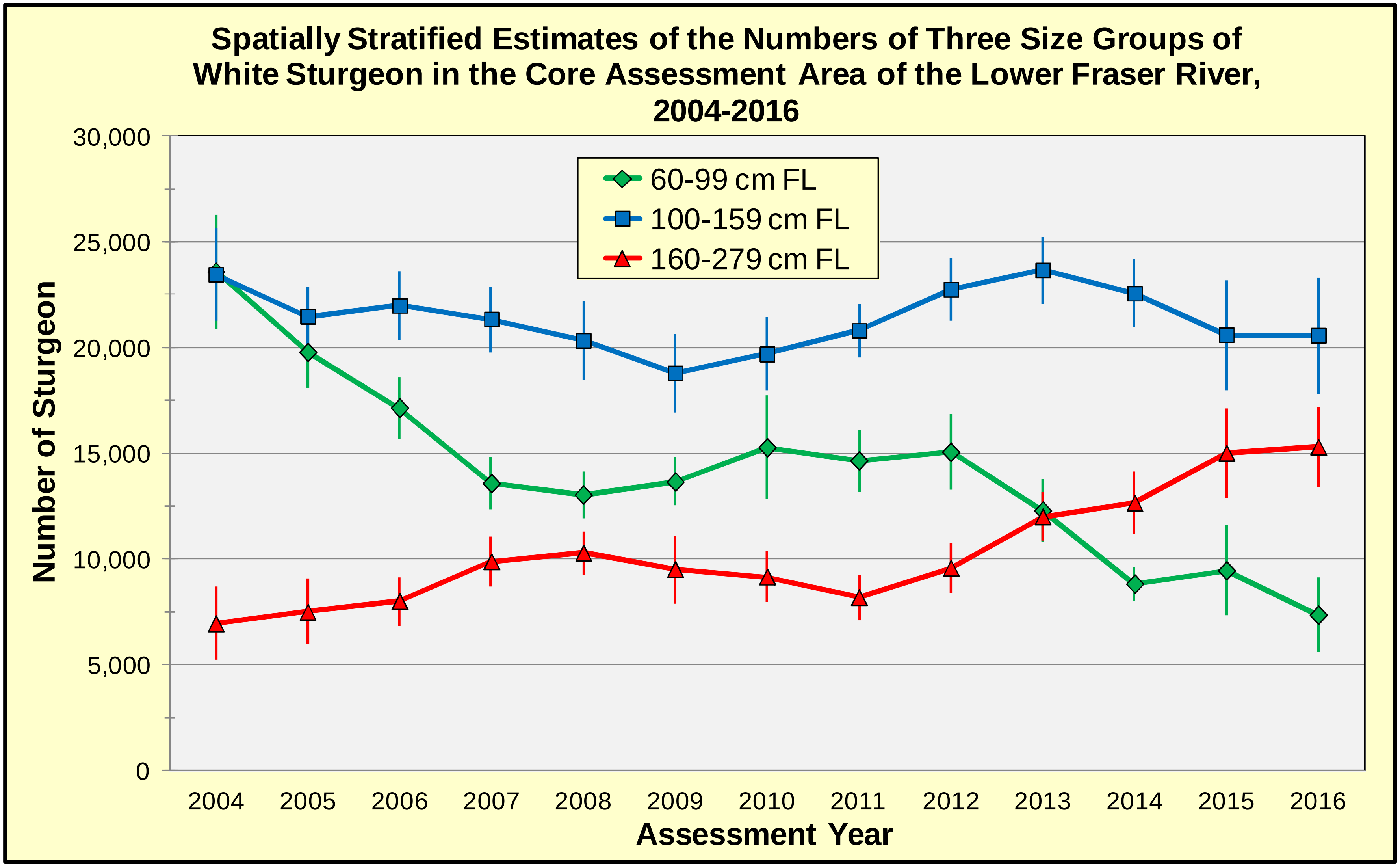

Figure 9. Estimated White Sturgeon abundances for three size groups (60-99 cm FL, 100-159 cm FL, and 160-279 cm FL) in the core assessment area of the lower Fraser River, 2004-2016. The error bars indicate the 95% CLs for each estimate. Within each sampling region in each year, the relative abundances have been scaled such that the size-specific estimates summed to the total estimated abundance of 60-279 cm sturgeon in that sampling region for that year.

Table 7. Abundance estimates for 60-279 cm FL White Sturgeon in the core assessment area of the lower Fraser River, by 20-cm (FL) size group, 2016. Scaled MLE values were calculated by estimating MLE for each size bin, and then scaling the results so that they summed to the mean total estimate (Table 4). An illustration of these estimates and their associated HPD values is presented in Figure 10.

Size	Scaled		95% HPD[2]		
Group (cm)	MLE[1]	Percent	Low	High	CV[3] (%)
60-79	2,602	6.0	2,363	2,879	5.0
80-99	3,756	8.7	3,482	4,065	3.9
100-119	6,283	14.5	5,830	6,804	3.9
120-139	6,244	14.5	5,805	6,741	3.8
140-159	7,500	17.4	6,950	8,121	4.0
160-179	5,432	12.6	5,019	5,903	4.1
180-199	4,291	9.9	3,884	4,768	5.2
200-219	3,023	7.0	2,651	3,483	6.9
220-239	2,226	5.2	1,828	2,766	10.5
240-259	1,452	3.4	1,098	1,994	15.3
260-279	386	0.9	221	801	35.0
Total	43,196	100.0			4.3

[1] MLE - Maximum Likelihood Estimate
[2] HPD - Highest Probability Density
[3] CV - Coefficient of Variation

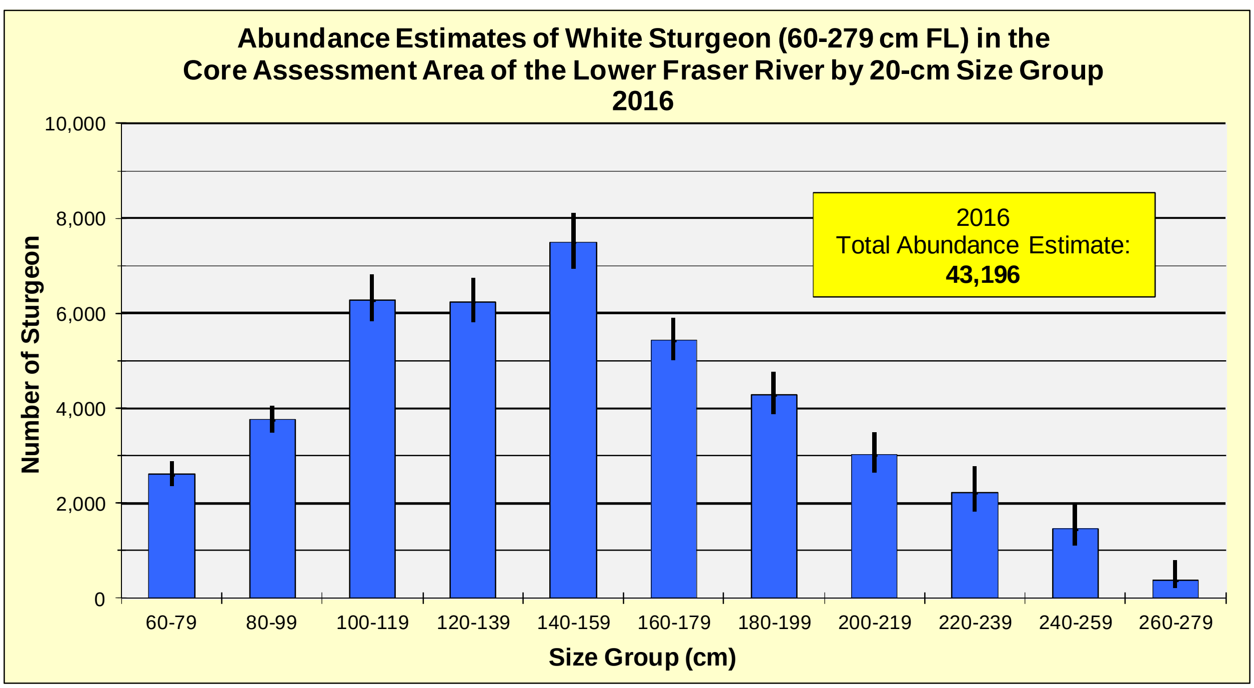

Figure 10. Abundance estimates of White Sturgeon (60-279 cm FL) in the core assessment area of the lower Fraser River, by 20-cm (FL) size group, 2016. Error bars show the 95% Highest Probability Density. See Table 7.

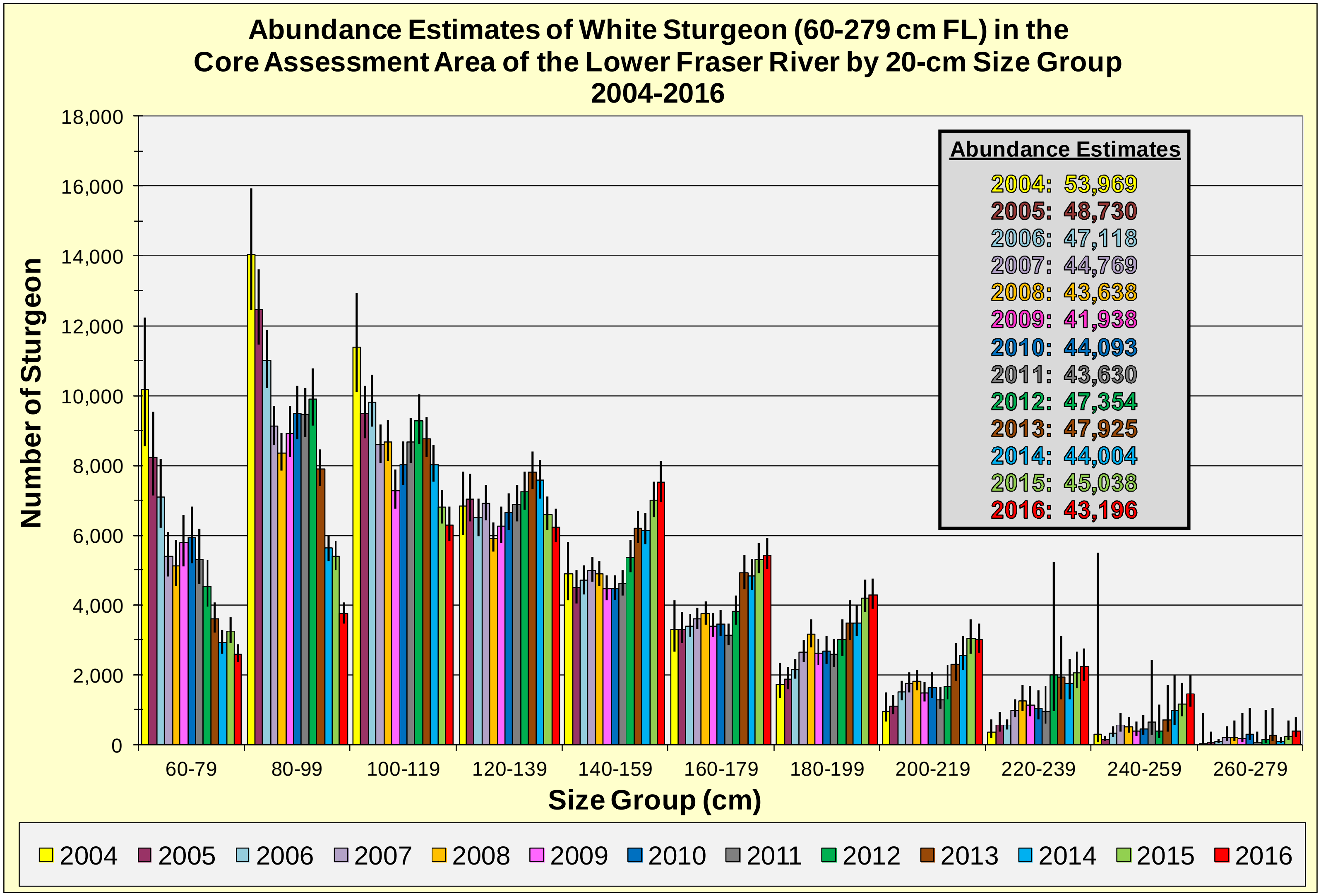

Figure 11. Abundance estimates of White Sturgeon (60-279 cm FL) in the core assessment area of the lower Fraser River, by 20-cm (FL) size group, for assessment years 2004 through 2016. Error bars show the 95% Highest Probability Density. Within each year, the relative abundances were scaled such that the size-specific estimates summed to the total estimated abundance of 60-279 cm sturgeon in the core assessment area for that year.

Growth Analyses

A comparison of average annual growth rates of White Sturgeon from 60-179 cm FL sampled from 2001-2016, by 20-cm FL size groups, suggested that annual growth rates for most size groups were greater before versus after 2005 (Figure 12). The average growth rate for all size groups in 2016 (3.6 cm/year) represented the lowest annual growth rate observed since the beginning of the program, and was well below the highest average annual growth rate of 5.7 cm/year observed in 2002 (Figure 12). The variability and periodicity of growth rates depicted in Figure 12 are likely associated with the availability of food (prey). For example, the relatively large returns of Pink and Chum salmon in 2001, 2003, and 2011 likely provided a substantial increase in the amount of food available to lower Fraser River White Sturgeon, either directly through the consumption of eggs and carcasses, or indirectly as a result of consuming organisms that benefited from the increased nutrient inputs brought into the rivers via salmon returns during those years.

Figure 13 provides average annual growth increments (cm) of White Sturgeon in the lower Fraser River by 20-cm FL size group during four time periods: 2001-04, 2005-09, 2010-12, and 2013-16. Average annual growth from 2005-2009 for all size groups (3.8 cm/year) represented a 32%

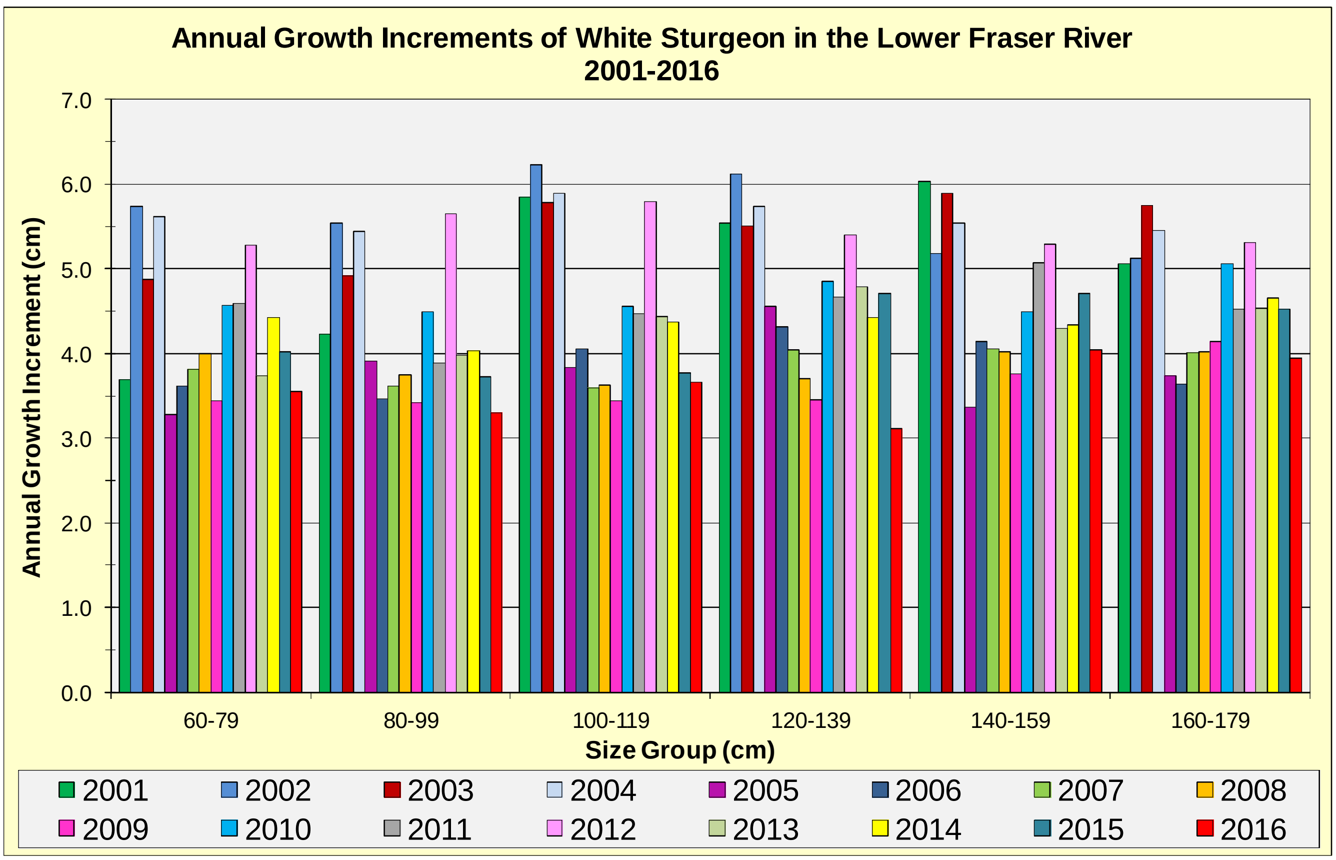

Figure 12. Average annual growth increments (cm) of White Sturgeon in the lower Fraser River, by 20-cm (FL) size group, 2001-2016. Annual growth was determined from measurements obtained from individual tagged sturgeon that were subsequently recaptured.

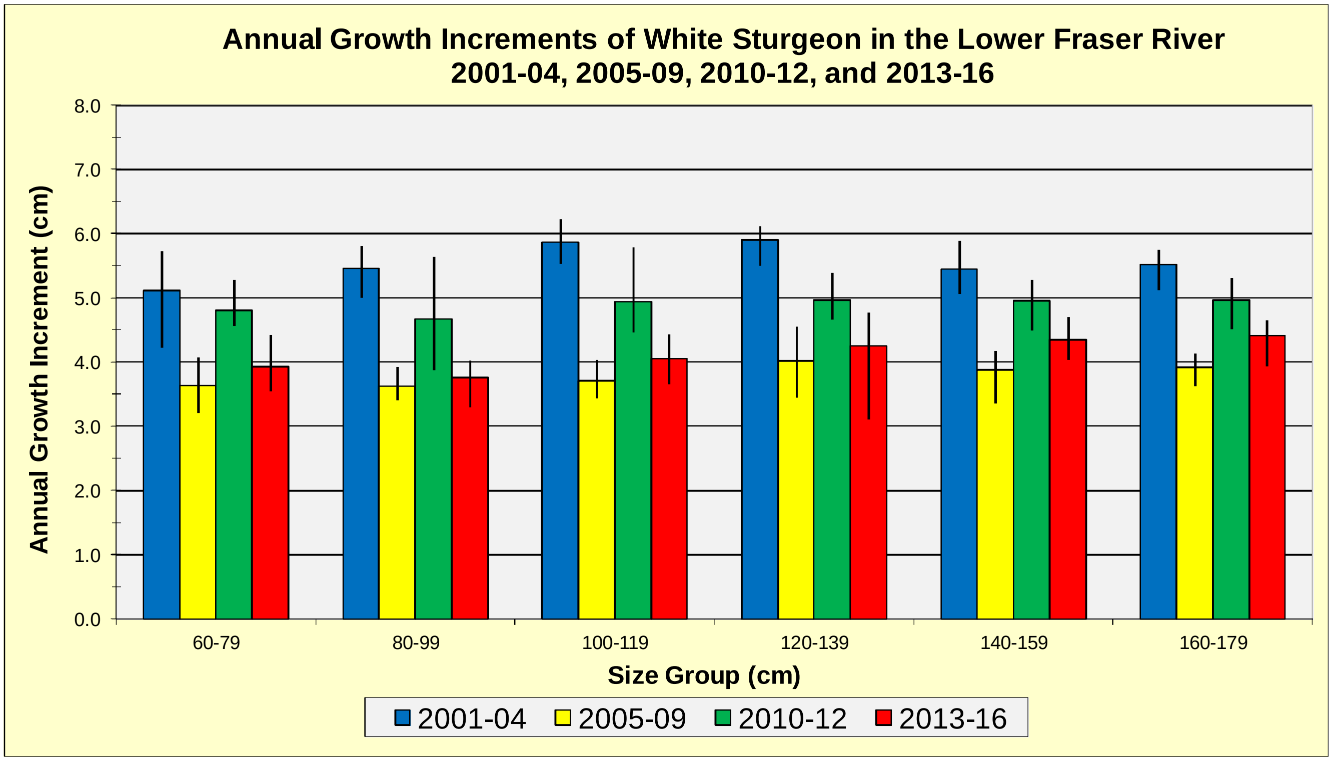

Figure 13. Average annual growth increments (cm) of White Sturgeon in the lower Fraser River, by 20-cm (FL) size group, during four time periods: 2001-04, 2005-09, 2010-12, and 2013-16. The error bars show the range of mean annual growth estimated for the years within each time period.

decrease from respective previous growth rates from 2001-2004 (5.6 cm/year; Figure 13). Average annual growth for all size groups increased during 2010-2012 (4.9 cm/year) before declining to an average of 4.1 cm/year from 2013-2016 (Figure 13).

DISCUSSION

Abundance Estimates

In 2015 we commenced using the term “abundance” rather than “population” for these estimates. The change is based on our understanding that the estimates do not represent the entirety of the population, based on our knowledge regarding the known presence of sturgeon outside of the core assessment area used in the analyses, and the omission of both small (under 60 cm FL) and large (over 279 cm FL) sturgeon in those estimates. Abundance estimates produced from data collected only from the core assessment area (Figure 1) can be considered representative “indices of abundance” that are generated from the same area, and for the same size groups of fish, that can be compared between and among assessment years to detect trends within the total population.

Abundance estimates presented in this paper are estimates of the mean number of White Sturgeon in the 60-279 cm FL size range that resided in the core assessment area over each two-year period. The large number of sturgeon tagged and examined for tags each year has resulted in relatively precise estimates (95% confidence intervals ±4.5-8.6 percent of the mean; see Table 5). The precision and accuracy of these estimates depended upon the input of point estimates for growth, movement, mortality, and undetected marks.

Importantly, the 2016 assessment year is the first year that the analytical model used the size range of 60-279 cm FL to produce abundance estimates. Prior to 2016, the size range used in the analytical model was 40-279 cm FL (Nelson et al. 2016). The exclusion of the 40-59 cm size group from the 2016 assessment was the result of a review of the levels of confidence associated with this size group, and the program objective to produce abundance estimates with high levels of confidence, and thus utility, for conservation assessment and management purposes. The abundance estimates for assessment years prior to 2016 provided in this report differ from previously published respective estimates in that the estimated numbers of White Sturgeon from 40-59 cm FL are excluded. Abundance estimates for assessment years prior to 2016 were regenerated from the analytical model and are presented in this report as both total annual estimates (from 2001-2016) and broken-out by size group (from 2004-2016).

Mark Rate Variation

The differences in observed annual mark rates among seasons suggest a potential population segregation between winter (low mark rates) and summer-fall (high mark rates). Preferred overwintering habitats may attract sturgeon from a wide area where sturgeon migrate and forage during the balance of the year, including locations outside the core assessment area. It is probable that sampling effort (i.e., tag applications) is not occurring, or occurring at a lower rate, at some of those other foraging and rearing areas, and thus fish from those areas have a lower probability of possessing a tag. When sturgeon from all areas concentrate in known overwintering locations within the core assessment area, the result could be a lower mark rate during the winter season (also there is less angling effort in winter months, and some program volunteers avoid angling in known overwintering areas).

Immigration, Emigration, and Movements

Since there will always be a portion of 60-279 cm FL lower Fraser River origin White Sturgeon located in marine and freshwater areas outside the core assessment area; the abundance estimates presented in this report do not represent the entire population (Nelson et al. 2016). Freshwater areas accessible to lower Fraser River White Sturgeon that are outside the core assessment area include: the entire North Arm and adjacent Middle Arm (north of Lulu Island, (~23 km), the lower Pitt River upstream of the Highway 7 Bridge (~17 km), Pitt Lake (~27 km), Harrison Lake (~55 km), and the section of the upper Fraser Canyon between Lady Franklin Rock and Hell's Gate (25 km; Figure 1). All marine waters westward of the entrance points of the Fraser River at Garry Point and Canoe Pass (Figure 1) are also outside the core assessment area.

Substantial numbers of White Sturgeon have been observed and captured in the bays and mouths of rivers in northern Puget Sound, with additional sightings and captures in the Southern Strait of Georgia and inlets/estuarine habitats on southern and western Vancouver Island (Nelson et al. 2013a). Although the origin (natal river) of White Sturgeon observed in marine waters adjacent to the Fraser estuary is currently unknown, their proximity to the Fraser River suggests that at least some are of Fraser origin. Acoustic telemetry data have shown that a portion of lower Fraser White Sturgeon may migrate to marine areas beyond the Fraser estuary, particularly during summer months (Robichaud et al. in press).

The distinct pattern for monthly catch of White Sturgeon from the Albion Test Fishery since 2000 (Figure 14) suggests that sturgeon are moving past this point in the river (Figure 1) during April and May, and again during September through November. The spring movement of White Sturgeon past the Albion Test Fishery site is likely explained by in-river foraging migrations from upstream overwintering locations into foraging areas in the lower river and estuary (in particular, areas that support spawning Pacific Eulachon), and perhaps upstream movements to late-spring and early-

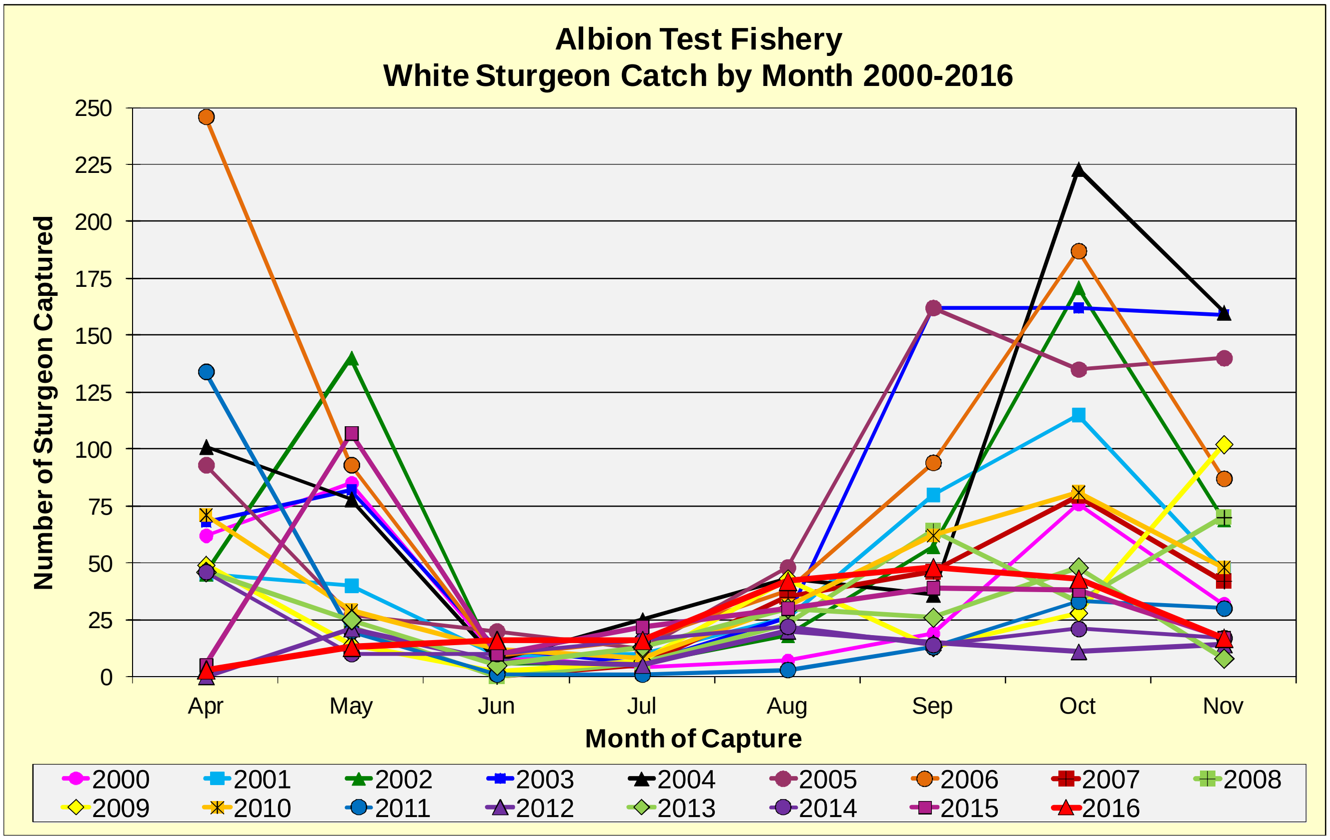

Figure 14. The number of White Sturgeon (all sizes) captured in the Albion Test Fishery during assessment net sets, by month, 2000-2016. Data from Fisheries and Oceans Canada.

summer spawning locations. Late summer and fall movements past the Albion Test Fishery site are likely both upstream and downstream migrations of sturgeon seeking out returning salmon stocks, and sturgeon returning to overwintering locations from summer/fall foraging areas.

Abundance Trends

Our estimates of the abundance of White Sturgeon in the lower Fraser River indicate that the population declined from 2003 to 2009 and has since been variable (Table 5, Figure 8). This decline has been reflected in several reports and publications (COSEWIC 2012, Nelson et al. 2013a, Hildebrand et al. 2016). The results from a recent comprehensive analysis of the entire 2000-2015 PIT tag dataset, using an Integrated Spatial Age-structured Mark-Recapture (ISAMR) model (Challenger et al. in prep.), have confirmed the abundance estimates and trends derived from the Bayesian analysis model (presented in this report).

A comparison of size-specific annual abundances for 2004-2016 reflects that there was a significant decline in the abundance of 60-99 cm FL sturgeon in the lower Fraser River between 2004 and 2006 (Figures 9 and 11). A subsequent decline in the abundance estimates for the 60-99 cm size group started in 2013 and has continued through 2016. The declines in estimated abundance of 60-99 cm FL sturgeon within the core assessment area are most likely due to reduced levels of recruitment of young juveniles into the population. Note that 60-99 cm White Sturgeon in the lower Fraser River are likely between 6-16 years old, and the average age for this size group is 10.7 years (age-length data from the 1995-99 provincial White Sturgeon study; RL&L 2000). There could be a number of factors limiting juvenile recruitment into the population, including:

- Reductions in spawning activity or spawning success. Reduced spawning activity could result from increased physiological stress, such as that caused by capture or handling (especially at high water temperatures, see McLean et al. 2016), or by limited food supplies. Spawning success could be limited by decreases in spawning habitat availability, or by reductions in spawning habitat quality, such as gravel structure or size;
- Increased mortality during early life stages (larval and post larval/fry). This could result from sub-optimal environmental conditions (water temperature, water chemistry, etc.), high levels of predation, limited availability of food, or by reductions in suitable feeding or rearing habitat; and
- Increased mortality of age-0 to age-4+ fish. Sturgeon of this size require specific rearing habitats that support suitable prey items, both of which are limited in the lower Fraser River. Juvenile sturgeon in this size group (up to approximately 35 cm FL) are also vulnerable to elevated salinity levels present in the lower Fraser River estuary (exposure to salinities over 16 ppt can result in high levels of mortality for small sturgeon; Amari et al. 2009).

The declines in the estimated abundance of 60-99 cm FL sturgeon in recent years could also be partly due to a combination of the following: smaller fish being less vulnerable to our primary sampling gear (angling); program volunteers changing their angling behavior (e.g., fishing methods and locations to target large fish); and increased proportions of small fish residing outside of the core assessment area (or in less well-sampled portions of the core assessment area).

The significant decreases in abundance estimates for sturgeon in the 80-99 cm and 100-119 cm size groups are consistent with the earlier declines of the 60-79 cm and 80-99 cm sizes (Figure 11). The abundance estimates for White Sturgeon over 140 cm FL have been generally trending upward since 2010 (Figure 11); this is likely due to harvest restrictions enacted in the early 1990s on recreational, commercial and First Nations fisheries, and the subsequent recruitment of those fish into larger size groups (with growth) over time. While an increasing number of adult spawning sturgeon provides potential security for population rebuilding, this can only be realized if effective spawning and subsequent juvenile recruitment is occurring at a level sufficient to maintain and grow the population over time.

The proportion of small (< 100 cm FL) White Sturgeon sampled by angling has decreased continually and significantly since the beginning of the program (Figure 15). In 2000, over half of all sturgeon captured by angling (53%) were less than 100 cm FL; by 2008 this proportion dropped to 35%; and by 2016 this proportion further declined to 24% (which is a 55.0% decrease from 2000; Figure 15). The apparent decline in the proportion of angled sturgeon under 100 cm FL may be in part a result of a changes in angler behaviour, particularly of guides, who may have become more successful in targeting the largest fish possible, using new technologies, new gear, and newly available information, quickly shared via electronic media. However, the continuing decline in the proportion of juvenile sturgeon observed in the annual angling sample may also be a direct reflection of the declining numbers of juvenile sturgeon present in the Lower Fraser River population.

The Albion Test Fishery, a gillnet test fishery conducted at rkm 58 in the lower Fraser River (see "Albion Test Fishery," Figure 1), provides additional evidence that over the course of the monitoring and assessment program there has been a declining proportion of juvenile sturgeon less than 100 cm FL within the population. In 2000, 67.8% of all sturgeon captured in the Albion Test Fishery were less than 100 cm FL; by 2008 this proportion dropped to 50%; and in 2016 it further declined to 23% (which is a 66% decrease from 2000; Figure 16). While there have been methodological changes for this test fishery over the years (especially between 2006 and 2007), including variation in net size, effort, and deployment schedules, and habitat changes have resulted from dredging

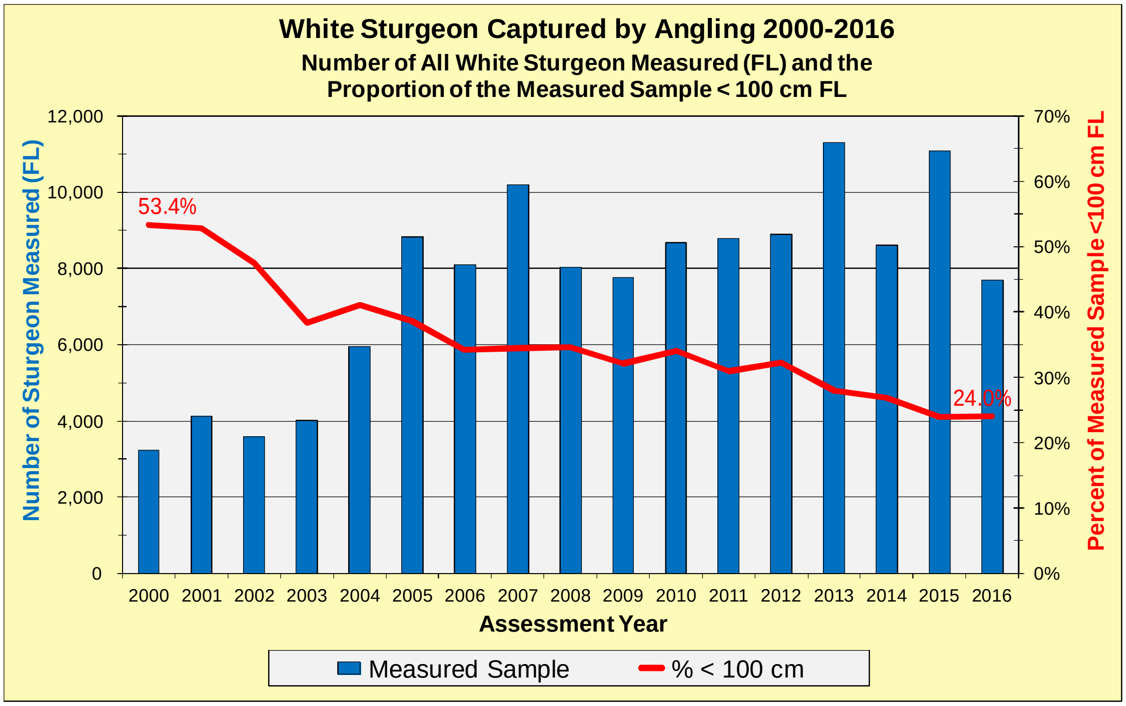

Figure 15. The annual proportions of White Sturgeon less than 100 cm FL from all measured samples captured by angling, 2000-2016. Declines reflected in this figure may be associated with declining numbers of small (< 100 cm FL) sturgeon and to changes in angler behaviour.

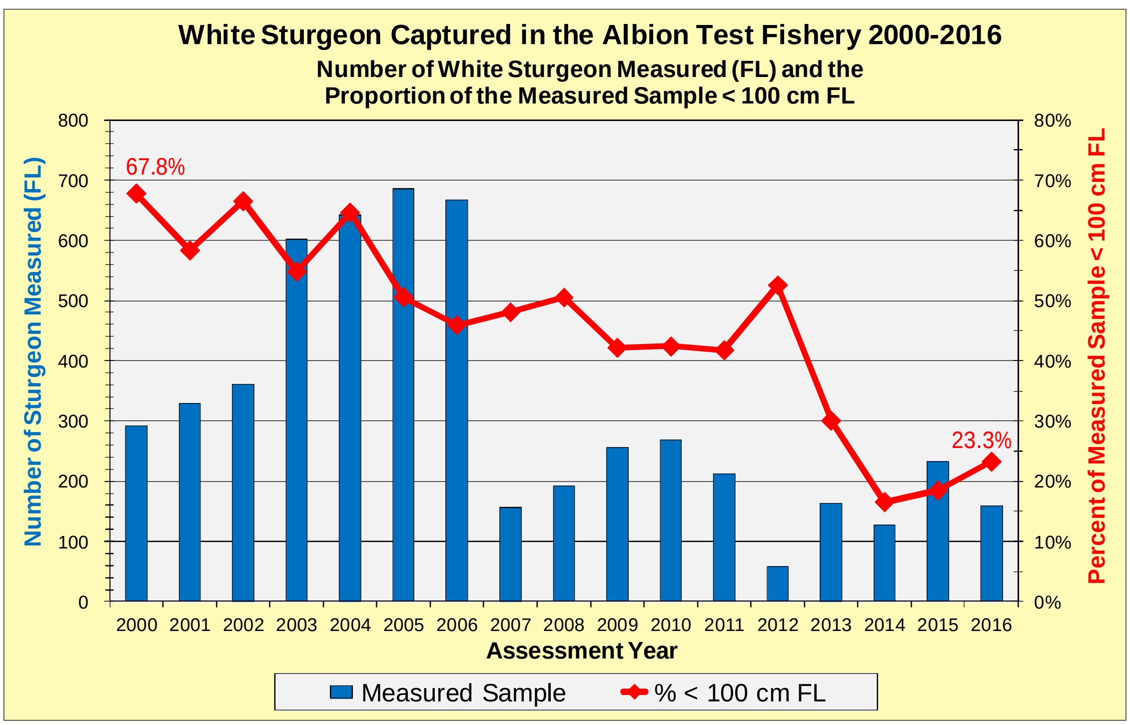

Figure 16. The annual proportions of White Sturgeon less than 100 cm FL from all measured samples captured in the Albion Test Fishery, 2000-2016. Methodological changes to the test fishery over the years do not explain the declines in small sturgeon proportions, especially since 2012.

activities, these cannot explain the observed declines in the proportion of small (< 100 cm) sturgeon sampled (especially since 2012, Figure 16). We believe that these data supply independent evidence of declining numbers of juvenile sturgeon present in the Lower Fraser River population.

ACKNOWLEDGEMENTS

The novel and reliable information that has been produced by this program is a direct result of the energy, commitment, and dedication of program volunteers and sponsors. The level of in-kind contributions to the program from program volunteers, however measured (in hours, equipment, dollars, or numbers of individuals), is second-to-none for recent BC-based fisheries research programs. Program volunteers are the true stewards of the resource that is Fraser River White Sturgeon. The level of program involvement by volunteers and the significant support and interest shown by program sponsors, provincial and federal resource authorities, and the public at large, is a testimony to the broad community commitment toward stock recovery of wild lower Fraser River White Sturgeon. All lower Fraser sturgeon anglers also support this work as the core financial support for the program has in recent years been provided through surcharges from the provincial White Sturgeon Conservation Licence that recreational anglers are required to purchase prior to angling for sturgeon in non-tidal waters. All (100%) of the funding collected from this surcharge is managed by the Habitat Conservation Trust Foundation through a dedicated account.

Much of the success of this program has been the result of strong leadership and scientific oversight provided by the FRSCS, a not-for-profit, registered society with a volunteer-based board of directors. The FRSCS has organized a science and technical committee, composed mostly of fishery science professionals, that provides key input regarding program design and direction and conducts critical reviews of program results. Individuals from the FRSCS Science and Technical Committee also serve on the Lower and Middle Fraser River White Sturgeon Technical Working Group and the National Recovery Team for White Sturgeon in Canada.

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APPENDICES

Appendix A

Sturgeon biosampling, tagging, and recapture data entry form

FRASER RIVER STUGEON CONSERVATION SOCIETY FAX to Jim Rissling: 604-792-2630 (phone: 604-792-4368)

WHITE STURGEON BIOSAMPLING, TAGGING, AND MARK- RECAPTURE RECORDS Page:______ of ________

Name/Phone Number of Person that Recorded Data: ____________________

Phone No: ____________________

Date (dd/mmm/yy ____________ Sampling Area: ________________ Weather: ____________________ No. Passengers: ______________

Vessel Information: Vessel Name ____________ Launch Location ______________ Launch Time: ____________ Return Time: ______________

Angling/Sampling Effort		Start Time	End Time	Total Minutes	Start Time	End Time	Total Minutes	Start Time	End Time	Total Minutes	Grand Total (Minutes)
Rod/Gear 1 (Name)											
Rod/Gear 2 (Name)											
Rod/Gear 3 (Name)											
Rod/Gear 4 (Name)											

COMPLETE FOR ALL STURGEON CAPTURED						TAGS APPLIED	RECAPTURES	tn2OTHER	
Fish No.	River Km (Captured)	Was the Sturgeon Scanned? (Yes/No)	Fork Length (cm)	Girth (cm)	Deformity / Wound Code[1]	Verified (Scanned at release) Tag Number	Tag Number	Condition code for sturgeon at release[2]	Comments

Comments:

[1]Deformity/wound/scar codes: DEF = physical deformity; BLED = bleeding; BITE = seal bite; CUT = slice or tear; NET = net scar; OTHER = other (note in comments)

[2]Condition codes: 1 = vigorous, no bleeding; 2 = vigorous, bleeding; 3 = lethargic, no bleeding; 4 = lethargic, bleeding; 5 = dead

Appendix B

Lower Fraser River sturgeon sampling, tagging, and recapture summary, by month and year, 1999-2016

Month	No. Scanned (All)	No. Released With Tag (Head)	No. Scanned, Not Tagged, Not Recaptured	No. Recaptured (Head Tag)	Mark Rate (%)	Year	No. Scanned (All)	No. Released With Tag (Head)	No. Scanned, Not Tagged, Not Recaptured	No. Recaptured (Head Tag)	Mark Rate (%)
Oct-99	96	89	7	0	0.0%						
Nov-99	206	182	24	0	0.0%						
Dec-99	157	143	14	0	0.0%	**1999**	459	414	45	0	**0.0%**
Jan-00	38	37	1	0	0.0%						
Feb-00	148	135	6	7	4.7%						
Mar-00	232	191	33	8	3.4%						
Apr-00	286	265	12	9	3.1%						
May-00	380	351	17	12	3.2%						
Jun-00	279	257	15	7	2.5%						
Jul-00	753	695	27	31	4.1%						
Aug-00	471	424	23	24	5.1%						
Sep-00	469	437	5	27	5.8%						
Oct-00	711	629	37	45	6.3%						
Nov-00	561	506	12	43	7.7%						
Dec-00	57	45	6	6	10.5%	**2000**	4,385	3,972	194	219	**5.0%**
Jan-01	178	165	0	13	7.3%						
Feb-01	152	134	0	18	11.8%						
Mar-01	299	250	0	49	16.4%						
Apr-01	423	340	30	53	12.5%						
May-01	410	360	5	45	11.0%						
Jun-01	509	427	8	74	14.5%						
Jul-01	432	355	14	63	14.6%						
Aug-01	844	717	19	108	12.8%						
Sep-01	582	484	4	94	16.2%						
Oct-01	851	711	26	114	13.4%						
Nov-01	512	417	6	89	17.4%						
Dec-01	316	197	78	41	13.0%	**2001**	5,508	4,557	190	761	**13.8%**
Jan-02	117	60	46	11	9.4%						
Feb-02	147	45	83	19	12.9%						
Mar-02	138	65	53	20	14.5%						
Apr-02	251	107	102	42	16.7%						
May-02	342	173	114	55	16.1%						
Jun-02	225	131	36	58	25.8%						
Jul-02	730	529	87	114	15.6%						
Aug-02	866	622	78	166	19.2%						
Sep-02	396	149	151	96	24.2%						
Oct-02	1,142	582	364	196	17.2%						
Nov-02	531	187	232	112	21.1%						
Dec-02	157	97	31	29	18.5%	**2002**	5,042	2,747	1,377	918	**18.2%**
Jan-03	72	55	11	6	8.3%						
Feb-03	39	20	12	7	17.9%						
Mar-03	131	89	28	14	10.7%						
Apr-03	451	290	77	84	18.6%						
May-03	553	383	84	86	15.6%						
Jun-03	310	180	73	57	18.4%						
Jul-03	474	311	92	71	15.0%						
Aug-03	674	473	89	112	16.6%						
Sep-03	1,132	758	134	240	21.2%						
Oct-03	835	585	69	181	21.7%						
Nov-03	659	395	132	132	20.0%						
Dec-03	114	97	1	16	14.0%	**2003**	5,444	3,636	802	1,006	**18.5%**
Jan-04	144	122	0	22	15.3%						
Feb-04	316	271	4	41	13.0%						
Mar-04	145	114	3	28	19.3%						
Apr-04	743	575	7	161	21.7%						
May-04	589	446	5	138	23.4%						
Jun-04	430	313	8	109	25.3%						
Jul-04	493	362	5	126	25.6%						
Aug-04	656	434	44	178	27.1%						
Sep-04	840	582	14	244	29.0%						
Oct-04	1,695	916	311	468	27.6%						
Nov-04	1,092	603	205	284	26.0%						
Dec-04	97	64	6	27	27.8%	**2004**	7,240	4,802	612	1,826	**25.2%**
Jan-05	28	22	0	6	21.4%						
Feb-05	221	178	0	43	19.5%						
Mar-05	288	222	1	65	22.6%						
Apr-05	831	572	20	239	28.8%						
May-05	459	279	19	161	35.1%						
Jun-05	738	438	17	283	38.3%						
Jul-05	757	479	20	258	34.1%						
Aug-05	1,581	786	148	647	40.9%						
Sep-05	1,835	767	415	653	35.6%						
Oct-05	2,092	965	320	807	38.6%						
Nov-05	1,067	420	312	335	31.4%						
Dec-05	286	136	92	58	20.3%	**2005**	10,183	5,264	1,364	3,555	**34.9%**

continued

Appendix B. Summary of White Sturgeon sampled in the general study area (see Figure 1) of the lower Fraser River, 1999-2016.

Month	No. Scanned (All)	No. Released With Tag (Head)	No. Scanned, Not Tagged, Not Recaptured	No. Recaptured (Head Tag)	Mark Rate (%)	Year	No. Scanned (All)	No. Released With Tag (Head)	No. Scanned, Not Tagged, Not Recaptured	No. Recaptured (Head Tag)	Mark Rate (%)
Jan-06	83	68	0	15	18.1%						
Feb-06	2	2	0	0	0.0%						
Mar-06	116	76	3	37	31.9%						
Apr-06	885	582	8	295	33.3%						
May-06	439	254	10	175	39.9%						
Jun-06	274	161	6	107	39.1%						
Jul-06	510	289	13	208	40.8%						
Aug-06	812	454	30	328	40.4%						
Sep-06	1,309	684	10	615	47.0%						
Oct-06	2,566	1,337	14	1,215	47.3%						
Nov-06	1,863	1,054	38	770	41.3%						
Dec-06	171	116	0	55	32.2%	**2006**	9,030	5,077	132	3,820	**42.3%**
Jan-07	59	45	0	14	23.7%						
Feb-07	122	83	0	39	32.0%						
Mar-07	558	359	1	198	35.5%						
Apr-07	602	363	5	234	38.9%						
May-07	318	148	3	167	52.5%						
Jun-07	460	222	2	236	51.3%						
Jul-07	832	378	3	451	54.2%						
Aug-07	1,463	620	6	837	57.2%						
Sep-07	2,673	1,256	36	1,381	51.7%						
Oct-07	2,288	1,091	16	1,181	51.6%						
Nov-07	1,219	614	17	588	48.2%						
Dec-07	43	27	0	16	37.2%	**2007**	10,637	5,206	89	5,342	**50.2%**
Jan-08	60	42	0	18	30.0%						
Feb-08	26	18	1	7	26.9%						
Mar-08	118	66	5	47	39.8%						
Apr-08	465	231	5	229	49.2%						
May-08	499	200	6	293	58.7%						
Jun-08	434	185	5	244	56.2%						
Jul-08	606	259	0	338	55.8%						
Aug-08	869	356	15	498	57.3%						
Sep-08	1,479	630	21	828	56.0%						
Oct-08	2,083	926	0	1,144	54.9%						
Nov-08	1,832	906	15	911	49.7%						
Dec-08	83	51	0	32	38.6%	**2008**	8,554	3,870	73	4,589	**53.6%**
Jan-09	22	13	0	9	40.9%						
Feb-09	89	61	0	28	31.5%						
Mar-09	146	82	0	64	43.8%						
Apr-09	533	254	8	271	50.8%						
May-09	321	100	0	221	68.8%						
Jun-09	348	124	3	221	63.5%						
Jul-09	434	183	5	246	56.7%						
Aug-09	1,078	390	16	672	62.3%						
Sep-09	1,798	654	16	1,128	62.7%						
Oct-09	2,081	849	24	1,208	58.0%						
Nov-09	1,262	588	16	658	52.1%						
Dec-09	143	61	15	67	46.9%	**2009**	8,255	3,359	103	4,793	**58.1%**
Jan-10	271	161	0	110	40.6%						
Feb-10	178	102	0	76	42.7%						
Mar-10	223	92	4	127	57.0%						
Apr-10	614	277	6	331	53.9%						
May-10	396	149	2	245	61.9%						
Jun-10	402	140	4	258	64.2%						
Jul-10	490	227	4	259	52.9%						
Aug-10	755	221	6	528	69.9%						
Sep-10	1,401	456	17	928	66.2%						
Oct-10	2,833	1,157	26	1,650	58.2%						
Nov-10	1,195	556	12	627	52.5%						
Dec-10	321	194	3	124	38.6%	**2010**	9,079	3,732	84	5,263	**58.0%**
Jan-11	178	113	0	65	36.5%						
Feb-11	41	22	0	19	46.3%						
Mar-11	138	71	0	67	48.6%						
Apr-11	756	336	8	412	54.5%						
May-11	339	148	4	187	55.2%						
Jun-11	176	48	0	128	72.7%						
Jul-11	588	236	4	348	59.2%						
Aug-11	1,092	327	4	761	69.7%						
Sep-11	2,283	773	12	1,498	65.6%						
Oct-11	2,339	998	35	1,306	55.8%						
Nov-11	1,084	475	24	585	54.0%						
Dec-11	121	55	2	64	52.9%	**2011**	9,135	3,602	93	5,440	**59.6%**

continued

Appendix B. Summary of White Sturgeon sampled in the general study area (see Figure 1) of the lower Fraser River, 1999-2016.

Month	No. Scanned (All)	No. Released With Tag (Head)	No. Scanned, Not Tagged, Not Recaptured	No. Recaptured (Head Tag)	Mark Rate (%)	Year	No. Scanned (All)	No. Released With Tag (Head)	No. Scanned, Not Tagged, Not Recaptured	No. Recaptured (Head Tag)	Mark Rate (%)
Jan-12	82	44	0	38	46.3%						
Feb-12	83	44	0	39	47.0%						
Mar-12	211	101	0	110	52.1%						
Apr-12	463	192	4	267	57.7%						
May-12	364	163	1	200	54.9%						
Jun-12	233	79	1	153	65.7%						
Jul-12	738	322	4	412	55.8%						
Aug-12	1,063	382	12	669	62.9%						
Sep-12	1,755	755	13	987	56.2%						
Oct-12	2,820	1,229	28	1,563	55.4%						
Nov-12	1,061	404	9	648	61.1%						
Dec-12	322	149	2	171	53.1%	**2012**	9,195	3,864	74	5,257	**57.2%**
Jan-13	220	97	0	123	55.9%						
Feb-13	342	166	1	175	51.2%						
Mar-13	503	237	2	264	52.5%						
Apr-13	923	387	16	520	56.3%						
May-13	673	221	4	448	66.6%						
Jun-13	455	164	4	287	63.1%						
Jul-13	769	279	2	488	63.5%						
Aug-13	1,183	404	15	764	64.6%						
Sep-13	2,655	875	30	1,750	65.9%						
Oct-13	2,750	1,005	36	1,709	62.1%						
Nov-13	1,572	558	14	1,000	63.6%						
Dec-13	110	44	0	66	60.0%	**2013**	12,155	4,437	124	7,594	**62.5%**
Jan-14	144	60	1	83	57.6%						
Feb-14	102	50	0	52	51.0%						
Mar-14	470	188	1	281	59.8%						
Apr-14	867	340	7	520	60.0%						
May-14	485	133	4	348	71.8%						
Jun-14	460	129	5	326	70.9%						
Jul-14	819	261	10	548	66.9%						
Aug-14	1,107	197	119	791	71.5%						
Sep-14	1,386	325	161	900	64.9%						
Oct-14	2,135	587	135	1,413	66.2%						
Nov-14	961	286	56	619	64.4%						
Dec-14	254	81	26	147	57.9%	**2014**	9,190	2,637	525	6,028	**65.6%**
Jan-15	414	126	42	246	59.4%						
Feb-15	293	149	11	133	45.4%						
Mar-15	355	108	7	240	67.6%						
Apr-15	756	265	12	479	63.4%						
May-15	571	194	4	373	65.3%						
Jun-15	398	122	5	271	68.1%						
Jul-15	877	279	6	592	67.5%						
Aug-15	1,333	353	11	969	72.7%						
Sep-15	2,402	650	44	1,708	71.1%						
Oct-15	2,696	918	52	1,726	64.0%						
Nov-15	1,017	274	16	727	71.5%						
Dec-15	304	120	2	182	59.9%	**2015**	11,416	3,558	212	7,646	**67.0%**
Jan-16	269	107	0	162	60.2%						
Feb-16	328	84	8	236	72.0%						
Mar-16	670	193	6	471	70.3%						
Apr-16	873	273	11	589	67.5%						
May-16	312	81	4	227	72.8%						
Jun-16	556	136	6	414	74.5%						
Jul-16	932	209	17	706	75.8%						
Aug-16	832	203	16	613	73.7%						
Sep-16	1,078	353	16	709	65.8%						
Oct-16	1,532	409	15	1,108	72.3%						
Nov-16	496	121	2	373	75.2%						
Dec-16	4	1	1	2	50.0%	**2016**	7,882	2,170	102	5,610	**71.2%**
					Totals All Years	**1999-2016**	**142,789**	**66,904**	**6,195**	**69,667**	**48.8%**