Species at Risk Act
Recovery Strategy Report Series

Report on the Progress of Recovery Strategy Implementation for the White Sturgeon (*Acipenser transmontanus*) in Canada for the Period 2014 to 2020

White Sturgeon

2023

Canada

Recommended citation:

Fisheries and Oceans Canada. 2023. Report on the Progress of Recovery Strategy Implementation for the White Sturgeon (*Acipenser transmontanus*) in Canada for the Period 2014 to 2020. *Species at Risk Act* Recovery Strategy Report Series. Fisheries and Oceans Canada, Ottawa. v + 113 pp.

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Cover illustration: Juvenile White Sturgeon, photo by David Gluns.

Également disponible en français sous le titre
« Rapport sur les progrès de la mise en œuvre du programme de rétablissement de l'esturgeon blanc (*Acipenser transmontanus*) au Canada pour la période 2014 à 2020 »

ISBN 978-0-660-44636-3
Catalogue no. En3-4/181-1-2023E-PDF

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for the protection of species at risk throughout Canada. Under section 46 of the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the competent ministers are responsible for reporting on the implementation of the recovery strategy for a species at risk, and on the progress towards meeting its objectives within 5 years of the date when the final recovery strategy was placed on the Species at Risk Public Registry, and in every subsequent 5-year period until its objectives have been achieved or the species' recovery is no longer feasible.

Reporting on the progress of recovery strategy implementation requires reporting on the collective efforts of the competent ministers, provincial and territorial governments, and all other parties involved in conducting activities that contribute to the species' recovery. Recovery strategies identify broad strategies and approaches that will provide the best chance of ensuring the survival and recovery of species at risk. Some of the identified broad strategies and approaches are sequential to the progress or completion of others and not all may be undertaken or show significant progress during the timeframe of a report on the progress of recovery strategy implementation (progress report).

The Minister of Fisheries and Oceans is the sole competent minister under SARA for Upper Fraser River, Upper Columbia River, and Kootenay River nationally significant populations. The Minister of Fisheries and Oceans and the Minister responsible for Parks Canada are the competent ministers under SARA for the Nechako River nationally significant population as the distribution and critical habitat of the population overlap with part of the property of Fort St. James National Historic Site under Parks Canada's jurisdiction. The Minister of Fisheries and Oceans prepared this progress report in consultation with the Minister responsible for Parks Canada.

As stated in the preamble to SARA, success in the recovery of species at risk depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in the recovery strategy and will not be achieved by Fisheries and Oceans Canada (DFO), Parks Canada or any other jurisdiction alone. The cost of recovering and conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing the recovery strategy for the White Sturgeon for the benefit of the species and Canadian society as a whole.

Acknowledgments

This progress report was developed by Maggie Boothroyd, Ahdia Hassan, Herb Klassen, Claire Salvador, and Erin Gertzen (DFO). To the extent possible, this progress report has been prepared in collaboration with the British Columbia (BC) Ministry of Environment and Climate Change Strategy, BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development, United States co-managers, National White Sturgeon Recovery Team, Nechako White Sturgeon Recovery Initiative, Upper Columbia River White Sturgeon Recovery Initiative, co-managers and technical experts on Kootenay White Sturgeon, and Indigenous partners. DFO would also like to express its appreciations to all individuals and organizations who have contributed to the recovery of the White Sturgeon.

Louise Porto (Wood) and Larry Hildebrand (RiverRun Consulting) compiled an initial list of actions completed and anticipated future needs for the recovery of the 4 SARA-listed White Sturgeon populations. Broad membership of basin-level White Sturgeon Technical Working Groups reviewed and contributed to the information compiled.

Executive summary

Four nationally significant populations (NSPs) of White Sturgeon (Upper Fraser River, Nechako River, Upper Columbia River, and Kootenay River[1]) were listed as endangered under the *Species at Risk Act* (SARA) in 2006. The "Recovery Strategy for White Sturgeon (*Acipenser transmontanus*) in Canada" was published on the Species at Risk Public Registry in 2014 (recovery strategy; DFO 2014).

Threats identified for White Sturgeon include: loss of habitat quality and quantity, habitat fragmentation, altered hydrograph components, pollution, fishing and industrial effects (direct and indirect), reduced turbidity, altered thermal regime, effects of small population size, hatchery and aquaculture effects on health and population, reduced or altered food supply (including fishing of White Sturgeon prey base), change in ecological community (predation / competition), and disease. Threat risks vary among populations. Details are described in section 4 of the recovery strategy.

The recovery goal and population and distribution objectives for White Sturgeon, described in section 7 of the recovery strategy, are:

Recovery goal:

- ensure that each of the populations are sustainable throughout their natural range, are self-sustaining through natural reproduction, and to increase or restore opportunities for beneficial use, if and when feasible

Population and distribution objectives[2]:

1. prevent extirpation of White Sturgeon in each of the 4 identified populations by preventing net loss of reproductive potential;
2. initiate, within 5 years, pilot studies towards restoration of natural recruitment for each population that is affected by dams. Within 10 years, identify methods for each population that, if and when implemented, have a high likelihood of restoring recruitment to a level sufficient to achieve the other recovery measures listed herein;
3. reach or exceed all of the following population and distribution targets for survival or recovery within 50 years:
    a. 1,000 mature individuals in an approximately 1:1 sex ratio at maturity;
    b. distribution over the natural range, with the exception of Duncan Reservoir, Slocan Lake, the lower Kootenay River between Corra Linn and Brilliant Dams, and the Columbia River upstream of Revelstoke Dam; and,
    c. ongoing natural recruitment sufficient to meet all other targets;
4. reach or exceed population and distribution targets for beneficial use within specified timeframes. As success is achieved in meeting the biological recovery targets, the beneficial use targets and timelines will be established and adjusted. Such targets may vary among populations.

[1] Renamed White Sturgeon (Upper Kootenay River population) in 2019 (SOR/2019-287, order amending the federal *Species at Risk Act*), but referred to as Kootenay River population within this progress report for consistency with the recovery strategy.

[2] The only population objective that is directly applicable for the Upper Fraser River population is objective 1, since the population is thought to be at or near historical levels. All population and distribution objectives are applicable for the other 3 SARA-listed NSPs.

The “Report on the Progress of Recovery Strategy Implementation for White Sturgeon in Canada for the Period 2014 to 2020” (progress report) reports on the progress made by Fisheries and Oceans Canada (DFO) and its partners towards implementing the recovery strategy and achieving its objectives. During this time period, progress has been made towards recovery of all 4 SARA-listed White Sturgeon populations, including:

- protection of critical habitat for all SARA-listed populations through SARA critical habitat orders in 2016
- the continuation of monitoring programs to inform management and provide a method to measure success of recovery activities
- research to clarify and mitigate threats
- increased stakeholder and public awareness through outreach initiatives

During this time period, progress has been made towards restoring natural recruitment of the dam-affected populations in the Nechako, Upper Columbia, and Kootenay rivers, including:

- research to refine the mechanism(s) of recruitment failure
- pilot experimental spawning habitat restorations
- studies to inform larger-scale restorations in the Nechako and Upper Columbia rivers
- large-scale restoration to enhance habitat for all life stages of White Sturgeon in the Kootenay system

The condition of the Upper Fraser River White Sturgeon NSP remains stable. The 3 dam-affected populations continue to experience recruitment failure[3]; however, recruitment into these populations has been maintained through conservation aquaculture. While there has been measurable progress towards meeting the recovery goal and population and distribution objectives presented in the recovery strategy, further work is required to support recovery of the 4 SARA-listed White Sturgeon populations. Priority next steps include: continuing research to clarify and mitigate threats to all SARA-listed populations with a focus on understanding and reversing recruitment failure in dam-affected populations in the Nechako, Upper Columbia, and Kootenay rivers; continuing population monitoring and research; and maintaining and restoring ecosystem functions relevant to White Sturgeon.

[3] In the Columbia, Kootenay and Nechako rivers, the cause of decline is primarily ongoing recruitment failure. In each of the three rivers, regular spawning occurs, but viable offspring do not recruit to the juvenile stage in sufficient numbers to sustain the population.

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1. Introduction

The “Report on the Progress of Recovery Strategy Implementation for the White Sturgeon (*Acipenser transmontanus*) in Canada for the Period 2014 to 2020” (progress report) outlines the progress made towards meeting the objectives listed in the “Recovery Strategy for White Sturgeon (*Acipenser transmontanus*) in Canada” (recovery strategy) (Fisheries and Oceans Canada [DFO] 2014) during the indicated time period for the 4 White Sturgeon nationally significant populations (NSPs) listed under the *Species at Risk Act* (S.C. 2002, c.29) (SARA): Upper Fraser River, Nechako River, Upper Columbia River, and Kootenay River[4]. The progress report is one in a series of documents for this species that are linked and should be taken into consideration together; including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports (COSEWIC 2003; 2012), science advisory report from the recovery potential assessments (DFO 2007; 2016), and recovery strategy (DFO 2014).

Section 2 of the progress report provides an overview of key information on the threats to the species, recovery goal and population and distribution objectives for achieving its recovery, and performance measures to measure the progress of recovery. For more details, readers should refer back to the “Recovery Strategy for White Sturgeon (*Acipenser transmontanus*) in Canada” (DFO 2014). Progress in carrying out the strategies, and their associated research and management activities, is reported in section 3.1 of this report. Section 3.2 reports on the activities identified in the schedule of studies to identify critical habitat. Section 3.3 reports on the progress towards meeting the performance measures and other commitments (for example, action plan and critical habitat order) identified in the recovery strategy. Section 4 summarizes the progress toward achieving the population and distribution objectives.

2. Background

2.1 COSEWIC assessment summary and threats to the species and its critical habitat

In 2003, COSEWIC assessed White Sturgeon in Canada as endangered. Within Canada, 6 NSPs were described based on geography, genetics and demographics: Lower Fraser River, Middle Fraser River, Upper Fraser River, Nechako River, Upper Columbia River, and Kootenay River (COSEWIC 2003).

The listing of the latter 4 NSPs of White Sturgeon (Upper Fraser River, Nechako River, Upper Columbia River, and Kootenay River) as endangered under SARA in 2006 led to the development and publication of the “Recovery Strategy for White Sturgeon (*Acipenser transmontanus*) in Canada” (recovery strategy) (DFO 2014). The recovery strategy is consistent with the information provided in the COSEWIC status report (COSEWIC 2003) and the COSEWIC summary information is included in section 1.1 of the recovery strategy. The listing of these NSPs and the development of the recovery strategy were further informed by the recovery potential assessment for White Sturgeon (DFO 2007).

[4] Renamed White Sturgeon (Upper Kootenay River population) in 2019 (SOR/2019-287, order amending the federal *Species at Risk Act*), but referred to as Kootenay River population within this progress report for consistency with the recovery strategy.

In November 2012, COSEWIC re-examined White Sturgeon, and assessed the species as 4 separate designatable units (DUs): the Lower Fraser River DU, assessed as threatened; the Upper Fraser River DU, assessed as endangered; the Upper Columbia River DU, assessed as endangered; and the Upper Kootenay River DU, assessed as endangered (COSEWIC 2012). These DUs differ in genetic structure and distribution from the 6 NSPs previously identified in the 2003 COSEWIC assessment[5]; however, this progress report and the recovery strategy were prepared in response to the 2006 SARA listing of the Upper Columbia River, Nechako River, Upper Fraser River, and Kootenay River NSPs.

The recovery strategy identifies threats to survival and recovery of the White Sturgeon and threats to its critical habitat. Section 4 of the recovery strategy provides information on threats to the species' survival and recovery. While the risk of threats varies among populations, the primary species-level threats to White Sturgeon include: loss of habitat quality and quantity, habitat fragmentation, altered hydrograph components[6], pollution, fishing and industrial effects (direct and indirect), reduced turbidity, altered thermal regime, effects of small population size, hatchery and aquaculture effects on health and population, reduced or altered food supply (including fishing of White Sturgeon prey base), change in ecological community (predation / competition), and disease.

Critical habitat for the White Sturgeon has been identified, to the extent possible, in section 8 of the recovery strategy (DFO 2014). The recovery strategy also provides examples of activities that are likely to result in destruction to critical habitat (that is, threats to critical habitat). The list of activities provided in tables 20 to 23 of the recovery strategy are neither exhaustive nor exclusive, and their inclusion has been guided by the relevant threats to habitat described in the recovery strategy. For more details on the activities likely to result in the destruction of critical habitat, consult section 8.7 of the recovery strategy.

2.2 Recovery

This section summarizes the information, found in the recovery strategy (DFO 2014), on the recovery goal and population and distribution objectives that are necessary for the recovery of the White Sturgeon and on performance measures that provide a way to define and measure progress toward achieving the recovery goal and population and distribution objectives.

Section 7 of the recovery strategy (DFO 2014) identified the following recovery goal and population and distribution objectives necessary for the recovery of the species.

Recovery goal:

- ensure that each of the populations are sustainable throughout their natural range, are self-sustaining through natural reproduction, and to increase or restore opportunities for beneficial use, if and when feasible

[5] In November 2012, COSEWIC reassessed White Sturgeon and divided the species into four Designatable Units (DUs). In some areas, these DUs differ in genetic structure and distribution from the six NSPs previously identified in the COSEWIC 2003 assessment. The geographic extents of the Upper Columbia River, Kootenay River, and Lower Fraser River NSPs are the same as the species' range in the Upper Columbia River, Upper Kootenay River, and Lower Fraser River DUs, respectively. The Middle Fraser River, Upper Fraser River, and Nechako River NSPs were combined into a single DU referred to as the Upper Fraser River DU.

[6] Altered hydrograph components may be related to flow regulation, flow diversion, and anthropogenic activities causing climate change.

Population and distribution objectives[7]:

1. prevent extirpation of White Sturgeon in each of the four identified populations by preventing net loss of reproductive potential
2. initiate, within 5 years, pilot studies towards restoration of natural recruitment for each population that is affected by dams. Within 10 years, identify methods for each population that, if and when implemented, have a high likelihood of restoring recruitment to a level sufficient to achieve the other recovery measures listed herein
3. reach or exceed all of the following population and distribution targets for survival or recovery within 50 years:
    a. 1,000 mature individuals in an approximately 1:1 sex ratio at maturity
    b. distribution over the natural range, with the exception of Duncan Reservoir, Slocan Lake, the lower Kootenay River between Corra Linn and Brilliant Dams, and the Columbia River upstream of Revelstoke Dam
    c. ongoing natural recruitment sufficient to meet all other targets
4. reach or exceed population and distribution targets for beneficial use within specified timeframes. As success is achieved in meeting the biological recovery targets, the beneficial use targets and timelines will be established and adjusted. Such targets may vary among populations

Section 7.5 of the recovery strategy includes the following performance measures[8] to define and measure progress toward achieving the recovery goal and population and distribution objectives:

Performance measures:

- Have targets been achieved?
- Has critical habitat been identified?
- Have experimental trials been initiated to restore natural recruitment?
- Have experimental results shown that natural recruitment can be restored to necessary levels?
- Has recruitment been restored in dam-affected populations?
- Have the most serious threats been defined?
- Have these threats been sufficiently mitigated?
- Have key information gaps been filled?
- Has general awareness of sturgeon conservation been increased?
- Is the ecosystem “healthy” for White Sturgeon?

[7] The only population objective that is directly applicable for the Upper Fraser NSP is objective 1, since the population is thought to be at or near historical levels. All population and distribution objectives are applicable for the other 3 SARA-listed NSPs.

[8] As White Sturgeon is a slow-growing, late-maturing, and long-lived species, performance measures were developed that could be measured repeatedly throughout the recovery process. The performance measures are presented here as questions, the answers to which can be plotted in time to monitor progress (DFO 2014).

3. Progress towards recovery

The recovery strategy for the White Sturgeon divides the recovery effort into 7 strategies, and their associated research and management activities (see table 5 in the recovery strategy; DFO 2014):

Strategy A: meet or exceed recovery population targets within specified timeframe

- A-1: set up conservation aquaculture where needed
- A-2: monitor population trends
- A-3: establish parameters for beneficial use

Strategy B: protect critical habitats

- B-1: identify habitat requirements for all life stages
- B-2: define critical habitat (including related ecological processes)
- B-3: identify critical habitats for designation and protection
- B-4: protect, maintain and enhance critical habitat for White Sturgeon
- B-5: ensure habitat diversity, connectivity and productivity
- B-6: work cooperatively to develop plans to protect habitat

Strategy C: restore natural recruitment

- C-1: determine accuracy of recruitment index time series
- C-2: identify temporal correlations between significant recruitment shifts (peaks or drops) and environmental changes
- C-3: examine potential mechanism of recruitment effect
- C-4: undertake meso-scale field trials
- C-5: undertake larger scale field trials
- C-6: design and implement longer term restoration program
- C-7: determine the habitat requirements for dam affected population enhancement or recovery
- C-8: initiate, within 5 years, pilot studies towards restoration of natural recruitment for each population that is affected by dams
- C-9: within 10 years, identify methods for each population that, if and when implemented, can restore recruitment to a level sufficient to achieve the other recovery measures listed herein

Strategy D: clarify and mitigate threats

- D-1: clarify the following threats and their relative risks:
    - D-1a fishing
    - D-1b pollution
    - D-1c predation
- D-2: clarify threats to:
    - D-2a food supply
    - D-2b habitat (including effects of flow regulation)
- D-3: undertake specific actions to address risks:
    - D-3a protect, maintain and enhance critical habitat
    - D-3b address illegal harvest
    - D-3c minimize bycatch and mitigate impacts from fisheries through regulation and best practices

    - D-3d limit and address pollutant discharges and contaminant loading, especially adjacent to important or critical habitats
    - D-3e protect, maintain and enhance water quality
    - D-3f mitigate interactions of White Sturgeon with industrial structures and activities
    - D-3g manage risks from conservation hatchery introductions
    - D-3h better understand, maintain and enhance food availability for all life stages of each population
- D-4: monitor threat indicators and population trends
- D-5: work cooperatively to develop plans to mitigate threats to White Sturgeon

Strategy E: address information gaps that inhibit conservation of White Sturgeon

- E-1: address basic biological data gaps

Strategy F: increase stakeholder and general public awareness of White Sturgeon and its conservation needs

- F-1: maintain and where possible increase awareness and stewardship of White Sturgeon throughout its natural range
- F-2: engage in effective public education of the species and its conservation needs
- F-3: support learning and communication across all working groups
- F-4: ensure participation from community and technical experts

Strategy G: maintain and where necessary, restore ecosystem functions relevant to White Sturgeon

- G-1: incorporate the needs of healthy White Sturgeon populations into the management of White Sturgeon prey species, especially salmon and resident sportfish
- G-2: accommodate other species' needs during recovery of White Sturgeon
- G-3: closely manage non-native predatory fish species
- G-4: dialogue with regulatory agencies that have influence or jurisdiction over White Sturgeon prey species

To simplify the tables in this section, the above coding for the strategies, and their associated research and management activities has been used.

Progress in carrying out these strategies, and their associated research and management activities is reported in section 3.1 of this report. Section 3.2 reports on the activities identified in the schedule of studies to identify critical habitat. Section 3.3 reports on the progress towards meeting the performance measures and other commitments (for example, action plan and critical habitat order) identified in the recovery strategy and information obtained through implementing the recovery strategy.

3.1 Activities supporting recovery

Tables 1 to 4 provide information on implementation of activities undertaken to address the strategies, and their associated research and management activities identified in the recovery planning table of the recovery strategy (DFO 2014)[9].

List of tables in this section:

[9] Some activities that support the recovery of White Sturgeon pre-date the reporting period for this progress report. For a summary of recovery-related actions that were completed (or were underway) prior to 2014, please refer to the recovery strategy (DFO 2014).

Table 1. Details of activities supporting the recovery of the Upper Fraser River White Sturgeon nationally significant population (NSP) from 2014 to 2020.

Strategy	Activity	Descriptions and results	Participants[10]
A. Meet or exceed recovery population targets within specified timeframe	A-1 Set up conservation aquaculture where needed	Not applicable. The Upper Fraser River NSP is not experiencing recruitment failure and the recovery strategy did not identify the need for conservation aquaculture to enhance population size beyond its current abundance.	N/A
A. Meet or exceed recovery population targets within specified timeframe	A-2 Monitor population trends	A standardized monitoring program, led by Lheidli T'enneh First Nation (Lheidli T'enneh), was completed annually during the reporting period and is ongoing. This adult and juvenile monitoring program includes a mark-recapture program, spawn monitoring, and movement studies (including adult telemetry; Lheidli T'enneh 2020). Ongoing monitoring efforts suggest the Upper Fraser River White Sturgeon NSP is near historical levels and the age structure indicates the population is stable and recruitment is successful (Lheidli T'enneh 2017). Collaborative reporting for juvenile monitoring by Carrier Sekani Tribal Council (CSTC), British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC MFLNRORD), Lheidli T'enneh, and Freshwater Fisheries Society of BC (FFSBC) for the Nechako, Upper, and Middle Fraser River NSPs began in 2019 and is ongoing (see CSTC 2020a). Results identified wild and hatchery-origin juvenile movements between the Upper Fraser River NSP, Middle Fraser River NSP and Nechako River NSP ranges. Nechako hatchery-origin juveniles were first captured in the Upper Fraser River	BC Ministry of Environment and Climate Change Strategy (BC ENV), BC MFLNRORD, CSTC, Fisheries and Oceans Canada (DFO), FFSBC, Lheidli T'enneh, Nechako White Sturgeon Recovery Initiative Technical Working Group (NWSRI TWG[12]

[10] Participants are listed in alphabetical order.

[12] The NWSRI supports recovery for the Nechako River White Sturgeon NSP and the Upper Fraser River White Sturgeon NSP due to similar geographic location and endangered status. NWSRI TWG membership includes: BC ENV, BC MFLNRORD, DFO, Lheidli T'enneh, Tl'azt'en First Nation, CSTC, FFSBC, University of BC and Rio Tinto Alcan. Note: Rio Tinto Alcan participates in Nechako River White Sturgeon NSP recovery measures only and Lheidli T'enneh participates in Upper Fraser River White Sturgeon NSP recovery measures only.

Strategy	Activity	Descriptions and results	Participants[10]
		in 2018 (for more detail on hatchery-origin movement, refer to table 2 B-1; CSTC 2020a). Analysis of adult telemetry data identified important habitats (that is, adult holding, feeding and overwintering) and seasonal movements for the Upper Fraser River NSP (using data from 2007 to 2019; Lheidli T'enneh 2020), and detected movement of Upper Fraser River NSP, Middle Fraser River NSP and Nechako River NSP adults between their respective ranges (Lheidli T'enneh 2020; Williamson et al. 2021[11]).	
A. Meet or exceed recovery population targets within specified timeframe	A-3 Establish parameters for beneficial use	Modelling in the "Recovery Potential Assessment for White Sturgeon (*Acipenser transmontanus*) Upper Fraser River Designatable Unit" (DFO 2016) shows that allowable harm is at or below current human-induced mortality levels and is likely near zero, precluding opportunity for beneficial use in this population. Beneficial use parameters have not been established.	DFO
B. Protect critical habitats	B-1 Identify habitat requirements for all life stages	Data on habitat use has been collected as part of ongoing population monitoring efforts (refer to A-2); high use habitats for juvenile rearing and feeding (for example, Longworth Canyon) and important adult habitats (that is, holding, feeding and overwintering) have been identified. Efforts to confirm spawning and early life stage habitat requirements are ongoing and include adult telemetry (to identify spawning sites, timing, and periodicity), and periodic egg matting (to confirm potential spawning sites; Lheidli T'enneh 2020). Telemetry data identified the Willow River, Bowron, and Nechako River confluences as potential spawning locations as tagged individuals make annual migrations to cobble benthic substrate in these areas; however, egg matting efforts have not confirmed spawning use (Lheidli T'enneh 2020).	BC MFLNRORD, CSTC, DFO, Lheidli T'enneh, NWSRI TWG

[11] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[10]
B. Protect critical habitats	B-2 Define critical habitat (including ecological processes)	Geographic locations of critical habitats for White Sturgeon were identified in section 8.5 of the recovery strategy (DFO 2014). Potential spawning locations (for example, the Bowron, Willow, and Nechako confluences) were identified as critical habitat (refer to table 5); monitoring is ongoing to identify additional critical habitat, particularly for spawning and early life stages (refer to B-1 and table 5). A critical habitat order was put in place in 2016.	DFO, Lheidli T'enneh, NWSRI TWG
B. Protect critical habitats	B-3 Identify critical habitats for designation and protection	Refer to B-2.	DFO, Lheidli T'enneh, NWSRI TWG
B. Protect critical habitats	B-4 Protect, maintain, and enhance critical habitat for White Sturgeon	A critical habitat order was put in place in 2016. Enhancement of Upper Fraser River White Sturgeon NSP critical habitat has not occurred.	DFO
B. Protect critical habitats	B-5 Ensure habitat diversity, connectivity, and productivity	No actions taken during this reporting period. The extent of suitable habitat for the Upper Fraser River White Sturgeon NSP is at or near historical levels (DFO 2014). However, it is unknown if habitat degradation in connected waterbodies may negatively affect the Upper Fraser River White Sturgeon NSP.	N/A
B. Protect critical habitats	B-6 Work cooperatively to protect habitat	A number of habitat restoration-focused groups exist within the range of Upper Fraser River White Sturgeon NSP, including: Fraser Basin Council, Farmland-Riparian Interface Stewardship Program, Fraser Salmon and Watershed Program, and Rivershed Society of BC's Fraser Watershed Initiative. These initiatives aim to conserve and maintain important habitats for resident species in the Fraser watershed (including White Sturgeon).	Stewardship groups

Strategy	Activity	Descriptions and results	Participants[10]
C. Restore natural recruitment	C-1 to C-9	Not applicable. The Upper Fraser River White Sturgeon NSP is not experiencing recruitment failure.	N/A
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: a. fishing	Risks associated with fishing were assessed as low for the Upper Fraser River White Sturgeon NSP; however, the amount of illegal harvest is unknown (DFO 2014, 2016).	DFO
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: b. pollution	Early life stage White Sturgeon are highly sensitive to particular toxins (for example, copper) relative to other fish (Calfee et al. 2014; Vardy et al. 2014, 2015; Wang et al. 2014); in lab studies, below lethal concentrations, contaminants resulted in sublethal effects such as altered movement, diminished hiding, disruption in sodium uptake, and loss of equilibrium (Calfee et al. 2014; Little et al. 2014; Wang et al. 2014; Shekh et al. 2019). Potential contaminant sources in the Upper Fraser River include pulp mill and mine effluent, and spills from railway crossings. Prince George has a large industrial area that includes pulp mills, refineries, and chemical plants. Impact of effluents on early life stages specific to the Upper Fraser River White Sturgeon NSP is unknown as early life stage habitats have not been confirmed (refer to B-2).	Academia
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: c. predation	As the threat of predation is ranked low for the Upper Fraser River White Sturgeon NSP (DFO 2014), no actions are underway or planned. River Otters (*Lontra canadensis*) have been identified as predators of juvenile White Sturgeon in the Nechako River (refer to table 2 D-1c for details on ongoing research). One predation mortality identified was of a wild-origin fish originally tagged in the Upper Fraser River.	Academia, NWSRI TWG
D. Clarify and mitigate threats	D-2 Clarify threats to: a. food supply	The Upper Fraser Fisheries Conservation Alliance (UFFCA) collected traditional ecological knowledge on Upper Fraser River and Nechako	CSTC, DFO, Indigenous organizations,

Strategy	Activity	Descriptions and results	Participants[10]
		River White Sturgeon NSPs[13]. Results identified Sockeye Salmon (*Oncorhynchus nerka*) as an important White Sturgeon food source in the Nechako River and Upper Fraser River (UFFCA 2018), and ongoing monitoring has identified Sockeye Salmon as the preferred bait for White Sturgeon fishing (CSTC 2020a). Several Chinook Salmon (*Oncorhynchus tshawytscha*), Sockeye Salmon, and Coho Salmon (*Oncorhynchus kisutch*) stocks migrating through Fraser River basin were assessed as species at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 20117, 2018) and are under consideration for listing under the *Species at Risk Act* (SARA); salmon management and monitoring is ongoing. The Big Bar landslide in 2019 further impacted Fraser River salmon stocks, which are important prey species for White Sturgeon, by restricting upstream access (Grant et al. 2019).	stewardship groups, UFFCA
D. Clarify and mitigate threats	D-2 Clarify threats to: b. habitat (including effects of flow regulation)	No actions taken during this reporting period. The extent of suitable habitat for the Upper Fraser River NSP is at or near historical levels and the mainstem of the Fraser River is not subject to flow regulation (DFO 2014).	N/A
D. Clarify and mitigate threats	D-3 Undertake specific actions to: a. protect, maintain, and enhance critical habitat	Refer to B-2 to B-5 and table 5.	DFO, Lheidli T'enneh, NWSRI TWG

[13] First Nations interviewed and engaged included Saik'uz, Nadleh Whut'en, and Stellat'en First Nations.

Strategy	Activity	Descriptions and results	Participants[10]
D. Clarify and mitigate threats	D-3 Undertake specific actions to: b. address illegal harvest	Year-round compliance patrols are conducted by DFO to enforce SARA prohibitions and the White Sturgeon fishing closure.	DFO
D. Clarify and mitigate threats	D-3 Undertake specific actions to: c. minimize bycatch and mitigate impacts from fisheries through regulation and best practices	White Sturgeon bycaught in First Nation Food, Social, and Ceremonial (FSC) salmon fisheries are required to be released unharmed, and retention of dead White Sturgeon is not permitted. Ongoing community outreach and awareness programs including the Emergency Sturgeon Release Boat Kit Program that was initiated by CSTC and NWSRI in 2011 help mitigate bycatch mortalities associated with First Nation FSC fisheries. • Since the program's inception, 86 sturgeon have been released in the Upper Fraser and Nechako rivers (NWSRI 2020) • Since 2014, an on-site bycatch monitor has been hired for each participating First Nation[14] to facilitate outreach and the distribution of boat kits	CSTC, DFO, First Nations, NWSRI TWG
D. Clarify and mitigate threats	D-3 Undertake specific actions to: d. limit and address pollutant discharges and contaminant loading, especially adjacent to important or critical habitats	Threats related to pollution are mitigated through protections by provincial and federal regulatory reviews. Refer to D-1b for details on the threat of pollution for the Upper Fraser River NSP.	BC ENV, BC MFLNRORD, DFO, Environment and Climate Change Canada (ECCC), industry

[14] First Nations participating in the Emergency Boat Kit Program include Lheidli T'enneh, Nak'azdli Whuten, Saik'uz, Stellat'en, Takla, Tl'azt'en, Yekooche First Nations.

Strategy	Activity	Descriptions and results	Participants[10]
D. Clarify and mitigate threats	D-3 Undertake specific actions to: e. protect, maintain, and enhance water quality	Refer to D-3d.	BC ENV, BC MFLNRORD, DFO, ECCC, industry
D. Clarify and mitigate threats	D-3 Undertake specific actions to: f. mitigate interactions of White Sturgeon with industrial structures and activities	Provincial and federal regulatory review of projects that may impact White Sturgeon and/or its habitat is ongoing.	BC ENV, BC MFLNRORD, DFO
D. Clarify and mitigate threats	D-3 Undertake specific actions to: g. manage risks from conservation hatchery introductions	The FFSBC-run Nechako White Sturgeon Conservation Centre (NWSCC) hatchery applies adaptive management and mitigation measures to aid imprinting and minimize straying (see table 2 A-1 for more details). An ongoing collaborative juvenile monitoring program helps track Nechako hatchery-origin fish within the Fraser River (refer to A-2 and table 2 D-3g; CSTC 2020a). This program provides data to support the assessment of potential genetic and demographic risks of Nechako hatchery-origin fish straying to the Upper and Middle Fraser River NSPs; this analysis has been initiated (refer to table 2 D-3g).	Academia, BC ENV, BC MFLNRORD, CSTC, DFO, FFSBC, Lheidli T'enneh, NWSCC, NWSRI TWG
D. Clarify and mitigate threats	D-3 Undertake specific actions to: h. better understand, maintain, and	Threats associated with prey species were described in D-2a. A number of habitat-restoration focused groups that aim to conserve and maintain important habitats for resident species exist within the range of Upper Fraser River White Sturgeon (refer to B-6).	BC ENV, BC MFLNRORD, CSTC, DFO, Indigenous organizations,

Strategy	Activity	Descriptions and results	Participants[10]
	enhance food availability for all life stages of each population	BC Salmon Restoration and Innovation Fund supports protection and restoration activities for priority wild fish stocks, including Upper Fraser salmon (for example, Spruce City Wildlife Association received funding towards the Upper Fraser Chinook Strategic Enhancement Program). The Big Bar landslide response to date includes: • an improved “nature-like” fishway to support volitional passage past the slide site during moderate freshet conditions and lower flows • alternative fish passage systems such as “trap and transport” when water levels are too high to allow volitional passage • an emergency enhancement program to help conserve and rebuild salmon populations impacted by the slide and under severe conservation threat, including early-timed sockeye stocks • a monitoring program to track and understand fish population movement, timing, fate and health in near real-time	stewardship groups, UFFCA
D. Clarify and mitigate threats	D-4 Monitor threat indicators and population trends	Monitoring population trends is ongoing (refer to A-2). Monitoring threat indicators is ongoing (refer to D-1c and D-2b).	BC ENV, BC MFLNRORD, CSTC, DFO, Lheidli T’enneh, NWSRI TWG, stewardship groups
D. Clarify and mitigate threats	D-5 Work cooperatively to develop plans to mitigate threats to White Sturgeon	The NWSRI supports recovery of the Nechako River NSP and the Upper Fraser River NSP. NWSRI includes a Community Working Group (NWSRI CWG[15]) that focuses on outreach and a Technical Working Group (TWG) that focuses on research and recovery, including recently formed sub-committees that focus on predation and habitat restoration (refer to table 2 D-5).	BC ENV, BC MFLNRORD, DFO, NWSRI, NWSRT

[15] The NWSRI CWG is comprised of approximately 20 individuals representing Indigenous organizations, non-governmental organizations, industry, local, regional, provincial and federal governments, and interested public.

Strategy	Activity	Descriptions and results	Participants[10]
		There is representation from each basin that contains White Sturgeon on the National White Sturgeon Recovery Team (NWSRT)[16], providing an avenue to coordinate recovery and management efforts for White Sturgeon in Canada.	
E. Address information gaps that inhibit the conservation of White Sturgeon	E-1 Address basic biological data gaps	Genetic stock identification studies, initiated during the reporting period, are underway to examine levels of distinctness and exchange between Nechako, Middle and Upper Fraser River White Sturgeon NSPs, as well as identifying cause(s) of downstream movement (McAdam pers. comm. 2021). Work has been conducted to address basic biological gaps for Upper Fraser River White Sturgeon including: population monitoring that addresses demographic gaps (for example, population abundance and structure; refer to A-2); spawn monitoring to address life history and ecological gaps (for example, spawn periodicity; refer to B-1); and studies to assess prey preferences (refer to D-2a). Refer to table 5 for information on knowledge gaps related to critical habitat.	Academia, BC ENV, BC MFLNRORD, CSTC, FFSBC, Lheidli T'enneh, NWSRI TWG, stewardship groups, UFFCA
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-1 Maintain and where possible increase awareness and stewardship of White Sturgeon throughout its natural range	The Emergency Boat Kit Program includes a community outreach and awareness component to mitigate bycatch mortalities associated with FSC salmon fisheries (refer to D-3c). NWSRI TWG members advocate for White Sturgeon recovery and communicate scientific research findings through a variety of forums including conferences, guest lectures at academic institutions, and media coverage.	Academia, BC MFLNRORD, CSTC, DFO, FRSCS, industry, municipalities, NWSRI, stewardship groups

[16] NWSRT membership: DFO and BC ENV co-chairs, chairs for each basin-level TWG, and Indigenous organizations.

Strategy	Activity	Descriptions and results	Participants[10]
		The Fraser River Sturgeon Conservation Society (FRSCS) is an environmental stewardship and research organization with public outreach components, including: • curriculum-based Sturgeon Education Program which is shared with over 100,000 students annually • FRSCS website's interactive Adopt a Sturgeon program that allows 'adoptive parents' to track their fish and learn more about its habitat, issues affecting its survival and its life history through research and its recapture history Exploration Place in Prince George has a display outlining White Sturgeon recovery efforts.	
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-2 Engage in effective public education of the species and its conservation needs	Refer to F-1.	Academia, BC MFLNRORD, CSTC, DFO, FRSCS, industry, municipalities, NWSRI, stewardship groups
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-3 Support learning and communication across all working groups	Refer to D-5. The NWSRT chairs participate in the NWSRI TWG and provide exchange of information between basin-level working groups.	BC ENV, BC MFLNRORD, DFO, NWSRI, NWSRT
F. Increase stakeholder and general public awareness of White Sturgeon	F-4 Ensure participation from community and technical experts	Refer to D-5, F-1, and F-3.	Academia, BC MFLNRORD, CSTC, DFO, industry, municipalities,

Strategy	Activity	Descriptions and results	Participants[10]
and its conservation needs			NWSRI, NWSRT, stewardship groups
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-1 Incorporate the needs of healthy White Sturgeon populations into the management of White Sturgeon prey species, especially salmon and resident sportfish	No actions taken during this reporting period.	N/A
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-2 Accommodate other species' needs during recovery of White Sturgeon	No actions taken during this reporting period.	N/A
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-3 Closely manage non-native predatory fish species	No non-native predatory fish species have been identified as impacting the Upper Fraser River White Sturgeon NSP.	N/A

Strategy	Activity	Descriptions and results	Participants[10]
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-4 Dialogue with regulatory agencies that have influence or jurisdiction over White Sturgeon prey species	No actions taken during this reporting period.	N/A

Table 2. Details of activities supporting the recovery of the Nechako River White Sturgeon nationally significant population (NSP) from 2014 to 2020.

Strategy	Activity	Descriptions and results	Participants[17]
A. Meet or exceed recovery population targets within specified timeframe	A-1 Set up conservation aquaculture where needed	Conservation aquaculture was initiated for the Nechako River White Sturgeon NSP in 2006 with a pilot project that continued until 2010 (DFO [Fisheries and Oceans Canada] 2014) a permanent conservation aquaculture facility, the Freshwater Fisheries Society of BC (FFSBC)-run Nechako White Sturgeon Conservation Centre (NWSCC), was completed in 2014 and started juvenile releases in 2015. Over 40,000 hatchery-origin juveniles have been released since the program's initiation (NWSRI 2020). NWSCC adaptively manages the conservation aquaculture program; release strategies have changed over time to release fewer and larger individuals (Davies and McAdam 2018). Wild egg captures for rearing at NWSCC began in 2014 to increase genetic diversity of hatchery progeny and is used in combination with broodstock (NWSRI 2019). Experimental releases of 300,000 and 250,000 fertilized eggs occurred in 2011 and 2016, respectively, to assess the success of spawning substrate enhancements (Carrier Sekani Tribal Council [CSTC] 2020a; refer to C-4).	FFSBC, Nechako White Sturgeon Recovery Initiative Technical Working Group (NWSRI TWG)[18]
A. Meet or exceed recovery population targets within	A-2 Monitor population trends	In 2015, the adult population was estimated to be ~545 (90% confidence interval 460 and 640; Carruthers et al., in preparation as reported in DFO 2016).	BC Ministry of Environment and Climate Change Strategy (BC

[17] Participants are listed in alphabetical order.

[18]The NWSRI supports recovery for the Nechako River White Sturgeon NSP and the Upper Fraser River White Sturgeon NSP due to similar geographic location and endangered status. NWSRI TWG membership includes: BC ENV, BC MFLNRORD, Fisheries and Oceans Canada (DFO), Lheidli T'enneh First Nation (Lheidli T'enneh), Tl'azt'en First Nation, CSTC, FFSBC, University of BC and Rio Tinto Alcan. Note: Rio Tinto Alcan participates in Nechako River White Sturgeon NSP recovery measures only and Lheidli T'enneh participates in Upper Fraser River White Sturgeon NSP recovery measures only.

Strategy	Activity	Descriptions and results	Participants[17]
specified timeframe		A standardized adult monitoring program, led by CSTC, was completed annually during the reporting period and is ongoing. This adult monitoring program includes a mark-recapture program, spawn monitoring, and movement studies (CSTC 2020a; CSTC 2020b). • Annual spawn monitoring includes: adult telemetry to track spawn movements and provide information on spawn time and periodicity; egg matting to collect wild eggs for rearing at NWSCC (refer to A-1); and larval sampling through fyke netting and trawling[19] (CSTC 2020b) • Analyses of Upper Fraser River and Nechako River White Sturgeon adult telemetry data detected movement of Upper Fraser River NSP, Middle Fraser River NSP and Nechako River NSP adults between their respective ranges (Lheidli T'enneh 2020; Williamson et al. 2021[20]) A standardized wild and hatchery-origin juvenile index sampling protocol was developed in 2009 (CSTC 2009) and is conducted annually. In 2017, the protocol was augmented to include a larger area which includes Stuart River, Stuart Lake and Fraser Lake, and larger hook sizes to target older juveniles to support more robust estimates of population size, distribution, and survival (CSTC 2017). • Juvenile index sampling results indicate White Sturgeon are not susceptible to the sampling gear until age 3 years, and thus, individuals younger than 3 years old represent a gap in juvenile sampling (CSTC 2017) • Trends indicate declining capture numbers and catch-per-unit-effort and increasing recapture rates for hatchery cohorts in the Nechako River. This may indicate hatchery-origin juvenile survival rates are lower than anticipated in the Nechako River (CSTC 2020a)	ENV), British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC MFLNRORD), CSTC, DFO, FFSBC, Lheidli T'enneh, NWSRI TWG

[19] Fyke netting and trawling began in 2019.
[20] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[17]
		• Small numbers of wild-origin early juveniles and observations (albeit very limited) of wild-origin late juveniles and sub-adults suggest at least some degree of natural recruitment (CSTC 2017) Juvenile telemetry monitoring was initiated in 2015 and spans the Nechako River, its tributaries, and portions of the Fraser River. Tracking efforts include aerial and boat surveys, and fixed stations in the Nechako and Fraser rivers. Analysis of juvenile telemetry data (years 2015 to 2020) is underway (Davies, in prep). Preliminary study results show high hatchery-origin mortality rates and identified predation as a substantial cause of mortality (Babey et al. 2020; CSTC 2020a). Collaborative reporting for juvenile monitoring by CSTC, BC MFLNRORD, Lheidli T'enneh, and FFSBC for the Nechako, Upper, and Middle Fraser River NSPs began in 2019 and is ongoing (see CSTC 2020a for collaborative juvenile report). Data from 2018 to 2019 indicate a total of 38 and 14 Nechako hatchery-origin juvenile captures in the Middle and Upper Fraser River NSP ranges, respectively (CSTC 2020a).	
A. Meet or exceed recovery population targets within specified timeframe	A-3 Establish parameters for beneficial use	Beneficial use parameters have not been established as abundance and natural recruitment rates are not sufficient to support beneficial use at this time (refer to table 10, strategy A).	N/A
B. Protect critical habitats	B-1 Identify habitat requirements for all life stages	Data on habitat use has been collected as part of ongoing population monitoring efforts (refer to A-2). • Ongoing spawn monitoring has refined knowledge of spawning locations and egg deposition habitats within the Vanderhoof spawning area (CSTC 2020b) • Habitats with high juvenile abundance have been identified through juvenile index sampling (CSTC 2020a)	Academia, BC ENV, BC MFLNRORD, CSTC, DFO, FFSBC, Lheidli T'enneh, NWSRI TWG

Strategy	Activity	Descriptions and results	Participants[17]
		• Hatchery-origin juveniles were captured in Stuart Lake and Fraser Lake for the first time in 2020, following expansion of the juvenile index sampling to these areas in 2017 (CSTC, in prep) • Analysis of juvenile telemetry data (years 2015 to 2020) is underway and will provide information on juvenile habitat use and movements (Davies, in prep) Laboratory studies are ongoing to evaluate the effects of environmental factors on White Sturgeon egg and larval growth, survival and development (McAdam pers. comm. 2021[21]); these studies have informed experimental in-river enhancements of spawning habitat (refer to C-4), provide information to fill biological knowledge gaps (refer to E-1), and inform hatchery rearing techniques (refer to A-1). • Laboratory studies incubating embryos at varying temperatures showed increased larval development rate, growth rate, and the development of thermal tolerance (that is, thermal range in which organisms can maintain normal function) for embryos incubated at 12°C compared with 15°C and 18°C (Cheung 2019) • Laboratory studies were recently completed on the consequences of delayed initial feeding on larvae, competition among early juveniles, and the effects of environmental variables (for example, substrate) on larval drift (McAdam pers. comm. 2021[22]) Ongoing sediment transport research aims to characterize the physical condition of the spawning substrate to inform future restoration (refer to C-3).	
B. Protect critical habitats	B-2 Define critical habitat (including ecological processes)	Geographic locations of critical habitats for White Sturgeon were identified in section 8.5 of the recovery strategy (DFO 2014); ongoing monitoring efforts may inform critical habitat refinement (refer to B-1 and table 6).	CSTC, DFO, NWSRI TWG

[21] Work was completed within the reporting period.
[22] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[17]
		A critical habitat order was put in place in 2016.	
B. Protect critical habitats	B-3 Identify critical habitats for designation and protection	Refer to B-2.	CSTC, DFO, NWSRI TWG
B. Protect critical habitats	B-4 Protect, maintain, and enhance critical habitat for White Sturgeon	A critical habitat order was put in place in 2016. Experimental spawning habitat restoration through spawning substrate restoration and cleaning are ongoing (refer to C-4) and a sub-committee was formed to plan larger restorations (refer to B-6).	BC ENV, BC MFLNRORD, CSTC, DFO, FFSBC, NWSRI TWG
B. Protect critical habitats	B-5 Ensure habitat diversity, connectivity, and productivity	Initiatives to restore habitat in the spawning reach have been completed and are ongoing (refer C-4); these aim to refine and mitigate cause(s) of recruitment failure, and increase White Sturgeon productivity. The Nechako Environment and Water Stewardship Society (NEWSS) has been involved in a number of restoration projects for fish passage, beaver dams, and increasing habitat complexity (DWB 2014; Pollock et al. 2015); the projects mainly target salmon, but include restoration activities within the Nechako River White Sturgeon NSP range (for example, NEWSS and BC MFLNRORD Chilako River restoration project).	BC ENV, BC MFLNRORD, CSTC, DFO, FFSBC, industry, municipalities, Nechako Environmental Enhancement Fund, NEWSS, NWSRI, stewardship groups

Strategy	Activity	Descriptions and results	Participants[17]
B. Protect critical habitats	B-6 Work cooperatively to protect habitat	Efforts to develop a coordinated approach to habitat restoration are currently underway through a sub-committee of the NWSRI TWG; this subgroup aims to identify data gaps that limit implementation of substrate restoration and will help set direction for future restoration efforts (for example, spawning substrate enhancements). A number of habitat restoration-focused groups exist within the range of the Nechako River White Sturgeon NSP, including: Fraser Basin Council (FBC), Farmland-Riparian Interface Stewardship Program, Fraser Salmon and Watershed Program, and Rivershed Society of BC's Fraser Watershed Initiative. These initiatives aim to conserve and maintain important habitats for resident species in the Fraser watershed (including White Sturgeon). FBC also has a subgroup that developed the Nechako Watershed Strategy, which aims to ensure the long-term environmental health of the Nechako watershed (FBC 2016).	BC ENV, BC MFLNRORD, DFO, industry, NWSRI TWG, stewardship groups
C. Restore natural recruitment	C-1 Determine accuracy of recruitment index time series	No new analysis was completed during this reporting period. Previous analysis of historical data shows recruitment was variable from 1946 until 1964, followed by a rapid decline after 1964 (McAdam et al. 2005).	Academia, BC ENV, NWSRI TWG
C. Restore natural recruitment	C-2 Identify temporal correlations between significant recruitment shifts (peaks or drops) and environmental changes	Ongoing monitoring (refer to A-2 and B-1) informs analyses on relationships between recruitment and environmental variables. • A recruitment pulse was observed following 2011 experimental spawning substrate restoration work (CSTC 2017); investigation into causality is ongoing • Recruitment pulses were also identified in 1994, 1995 and 2007 (Environmental Dynamics Inc. (EDI) 2016; McAdam 2020); evaluation of environmental factors associated with recruitment in those years is ongoing	Academia, BC ENV, BC MFLNRORD, CSTC, NWSRI TWG
C. Restore natural recruitment	C-3 Examine potential mechanism of	A review of recruitment failure hypotheses identified priority areas for future examination (EDI 2016). • Substrate changes due to altered flow (that is, increase of sand and silt) impacting early life stage survival was identified as a lead	Academia, BC ENV, BC MFLNRORD,

Strategy	Activity	Descriptions and results	Participants[17]
	recruitment effect	hypothesis for the cause of recruitment failure in the Nechako River (EDI 2016) • Post-release monitoring of hatchery-origin juveniles has identified high rates of predation mortality (refer to A-2; Babey et al. 2020; CSTC 2020a) Multiple laboratory studies have been completed or are underway including studies examining the effects of temperature, substrate, and alarm cues on growth and survival of early life stages (refer to B-1; for example, Boucher 2012, Boucher et al. 2014; Cheung 2019; McAdam pers. comm. 2021[23]). Flow and sediment transport dynamics in the Nechako River spawning reach were characterized (Gauthier-Fauteux 2017) and the contemporary and historical sources of fine sediment in the Nechako River have been assessed (Gateuille et al. 2019). Ongoing sediment transport research aims to characterize the physical condition of the spawning substrate during the spawning period, as well as short-term changes during high flows (>300 m^3/s) to inform future restoration (NHC 2015, 2016). Experimental spawning restoration through substrate enhancement and cleaning (refer to C-4) aims to characterize the mechanism(s) of recruitment failure through hypothesis testing.	CSTC, FFSBC, NWSRI TWG
C. Restore natural recruitment	C-4 Undertake meso-scale field trials	Coarse substrate was placed at 2 sites in the spawning reach in 2011 and 300,000 fertilized eggs from the conservation aquaculture program were released at one of the sites (the middle pad site). • Post-restoration monitoring showed sediments quickly infilled at the lower pad (NWSRI 2011), but habitat quality was maintained at the middle pad due to more limited sand inputs (NHC 2021[24])	BC ENV, BC MFLNRORD, CSTC, NWSRI TWG

[23] Work was completed within the reporting period.
[24] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[17]
		• A recruitment pulse was observed following 2011 experimental spawning substrate restoration work (CSTC 2017); investigation into causality ongoing A sediment cleaning plan was developed in 2015 based on the bedload and suspended sediment transport rates identified in the 2013 to 2015 Sediment Transport Study (NHC 2015, 2016). Spawning substrate cleaning occurred in 2016 using mechanical techniques to dislodge fine sediments from gravel interstices and 250,000 fertilized eggs from the conservation aquaculture program were released on the lower pad area. Post-cleaning monitoring suggested it improved the quality of sturgeon spawning habitat temporarily (NHC 2017). Experimental deep cleaning of spawning substrate was implemented in 2020 through manual cleaning by divers. Results showed hydraulic jetting was an effective method to remove fine substrates. Sediment traps indicated variable amounts of infilling after cleaning based on location (NHC 2021[25]). Ongoing monitoring efforts (refer to A-2) will inform outcomes of restoration efforts.	
C. Restore natural recruitment	C-5 Undertake larger scale field trials	Larger scale field trials were not completed during this reporting period. Completed restoration efforts that aimed to address recruitment failure include spawning substrate enhancement and cleaning (refer to C-4) and planning work for larger scale restoration efforts through a NWSRI sub-committee (refer to B-6).	BC ENV, NWSRI TWG

[25] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[17]
C. Restore natural recruitment	C-6 Design and implement longer-term field trials	Multiple ongoing activities are being implemented simultaneously in an attempt to restore natural recruitment, including: laboratory studies that provide information on early life stage requirements (refer to B-1); research to identify cause(s) of recruitment pulses (refer to C-2) and mechanism(s) of recruitment failure (refer to C-3); experimental spawning substrate enhancement and cleaning (refer to C-4); and ongoing monitoring to assess recovery efforts (refer to A-2). A review of previous habitat restoration efforts (including case studies in the Nechako and Columbia rivers) identified key habitat restoration needs and uncertainties to inform future work (McAdam et al. 2017).	Academia, BC ENV, BC MFLNRORD, CSTC, FFSBC, NWSRI TWG
C. Restore natural recruitment	C-7 Determine the habitat requirements for dam-affected population enhancement or recovery	Multiple activities are ongoing to determine the habitat requirements for enhancement or recovery of the Nechako River White Sturgeon NSP, including: annual monitoring that collects information on habitat use and movement (refer to A-2 and B-1); laboratory studies that provide information on early life stage requirements (refer to B-1); identification and review of recruitment failure hypotheses (refer to C-3); experimental spawning substrate enhancement and cleaning (refer to C-4); and the establishment of a NWSRI sub-committee to develop a restoration plan (refer to B-6).	Academia, BC ENV, BC MFLNRORD, CSTC, FFSBC, NWSRI TWG
C. Restore natural recruitment	C-8 Initiate, within 5 years, pilot studies towards restoration of natural recruitment for each population that is affected by dams	Multiple activities are being implemented simultaneously in an attempt to restore natural recruitment, including: laboratory studies that provide information on early life stage requirements (refer to B-1); research to identify cause(s) of recruitment pulses (refer to C-2) and mechanism(s) of recruitment failure (refer to C-3); experimental spawning substrate enhancement and cleaning (refer to C-4); and ongoing monitoring to assess recovery efforts (refer to A-2).	Academia, BC ENV, BC MFLNRORD, CSTC, FFSBC, NWSRI TWG

Strategy	Activity	Descriptions and results	Participants[17]
C. Restore natural recruitment	C-9 Within 10 years, identify methods for each population that, if and when implemented, can restore recruitment to a level sufficient to achieve the other recovery measures listed herein	Refer to C-8. Natural recruitment has not been restored to necessary levels. Conservation aquaculture is ongoing as a measure to prevent expiration of the Nechako River White Sturgeon NSP (refer to A-1) until natural recruitment is restored.	Academia, BC ENV, BC MFLNRORD, CSTC, FFSBC, NWSRI TWG
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: a. fishing	Risks associated with fishing were assessed as moderate for the Nechako River White Sturgeon NSP (DFO 2014, 2016).	DFO
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: b. pollution	Early life stage White Sturgeon are highly sensitive to particular toxins (for example, copper) relative to other fish (Calfee et al. 2014; Vardy et al. 2014, 2015; Wang et al. 2014); in lab studies, below lethal concentrations, contaminants resulted in sublethal effects such as altered movement, diminished hiding, disruption in sodium uptake, and loss of equilibrium (Calfee et al. 2014; Little et al. 2014; Wang et al. 2014; Shekh et al. 2019). Potential contaminant sources in the Nechako watershed include the Endako Mine, a sawmill at Fort St. James, a fueling installation, sewage treatment plants, and runoff from agricultural development in Vanderhoof and Fort Fraser (Owens et al. 2019). Sediment sampling in 2016 revealed concentrations of organopollutants, metals, and excessive nutrients in the sediments of the Nechako River and its major tributaries (Owens et al. 2019).	Academia, BC ENV, BC MFLNRORD

Strategy	Activity	Descriptions and results	Participants[17]
		Water monitoring programs in the Nechako River include a water quality monitoring station at Prince George and the Vanderhoof Hydrometric station; regular monitoring provides baseline water quality data and can identify changes and allow for management response to benefit resident species, including White Sturgeon.	
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: c. predation	Increased predation on early life stage White Sturgeon was identified as a high priority for further examination in a 2016 review of recruitment failure hypotheses (EDI 2016). Potential sources of predation include River Otters (*Lontra canadensis*), predatory birds, and other White Sturgeon. Unsuitable habitats may lead to higher predation on early life stages (for example, lack of interstitial spaces to hide from predators; McAdam pers. comm. 2021[26]). Juvenile telemetry efforts have identified predation as a substantial cause of mortality (refer to A-2), which led to further exploration of River Otter predation through studies initiated in 2016 (NWSRI 2019). These studies provided evidence of River Otter predation on hatchery-origin Nechako White Sturgeon juveniles; studies from 2016 to 2020 recovered up to 88 radio-telemetry tags and 1,170 PIT tags, with a large portion of tags found near otter feeding and latrine sites and a PIT tag from 1 wild individual (Babey et al. 2020; Babey 2020 pers. comm.). The NWSRI TWG formed a sub-committee in 2020 to develop a plan to address predation; the plan will identify management measures and areas of further examination.	Academia, BC ENV, BC MFLNRORD, CSTC, Lheidli T'enneh, NWSRI TWG
D. Clarify and mitigate threats	D-2 Clarify threats to: a. food supply	Upper Fraser Fisheries Conservation Alliance (UFFCA) identified Sockeye Salmon (*Oncorhynchus nerka*) as an important White Sturgeon food source in the Nechako (refer to table 1 D-2a), and	Academia, CSTC, DFO, Indigenous organizations,

[26] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[17]
		ongoing monitoring has identified Sockeye Salmon as the preferred bait for White Sturgeon fishing (CSTC 2020). Several Chinook Salmon (*Oncorhynchus tshawytscha*), Sockeye Salmon, and Coho Salmon (*Oncorhynchus kisutch*) stocks migrating through Fraser River basin were recently assessed as species at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2016, 2017, 2018) and are under consideration for listing under the *Species at Risk Act* (SARA); salmon management and monitoring is ongoing. In the Nechako River, numbers of returning Sockeye Salmon have declined over time and Chinook returns dropped to 588 in 2017 (Levy and Nicklin 2018); the Big Bar landslide in 2019 further impacted salmon stocks, which are important prey species for White Sturgeon, by restricting upstream access (Grant et al. 2019). A hybrid river water temperature model was developed for salmonids in the entire Fraser River (Islam et al. 2019), which provides information on habitat requirements of important White Sturgeon prey species.	NWSRI TWG, UFFCA
D. Clarify and mitigate threats	D-2 Clarify threats to: b. habitat (including effects of flow regulation)	Substrate change at spawning locations has been identified as a leading hypothesis for recruitment failure (McAdam et al. 2005; McAdam 2011; EDI 2016; refer to C-3). Ongoing sediment transport research aims to characterize the physical condition of the spawning substrate and inform future restoration (refer to C-3).	Academia, BC ENV, NWSRI TWG
D. Clarify and mitigate threats	D-3 Undertake specific actions to: a. protect, maintain, and	Refer to B-2 to B-5 and table 6.	BC ENV, CSTC, DFO, FFSBC, NWSRI TWG, stewardship groups

Strategy	Activity	Descriptions and results	Participants[17]
	enhance critical habitat		
D. Clarify and mitigate threats	D-3 Undertake specific actions to: b. address illegal harvest	Year-round compliance patrols are conducted by DFO to enforce SARA prohibitions and the White Sturgeon fishing closure.	DFO
D. Clarify and mitigate threats	D-3 Undertake specific actions to: c. minimize bycatch and mitigate impacts from fisheries through regulation and best practices	Commercial salmon fisheries are required to report White Sturgeon encounters. The last commercial fishery in the area took place in 2014 on the west side of Stellako Lake. The fishery was conducted with seine nets with mandatory release and reporting of White Sturgeon. White Sturgeon bycaught in First Nation Food, Social, and Ceremonial (FSC) salmon fisheries are required to be released unharmed, and retention of dead White Sturgeon is not permitted. Ongoing community outreach and awareness programs, including the Emergency Boat Kit Program that was initiated by the CSTC and NWSRI in 2011, help mitigate bycatch mortalities associated with First Nation FSC fisheries. • Since the program's inception, 86 sturgeon have been released in the Nechako and Upper Fraser rivers (NWSRI 2020) • Since 2014, an on-site bycatch monitor has been hired for each participating First Nation[27] to facilitate outreach and the distribution of boat kits	DFO, CSTC, First Nations, NWSRI TWG

[27] First Nations participating in the Emergency Boat Kit Program include Lheidli T'enneh, Nak'azdli Whuten, Saik'uz, Stellat'en, Takla, Tl'azt'en, and Yekooche First Nations.

Strategy	Activity	Descriptions and results	Participants[17]
D. Clarify and mitigate threats	D-3 Undertake specific actions to: d. limit and address pollutant discharges and contaminant loading, especially adjacent to important or critical habitats	Threats related to pollution are mitigated through protections by provincial and federal regulatory reviews. Refer to D-1b for details on the threat of pollution for Nechako River White Sturgeon NSP.	BC ENV, BC MFLNRORD, DFO, Environment and Climate Change Canada (ECCC), industry
D. Clarify and mitigate threats	D-3 Undertake specific actions to: e. protect, maintain, and enhance water quality	Refer to D-3d.	BC ENV, BC MFLNRORD, DFO, ECCC, industry
D. Clarify and mitigate threats	D-3 Undertake specific actions to: f. mitigate interactions of White Sturgeon with industrial structures and activities	Provincial and federal regulatory review of projects that may impact White Sturgeon and/or its habitat is ongoing.	BC ENV, BC MFLNRORD, DFO

Strategy	Activity	Descriptions and results	Participants[17]
D. Clarify and mitigate threats	D-3 Undertake specific actions to: g. manage risks from conservation hatchery introductions	The aquaculture program has been adaptively managed over time; key adaptations include shifting part of production to wild eggs/larvae and releasing fewer fish at larger sizes (refer to A-1). The program also screens for diseases, ploidy, and deformities. The ongoing collaborative juvenile monitoring program (refer to A-2) has detected Nechako hatchery-origin fish within the Fraser River (refer to table 1 D-3g; CSTC 2020a). This program provides data for analysis to identify potential genetic and demographic risks of Nechako hatchery-origin fish straying to the Upper and Middle Fraser River NSPs. The analysis is being initiated (refer to table 1 D-3g).	Academia, BC ENV, BC MFLNRORD, CSTC, DFO, FFSBC, Lheidli T'enneh, NWSCC, NWSRI TWG
D. Clarify and mitigate threats	D-3 Undertake specific actions to: h. better understand, maintain, and enhance food availability for all life stages of each population	Threats associated with prey species availability are described in D-2a. A number of habitat restoration-focused groups exist within the range of Nechako River White Sturgeon NSP (refer to B-6) and restoration projects have been completed that targeted salmon recovery (refer to B-5), which will benefit White Sturgeon. UFFCA has initiated a project that aims to improve fish habitat in 3 systems within the Nechako River watershed (that is, Chilacko River, Greer Creek, and Murray Creek) through rehabilitation of riparian ecosystems and construction of an overwintering pond in Murray Creek with anticipated benefits for prey species including Chinook Salmon. The Big Bar landslide response to date includes: an improved "nature-like" fishway, alternative fish passage systems, an emergency enhancement program, and a monitoring program (refer to table 1: D-3h).	BC ENV, BC MFLNRORD, CSTC, DFO, stewardship groups, UFFCA
D. Clarify and mitigate threats	D-4 Monitor threat indicators and population trends	Monitoring population trends is ongoing (refer to A-2). Monitoring threat indicators is ongoing (refer to D-1b-c and D-2a-b).	BC ENV, BC MFLNRORD, CSTC, DFO, NWSRI TWG,

Strategy	Activity	Descriptions and results	Participants[17]
		Data on predation mortalities are being incorporated into survival estimates (Davies in prep).	stewardship groups
D. Clarify and mitigate threats	D-5 Work cooperatively to develop plans to mitigate threats to White Sturgeon	The NWSRI supports recovery of the Nechako River NSP and the Upper Fraser River NSP. NWSRI includes a Community Working Group (CWG[28]) that focuses on outreach and a Technical Working Group (TWG) that focuses on research and recovery. • Ongoing NWSRI TWG work includes review of hatchery production plans, juvenile White Sturgeon index sampling, adult assessments, and research initiatives which include collaboration with universities to address information gaps • In 2020, the NWSRI TWG formed a habitat restoration sub-committee (refer to B-6) and a predation sub-committee (refer to D-1c) to address specific threats to White Sturgeon There is representation from each basin that contains White Sturgeon on the National White Sturgeon Recovery Team (NWSRT)[29], providing an avenue to coordinate recovery and management efforts for White Sturgeon in Canada.	Academia, BC ENV, BC MFLNRORD, CSTC, DFO, NWSRI, NWSRT, stewardship groups
E. Address information gaps that inhibit the conservation of White Sturgeon	E-1 Address basic biological data gaps	Genetic stock identification studies are underway to examine levels of distinctness and exchange between Nechako, Middle and Upper Fraser River White Sturgeon NSPs, as well as identifying cause(s) of downstream movement (McAdam pers. comm. 2021[30]). Work has been conducted to address basic biological gaps for Nechako River White Sturgeon, including: population monitoring to address demographic gaps (for example, population abundance and structure; refer to A-2); spawn monitoring to address life history and ecology gaps (for example, spawn periodicity; refer to B-1); laboratory studies to	Academia, BC ENV, BC MFLNRORD, CSTC, FFSBC, Lheidli T'enneh, NWSRI, UFFCA

[28] The NWSRI CWG is comprised of approximately 20 individuals representing Indigenous organizations, non-governmental organizations, industry, local, regional, provincial and federal governments, and interested public.
[29] NWSRT membership: DFO and BC ENV co-chairs, chairs for each basin-level TWG, and Indigenous organizations.
[30] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[17]
		address early life stage knowledge gaps (refer to B-1); and studies to assess prey preferences (refer to D-2a). Refer to C-4 for work conducted to address knowledge gaps specific to recruitment failure. Refer to table 6 for information on knowledge gaps related to critical habitat.	
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-1 Maintain and where possible increase awareness and stewardship of White Sturgeon throughout its natural range	The Emergency Boat Kit Program includes a community outreach and awareness component to mitigate bycatch mortalities associated with FSC salmon fisheries (refer to D-3c). NWSRI introduced the Healthy Watersheds for Sturgeon School Curriculum Program to School District 91 in 2014, with the goal of increasing awareness of the connection between maintaining healthy rivers, riparian areas, and watersheds to benefit sturgeon and all organisms (NWSRI 2020); this program includes Grade 11 students working for 1 day at NWSCC. NWSCC offers public tours, and has a Virtual Tour on the NWSRI website. NWSRI TWG members advocate for White Sturgeon recovery and communicate scientific research findings through a variety of forums including conferences, guest lectures at academic institutions, and through media coverage. NWSRI CWG engages annually with the public through a number of outreach initiatives (NWSRI 2020), including: • an annual juvenile sturgeon release event inviting students from School District 91 to name and release a hatchery-origin juvenile sturgeon that they can track through the "Where's my Fish?" page on the NWSRI website. These events include a number of booths	Academia, BC ENV, BC MFLNRORD, DFO, CSTC, FFSBC, First Nations, industry, municipalities, NWSRI, stewardship groups

Strategy	Activity	Descriptions and results	Participants[17]
		where students can learn about White Sturgeon ecology and research programs (NWSRI 2020) • other activities such as producing interpretive signs, increasing web and social media presence (including YouTube and Facebook), attending BC Rivers Day in Prince George, and producing annual reports and brochures for public distribution (NWSRI 2020) University of Northern British Columbia's Koh-Learning in our Watersheds project is a partnership with School District 91 that aims to enhance student opportunities for involvement in place-based learning, stewardship initiatives, and participation in environmental decision making, including engagement with Nechako White Sturgeon recovery. Exploration Place in Prince George has a display outlining White Sturgeon recovery efforts. Rio Tinto hosts the Watershed Engagement Initiative for the Nechako which includes discussion on Nechako River White Sturgeon recovery (EDI 2020).	
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-2 Engage in effective public education of the species and its conservation needs	Refer to F-1.	Academia, BC ENV, BC MFLNRORD, DFO, CSTC, industry, municipalities, NWSRI, stewardship groups

Strategy	Activity	Descriptions and results	Participants[17]
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-3 Support learning and communication across all working groups	Refer to D-5. The NWSRT chairs participate in the NWSRI TWG and provide exchange of information between basin-level working groups.	NWSRI, NWSRT
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-4 Ensure participation from community and technical experts	Refer to D-5, F-1 and F-3.	Academia, BC ENV, BC MFLNRORD, DFO, CSTC, FFSBC, First Nations, industry, municipalities, NWSRI, NWSRT, stewardship groups
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-1 Incorporate the needs of healthy White Sturgeon populations into the management of White Sturgeon prey species, especially salmon and resident sportfish	No actions taken during this reporting period.	N/A
G. Maintain and where	G-2 Accommodate	No actions taken during this reporting period.	N/A

Strategy	Activity	Descriptions and results	Participants[17]
necessary, restore ecosystem functions relevant to White Sturgeon	other species' needs during recovery of White Sturgeon		
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-3 Closely manage non-native predatory fish species	No non-native predatory fish species have been identified as impacting the Nechako White Sturgeon NSP.	N/A
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-4 Dialogue with regulatory agencies that have influence or jurisdiction over White Sturgeon prey species.	No actions taken during this reporting period.	N/A

Table 3. Details of activities supporting the recovery of the Upper Columbia River White Sturgeon nationally significant population (NSP) from 2014 to 2020.

Strategy	Activity	Descriptions and results	Participants[31]
A. Meet or exceed recovery population targets within specified timeframe	A-1 Set up conservation aquaculture where needed	Conservation aquaculture was initiated for the Upper Columbia River White Sturgeon NSP in 2001 and 2003 in Canada and the United States (US), respectively. • Hatchery releases are ongoing and have occurred annually into the Canadian portion of transboundary reach (2002 to present), the US portion of the transboundary reach (2004 to present), and Arrow Lakes (2007 to present) The conservation aquaculture programs are adaptively managed based on information collected through annual monitoring and survival rate estimates (refer to A-2). • Canadian and US conservation aquaculture programs replaced broodstock with wild egg/larvae collection in 2014 and 2010, respectively, to maximize genetic representation of the wild population • Release numbers in Canada have generally decreased over time (average number of fish released annually decreased from over 12,000 pre-2014 to below 1,500 post-2014) and average size at release has increased (FFSBC 2019) • The conservation aquaculture programs screen for diseases, ploidy and deformities (FFSBC 2019)	British Columbia (BC) Hydro, Colville Confederated Tribes (CCT), Freshwater Fisheries Society of British Columbia (FFSBC), industry, Spokane Tribe of Idaho (STI), Upper Columbia White Sturgeon Recovery Initiative (UCWSRI[32]), WDFW
A. Meet or exceed recovery population	A-2 Monitor population trends	Wild Upper Columbia River White Sturgeon NSP abundance estimates in Canada remained stable at 1,042 individuals (95% confidence interval 743 to 1,461; mostly adults; BC Hydro 2020) in 2018.	Academia, BC Hydro, CCT, FFSBC, industry,

[31] Participants are listed in alphabetical order.
[32] UCWSRI Canadian members include: BC Hydro, Fortis BC, Columbia Power Corporation (CPC)/Columbia Basin Trust (CBT), Teck Metals Ltd., Canadian Columbia River Inter-Tribal Fisheries Commission (Ktunaxa Nation), Okanagan Nation Alliance (ONA), FFSBC, British Columbia Ministry of Environment and Climate Change Strategy (BC ENV), BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC MFLNRORD), Fisheries and Oceans Canada (DFO), and private consultants; American members include: CCT, STI, Kootenai Tribe of Idaho, Idaho Department of Fish and Game, Northwest Power and Conservation Council, US Fish and Wildlife Service, Washing Department of Fish and Wildlife (WDWF), Bonneville Power Administration and private consultants.

Strategy	Activity	Descriptions and results	Participants[31]
targets within specified timeframe		A standardized monitoring program, led by BC Hydro, was completed annually during the reporting period and is ongoing. This adult and juvenile monitoring program includes periodic stock assessment surveys, spawn monitoring, juvenile indexing, and movement studies (including juvenile and adult telemetry; UCWSRI Operating Plan (OP) 2018). Sampling programs in Canada and the US were standardized in 2013 and provide data to estimate White Sturgeon survival rates and abundance for the entire transboundary population (UCWSRI OP 2018). Results reported below are for the Canadian portion of the Upper Columbia River White Sturgeon NSP. • Spawning events have been detected annually, but wild-origin juveniles represent <1% of captures in the juvenile monitoring program (BC Hydro 2020); increased abundance of hatchery-origin juveniles has likely reduced the ability to detect wild recruits • Hatchery-origin White Sturgeon currently represent >75% of the total population (including wild adults; BC Hydro 2020) • Hatchery-origin juveniles have higher survival than anticipated and there has been disproportionate survival among maternal family groups, resulting in decreased diversity within individual year-classes in the wild (BC Hydro 2017) • High numbers of hatchery-origin fish released in Canada have been moving to the US (BC Hydro 2020) • Movement rates are low for wild adults and tend to occur in summer months during spawning and feeding (BC Hydro 2020) • Individual growth rates of White Sturgeon in Canada have declined in recent years (Golder Associates Ltd. 2019) Various data management and analysis tools have been developed for the Upper Columbia River White Sturgeon NSP. • A relational database was developed in 2019 to house data collected by all of the UCWSRI partners (for example, capture,	ONA, STI, UCWSRI, WDFW

Strategy	Activity	Descriptions and results	Participants[31]
		telemetry and aquaculture releases; Howell and McLellan 2018a, 2019a, 2020a). Work to populate the database and refine query tools is ongoing • Various models (for example, Cormack-Jolly-Seber and POPAN; Golder Associates Ltd. 2019) have been developed to estimate abundance and survival • "The Upper Columbia Sturgeon Simulator" application is available online as a management tool to determine probable responses to various recovery and fishery actions (Challenger et al. 2021[33])	
A. Meet or exceed recovery population targets within specified timeframe	A-3 Establish parameters for beneficial use	Beneficial use parameters have not been established as natural recruitment rates are not sufficient to support beneficial use at this time (refer to table 11, strategy A).	N/A
B. Protect critical habitats	B-1 Identify habitat requirements for all life stages	Data on habitat use have been collected as part of ongoing population monitoring efforts (refer to A-2). • Several hydro facilities within the range of Upper Columbia River White Sturgeon NSP have telemetry programs to characterize movements and habitat use of sturgeon near facilities (UCWSRI OP 2018) • Analyses are underway to investigate hatchery-origin Upper Columbia White Sturgeon movements spatially and temporarily, accounting for biological (that is, age, sex, and size) and environmental (that is, temperature and discharge) factors (Jetter in prep) • Ongoing annual spawn monitoring at 4 sites in Canada and larval monitoring at 1 site in the US may further refine knowledge of spawning site locations, characteristics and periodicity (BC Hydro 2020; Golder Associates Ltd. and ONA 2020; Miller et al. 2020)	Academia, BC Hydro, CCT, FFSBC, industry, ONA, STI, UCWSRI, WDFW

[33] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[31]
		Laboratory studies evaluating the effects of substrate, temperature, and other environmental factors on early life stage growth, development, and survival are ongoing. • Substrate presence (gravel) was correlated with higher growth and survival (Baker et al. 2014; Boucher et al. 2014, 2018) and reduced cortisol levels (Bates et al. 2014) • Survival was higher at lower temperatures (Bates et al. 2014; Boucher et al. 2014) and rate of development increased at warmer temperatures (Jay et al. 2020)	
B. Protect critical habitats	B-2 Define critical habitat (including related ecological processes)	Geographic locations of critical habitats for White Sturgeon were identified in section 8.5 of the recovery strategy (DFO 2014); ongoing research and monitoring may inform critical habitat refinement (refer to B-1 and table 7). ○ The Kinnaird area (downstream of the Kootenay-Columbia River confluence) appears to support all White Sturgeon life stages based on monitoring but it is not currently identified as critical habitat. Annual spawning activity has been detected in the area since 2007 (BC Hydro 2019) A critical habitat order was put in place in 2016.	BC Hydro, DFO, UCWSRI
B. Protect critical habitats	B-3 Identify critical habitats for designation and protection	Refer to B-2.	BC Hydro, DFO, UCWSRI

Strategy	Activity	Descriptions and results	Participants[31]
B. Protect critical habitats	B-4 Protect, maintain and enhance critical habitat for White Sturgeon	A critical habitat order was put in place in 2016 (refer to B-2). The Arrow Lakes Reservoir Nutrient Restoration Program was implemented in 1999 and releases nitrogen and phosphorus into Arrow Lakes annually to enhance biological productivity in the system. The program has been successful in partially offsetting nutrient declines and increasing biological productivity, including increases in zooplankton abundance and higher Bull Trout (*Salvelinus confluentus*) condition factor (Bassett et al. 2020). Hydro facility operating plans are updated regularly and include management for habitat protection and flow management to support White Sturgeon spawning and egg incubation (refer to D-3f). Restoration feasibility assessments, experimental spawning substrate restoration and larval release studies are ongoing (refer to C-4).	BC ENV, BC Hydro, BC MFLNRORD, DFO, Fish and Wildlife Compensation Program (FWCP)[34], industry, UCWSRI
B. Protect critical habitats	B-5 Ensure habitat diversity, connectivity and productivity	There are a number of ongoing initiatives in the Columbia River to ensure habitat diversity and productivity, including restoration activities (refer to C-4), nutrient additions into Arrow Lakes Reservoir (refer to B-4), management of hydroelectric facility operations to protect sturgeon habitat (refer to D-3f), invasive species suppression (refer to G-3), and initiatives underway to increase prey base and fish passage in the Columbia River (refer to D-3h). The UCWSRI has an evergreen operational plan that includes prioritization of research and actions related to habitat diversity, connectivity, and productivity (UCWSRI OP 2018).	BC ENV, BC Hydro, BC MFLNRORD, CCT, DFO, FWCP, industry, ONA, UCWSRI, stewardship groups
B. Protect critical habitats	B-6 Work cooperatively to develop plans to protect habitat	The UCWSRI was formed in 2000 to coordinate Upper Columbia White Sturgeon recovery across jurisdictions, and includes co-managers and partners in the US and Canada.	UCWSRI

[34] FWCP is a partnership of BC Hydro, Province of BC, DFO, Indigenous organizations and public stakeholders to conserve and enhance fish and wildlife in watersheds affected by BC Hydro dams.

Strategy	Activity	Descriptions and results	Participants[31]
		The UCWSRI has an evergreen operational plan that includes prioritization of research and recovery actions (UCWSRI OP 2018).	
C. Restore natural recruitment	C-1 Determine accuracy of recruitment index time series	No new analyses were completed during this reporting period. The timing of recruitment declines for the Keenleyside, Waneta, and Roosevelt groups were estimated to be 1967 (95% CI = 1966 to 1971), 1977 (95% CI = 1976 to 1981), and 1968 (95% CI = 1967 to 1974), respectively (McAdam 2015).	Academia, BC ENV, BC Hydro, UCWSRI
C. Restore natural recruitment	C-2 Identify temporal correlations between significant recruitment shifts (peaks or drops) and environmental changes	Ongoing monitoring (refer to A-2 and B-1) informs analyses on relationships between recruitment and environmental variables. • Opportunistic assessments to determine effects of high flow events on White Sturgeon recruitment have been conducted during this reporting period (for example, BC Hydro 2015)	Academia, BC Hydro, CCT, industry, UCWSRI
C. Restore natural recruitment	C-3 Examine potential mechanism of recruitment effect	Retrospective evaluation identified substrate change as a leading hypothesis for recruitment failure in populations impacted by hydroelectric development (McAdam 2015). The UCWSRI Technical Working Group (TWG) formed a sub-committee in 2018 to review recruitment failure hypotheses identified in Gregory and Long 2008; the assessment of recruitment failure hypotheses is ongoing. Laboratory studies have been completed that examine the effects of substrate and temperature on early life stage growth and survival (refer to B1). Opportunistic assessments that relate flow to White Sturgeon recruitment are underway (refer to C-2).	Academia, BC ENV, BC Hydro, CCT, industry, STI, UCWSRI, WDFW

Strategy	Activity	Descriptions and results	Participants[31]
		Hydrodynamic models have been developed for Revelstoke Dam, Arrow Lakes Reservoir, and Waneta (see West et al. 2020) to inform flow requirements for larval distribution to suitable rearing areas; ongoing monitoring includes water temperature, velocity and elevation (BC Hydro 2017). Experimental spawning restoration through substrate enhancement (refer to C-4) aims to characterize the mechanism(s) of recruitment failure through hypothesis testing.	
C. Restore natural recruitment	C-4 Undertake meso-scale field trials	Experimental spawning substrate restoration studies are ongoing. • Substrate modification through boulder and cobble additions was tested in 2010 at Revelstoke; reduced larval captures at the modified site indicated habitat was enhanced for hiding at the yolk sac larvae stage (Crossman and Hildebrand 2014) • Sediment traps were installed at Waneta in 2020 to assess infilling of fine sediments as a prerequisite study to guide future restoration (McAdam pers. comm. 2021[35]) Hydrodynamic and individual-based early life stage (embryo to early larvae) models were developed for the US portion of the range to evaluate larvae drift behavior and its role in recruitment, as well as to inform larval translocation experiments (Bellgraph et al. 2015; Garavelli et al. in prep). • A larvae translocation experiment was conducted in the Roosevelt reach within the US portion of the range from 2017 to 2019 to test the hypothesis that feeding larvae are not reaching suitable rearing habitats; only 1 marked individual was recaptured, but it remains unclear whether this is due to low survival or inefficient sampling techniques (Howell and McLellan 2018b, 2019b, 2020b) A prerequisite study to determine feasibility of spawning substrate restoration through analysis of substrate and flow data at the	Academia, BC ENV, BC Hydro, CCT, STI, UCWSRI, WDFW

[35] Work was completed within the reporting period.

Strategy	Activity	Descriptions and results	Participants[31]
		Keenleyside, Kinnaird, and Waneta spawning sites was completed in 2020 (West et al. 2020).	
C. Restore natural recruitment	C-5 Undertake larger scale field trials	A prerequisite study to determine feasibility of spawning substrate restoration at Keenleyside, Kinnaird, and Waneta was completed in 2020 (refer to C-4). Planning of larger scale restoration at Keenleyside is underway; implementation is anticipated for 2022.	BC Hydro, UCWSRI
C. Restore natural recruitment	C-6 Design and implement longer term restoration program	Multiple activities are being implemented simultaneously in an attempt to restore natural recruitment, including: identification and review of recruitment failure hypotheses (refer to C-3); experimental spawning substrate enhancement (refer to C-4); sediment trapping to guide future restoration (refer to C-4); larval release studies (refer to C-4); prerequisite studies to determine feasibility of spawning substrate restoration (C-4); and ongoing monitoring to assess recovery efforts (refer to A-2). A review of previous habitat restoration efforts (including case studies in the Nechako and Columbia rivers) identified key habitat restoration needs and uncertainties to inform future work (McAdam et al. 2017).	Academia, BC ENV, BC Hydro, CCT, STI, UCWSRI, WDFW
C. Restore natural recruitment	C-7 Determine the habitat requirements for dam affected population enhancement or recovery	Multiple activities are ongoing to determine the habitat requirements for enhancement or recovery of the Upper Columbia River White Sturgeon, including: annual monitoring which collects information on habitat use and movement (refer to A-2 and B-1); laboratory studies that provide information on early life stage requirements (refer to B-1); identification and review of recruitment failure hypotheses (refer to C-3); hydrodynamic modeling which provides information on early life stage habitat requirements (refer to C-4): experimental spawning substrate enhancement (refer to C-4); larval release studies (refer to C-4); and prerequisite studies to determine feasibility of spawning substrate restoration (C-4).	Academia, BC ENV, BC Hydro, CCT, STI, UCWSRI, WDFW

Strategy	Activity	Descriptions and results	Participants[31]
C. Restore natural recruitment	C-8 Initiate, within 5 years, pilot studies towards restoration of natural recruitment for each population that is affected by dams	Multiple activities are being implemented simultaneously in an attempt to restore natural recruitment, including: laboratory studies that provide information on early life stage requirements (refer to B-1); identification and review of recruitment failure hypotheses (refer to C-3); experimental spawning substrate enhancement (refer to C-4); sediment trapping to guide future restoration (refer to C-4); larval release studies (refer to C-4); prerequisite studies to determine feasibility of spawning substrate restoration (C-4); and monitoring to assess recovery efforts (refer to A-2).	Academia, BC ENV, BC Hydro, CCT, STI, UCWSRI, WDFW
C. Restore natural recruitment	C-9 Within 10 years, identify methods for each population that, if and when implemented, can restore recruitment to a level sufficient to achieve the other recovery measures listed herein	Refer to C-8. Natural recruitment has not been restored to necessary levels. Conservation aquaculture is ongoing as a measure to prevent the extirpation of the Upper Columbia River White Sturgeon NSP (refer to A-1) until natural recruitment is restored.	Academia, BC ENV, BC Hydro, CCT, FFSBC, STI, UCWSRI, WDFW
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: a. fishing	Within the US range, tribal and recreational White Sturgeon fisheries were established in 2017 as a management tool to address concerns regarding potential family-overrepresentation within hatchery-origin fish (Miller et al. 2020). • Slot sizes and fishing windows are adaptively managed to target overrepresented year-classes and families • Catch of wild-origin fish within the permitted slot size has been documented	CCT, STI, WDFW

Strategy	Activity	Descriptions and results	Participants[31]
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: b. pollution	Early life stage White Sturgeon are highly sensitive to particular toxins (for example, copper and selenium) relative to other fish (Calfee et al. 2014; De Rui et al. 2014; Vardy et al. 2014, 2015; Wang et al. 2014; Zee et al. 2016); in lab studies, below lethal concentrations, contaminants resulted in sublethal effects such as altered movement, diminished hiding, disruption in sodium uptake, and loss of equilibrium (Calfee et al. 2014; Little et al. 2014; Wang et al. 2014; Shekh et al. 2019). Sediments sampled in the Columbia River contained high concentrations of copper, cadmium, zinc, and lead (Vardy et al. 2015), which can have adverse effects on the invertebrate community including substantial reductions in survival, growth, biomass, and reproduction (Besser et al. 2018). This may impact food availability for early life stage White Sturgeon. Elevated copper concentrations (up to 24 µg/L) were found at the sediment-water interface in the Upper Columbia River; these levels are toxic to early-life stage White Sturgeon (Puglis et al. 2020). Potential contaminant sources in the Upper Columbia River include pulp and paper mills, wastewater treatment plants, and mining and smelting operations (for example, the metallurgical facility in Trail, BC has historically released slag and currently releases liquid effluent; Vardy et al. 2015). Comprehensive contaminant and aquatic health investigations within the range of Upper Columbia River White Sturgeon NSP in the US and Canada, are underway or completed, respectively. • In Canada, results showed water quality guidelines were met, except for cadmium and mercury which exceeded guidelines above Teck Trail (Teck 2014) • In the US, extensive water quality assessments, fish tissue samples, toxicity bioassays for fish and benthic invertebrates, and mapping of	Academia, BC ENV, BC MFLNRORD, CCT, industry, Ktunaxa Nation Council (KNC), stewardship groups, UCWSRI

Strategy	Activity	Descriptions and results	Participants[31]
		sediment facies and detailed bathymetry were recently completed (Teck America Inc. 2020) • Contaminant analysis in tissues of White Sturgeon conducted in US and Canada deemed it safe for consumption (Teck 2014; KNC 2017) The UCWSRI TWG is currently reviewing recruitment failure hypotheses identified in Gregory and Long 2008, which include contaminant-related hypotheses regarding effects of direct consumption of toxins, as well as acute and chronic toxicity on early life stage White Sturgeon. A number of water monitoring programs in the Columbia basin are ongoing, including the Columbia River Integrated Environmental Monitoring Program and the Canadian Aquatic Biomonitoring Network (CBT 2017). Regular monitoring provides baseline water quality data and can identify changes and allow for management response to benefit resident species, including White Sturgeon.	
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: c. predation	Smallmouth Bass (*Micropterus dolomieu*) and suckers (*Catostomus* sp.) consumed White Sturgeon eggs under experimental conditions near Waneta (Golder Associates 2017). Suppression of Northern Pike (*Esox lucius*) and other invasive species is ongoing in Canada and US (refer to G-3); however, no White Sturgeon have been identified in the stomach contents of Northern Pike captured through this program (analyzed 2014 to 2018; Baxter and Neufeld 2015, 2018; Duncan et al. 2019; Smith et al 2020).	BC MFLNRORD, CCT, industry, ONA, STI, UCWSRI
D. Clarify and mitigate threats	D-2 Clarify threats to: a. food supply	Stomach content analysis following gastric lavage was used to clarify the diet of juveniles (Crossman et al. 2016). Juvenile (<60 cm TL) diet composition included invertebrate taxa such as Mysida, Trichoptera, Diptera, Isopoda, Pelecypoda, Gammaridae, Amphipoda, Ephemeroptera, and fish. Mysida were found to be an important food source despite low availability (Crossman et al. 2016).	BC ENV, BC Hydro, BC MFLNRORD, CCT, industry, ONA, STI, UCWSRI, WDFW

Strategy	Activity	Descriptions and results	Participants[31]
		Human development in the Columbia River has altered nutrient transport, thereby reducing biological productivity. A nutrient addition program in Arrow Lakes aims to increase system productivity (refer to B-4). Many non-native species inhabit the Upper Columbia River, including Northern Pike and Walleye (*Sander vitreus*; refer to G-3; Smith et al 2020), and may be prey and/or compete with White Sturgeon for food sources and habitat.	
D. Clarify and mitigate threats	D-2 Clarify threats to: b. habitat (including effects of flow regulation)	Substrate change at spawning locations has been identified as a leading hypothesis for recruitment failure in populations impacted by hydroelectric development (McAdam 2015; refer to C-3). Work is ongoing to better understand habitat conditions that would promote recruitment. The UCWSRI review of recruitment failure hypotheses includes habitat-related hypotheses (refer to C-4).	Academia, BC ENV, BC Hydro, industry, UCWSRI
D. Clarify and mitigate threats	D-3 Undertake specific actions to: a. protect, maintain, and enhance critical habitat	Refer to B-2 to B-5, and table 7. DFO developed critical habitat information packages and distributed them to landowners located near Upper Columbia River White Sturgeon critical habitat. Hydroelectric generating stations spill and operational changes have decreased total gas pressure through the implementation of a basin-wide model (Hadjerioua et al. 2015), which improves water quality within the range of Upper Columbia White Sturgeon.	Academia, BC ENV, BC Hydro, CCT, DFO, industry, stewardship groups, private landowners, STI, UCWSRI, WDFW
D. Clarify and mitigate threats	D-3 Undertake specific actions to: b. address illegal harvest	Year-round compliance patrols are conducted by DFO to enforce *Species at Risk Act* prohibitions and the White Sturgeon fishing closure. The Fishery Guardian program aims to build Indigenous capacity to deliver compliance, monitoring, and stewardship initiatives that will help protect fish and fish habitat, including species at risk. Fishery Guardians	DFO, KNC

Strategy	Activity	Descriptions and results	Participants[31]
		deliver their authorities under the *Fisheries Act* through year-round compliance patrols within the range of Upper Columbia River White Sturgeon NSP.	
D. Clarify and mitigate threats	D-3 Undertake specific actions to: c. minimize bycatch and mitigate impacts from fisheries through regulation and best practices	Patrols are conducted by DFO and Fishery Guardians (refer to D-3b). The US harvest fisheries aim to minimize interaction with non-target fish, including wild adults, through using slot sizes and seasonal closures (refer to D-1a).	CCT, DFO, KNC, STI, WDFW
D. Clarify and mitigate threats	D-3 Undertake specific actions to: d. limit and address pollutant discharges and contaminant loading, especially adjacent to important or critical habitats	Threats related to pollution are mitigated through protections by provincial and federal regulatory reviews. Refer to D-1b for details on the threat of pollution for Upper Columbia River White Sturgeon NSP.	BC ENV, BC MFLNRORD, DFO, Environment and Climate Change Canada (ECCC), industry
D. Clarify and mitigate threats	D-3 Undertake specific actions to: e. protect, maintain, and enhance water quality	Refer to D-3d.	BC ENV, BC MFLNRORD, DFO, ECCC, industry

Strategy	Activity	Descriptions and results	Participants[31]
D. Clarify and mitigate threats	D-3 Undertake specific actions to: f. mitigate interactions of White Sturgeon with industrial structures and activities	Provincial and federal regulatory review of projects that may impact White Sturgeon and/or its habitat is ongoing. Hydroelectric facilities within the Canadian range of Upper Columbia River White Sturgeon NSP have developed operating plans that are updated regularly and include management measures for habitat protection, protocols to mitigate interactions with White Sturgeon, and flow management to facilitate White Sturgeon spawning and egg incubation. A 2018 voluntary Protocol for Deceased White Sturgeon aims to collect biological information from deceased White Sturgeon and provides an avenue to notify regulatory agencies of any mortalities; several hydroelectric facility operators within the range of Upper Columbia River White Sturgeon adhere to these protocols.	BC ENV, BC Hydro, BC MFLNRORD, DFO, industry, UCWSRI
D. Clarify and mitigate threats	D-3 Undertake specific actions to: g. manage risks from conservation hatchery introductions	The aquaculture programs are adaptively managed over time; key adaptations include shifting to wild eggs/larvae and releasing fewer fish at larger size (refer to A-1). The programs screen for diseases, ploidy, and deformities (FFSBC 2019). Hatchery-origin juveniles have had higher survival than anticipated and there has been disproportionate survival among broodstock maternal family groups and year-classes (refer to A-2); as a response, several conservation actions have been implemented. • US researchers began removing select hatchery-origin fish in 2016 • The US opened tribal and recreational White Sturgeon fisheries in Lake Roosevelt in 2017, which allow the removal of individuals within a specified slot size (different slot size each year; Miller et al. 2020) • In Canada, DFO permitted the removals of select hatchery-origin fish in 2017; analysis is underway to assess the risk of overrepresentation and high abundance on wild reared White Sturgeon, and to determine whether more removals are required	BC Hydro, CCT, DFO, FFSBC, industry, STI, UCWSRI, WDFW

Strategy	Activity	Descriptions and results	Participants[31]
D. Clarify and mitigate threats	D-3 Undertake specific actions to: h. better understand, maintain, and enhance food availability for all life stages of each population	Threats associated with prey species availability were described in D-2a. The annual nutrient addition program at Arrow Lakes Reservoir (refer to B-4) aims to increase system productivity, thereby enhancing prey availability for White Sturgeon. Multiple initiatives in the US and Canada are underway to restore Pacific salmon populations and other native species within the Upper Columbia River. For example, the Upper Columbia United Tribes aim to restore passage of native fish species to historical habitats in the Upper Columbia River basin and the Columbia River Salmon Reintroduction Initiative aims to reintroduce salmon into their historical spawning grounds in Canada (Columbia Basin Tribes and First Nations 2015; Bring the Salmon Home Annual Report 2020). Suppression of Northern Pike and other invasive predators and competitors is ongoing in Canada and US (refer to G-3).	BC ENV, BC Hydro, BC MFLNRORD, CCT, DFO, FWCP, Indigenous organizations, ONA, STI, UCWSRI, WDFW
D. Clarify and mitigate threats	D-4 Monitor threat indicators and population trends	Monitoring population trends is ongoing (refer to A-2). Monitoring threat indicators is ongoing (refer to D-1a-c and D-2a-b).	BC ENV, BC Hydro, CCT, FWCP, industry, ONA, STI, UCWSRI, WDFW
D. Clarify and mitigate threats	D-5 Work cooperatively to develop plans to mitigate threats to White Sturgeon	The UCWSRI was formed in 2000 to coordinate Upper Columbia River White Sturgeon recovery across jurisdictions, and includes co-managers and partners in the US and Canada. Members include government agencies, industry, Indigenous organizations, and stakeholders. The UCWSRI TWG meets twice annually. ○ UCWSRI TWG ongoing work includes the support and review of hatchery and restoration plans, review of monitoring programs, sporadic public outreach, and prioritizing research objectives (UCWSRI OP 2018)	BC Hydro, DFO, industry, NWSRT, stewardship groups, UCWSRI

Strategy	Activity	Descriptions and results	Participants[31]
		○ UCWSRI TWG forms sub-committees for specific actions (for example, recruitment failure hypothesis review; refer to C-3) There is representation from each basin that contains White Sturgeon and Indigenous organizations on the National White Sturgeon Recovery Team (NWSRT)[36], providing an avenue to coordinate recovery and management efforts for White Sturgeon in Canada. Within Canada, Upper Columbia River White Sturgeon NSP recovery implementation has been largely coordinated through UCWSRI and funded through industry (for example, BC Hydro's Water Use Plan).	
E. Address information gaps that inhibit the conservation of White Sturgeon	E-1 Address basic biological data gaps	A genetic study estimated the number of effective breeders in 3 Canadian spawning areas; Waneta was identified as the main spawning area with 61% of the spawning population (Jay et al. 2014). Work has been conducted to address basic biological gaps for Upper Columbia River White Sturgeon including population monitoring to address demographic gaps (for example, population abundance and structure; refer to A-2), gastric lavage to clarify juvenile diets (refer to D-2a), and spawn monitoring to address life history and ecology gaps (for example, spawn periodicity; refer to B-1). Refer to C-4 for work conducted to address knowledge gaps specific to recruitment failure. Refer to table 7 for information on knowledge gaps related to critical habitat.	Academia, BC ENV, BC Hydro, CCT, industry, ONA, STI, UCWSRI, WDFW
F. Increase stakeholder and general public awareness of White Sturgeon	F-1 Maintain and where possible increase awareness and stewardship of	UCWSRI TWG members advocate for White Sturgeon recovery and communicate scientific research findings through a variety of forums including conferences, guest lectures at academic institutions, and through media coverage.	Academia, BC ENV, BC Hydro, DFO, FFSBC, industry, Indigenous

[36] NWSRT membership: DFO and BC ENV co-chairs, chairs for each basin-level TWG, and Indigenous organizations.

Strategy	Activity	Descriptions and results	Participants[31]
and its conservation needs	White Sturgeon throughout its natural range	UCWSRI and partners engage the public through a number of outreach initiatives. • UCWSRI website includes White Sturgeon facts, recovery documents, and an interactive Find My Sturgeon page • BC Hydro's Power Smart for Schools provides energy-related education resources online and includes activities that focus on White Sturgeon and their recovery In 2020, DFO developed critical habitat packages for distribution in the range of the Upper Columbia River White Sturgeon NSP (refer to D-3a).	organizations, stewardship groups, UCWSRI
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-2 Engage in effective public education of the species and its conservation needs	Refer to F-1.	Academia, BC ENV, BC Hydro, DFO, FFSBC, industry, Indigenous organizations, stewardship groups, UCWSRI
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-3 Support learning and communication across all working groups	Refer to D-5. The NWSRT chairs participate in the UCWSRI TWG and provide exchange of information between basin-level working groups and Indigenous organizations. Periodic meetings between the Upper Columbia and Kootenay River White Sturgeon NSP working groups at basin-wide conferences (for example, at the Lake Roosevelt Forum Conference in 2016) promote information exchange on knowledge gaps and recovery efforts (UCWSRI OP 2018).	NWSRT, UCWSRI
F. Increase stakeholder and general public awareness of	F-4 Ensure participation from community	Refer to D-5, F-1 and F-3	BC ENV, BC Hydro, DFO, FFSBC, industry, Indigenous

Strategy	Activity	Descriptions and results	Participants[31]
White Sturgeon and its conservation needs	and technical experts		organizations, stewardship groups, UCWSRI
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-1 Incorporate the needs of healthy White Sturgeon populations into the management of White Sturgeon prey species, especially salmon and resident sportfish	No actions taken during this reporting period.	N/A
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-2 Accommodate other species' needs during recovery of White Sturgeon	No actions taken during this reporting period.	N/A
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-3 Closely manage non-native predatory fish species	A number of non-native species occur within the Upper Columbia River system including Northern Pike, Walleye, and Smallmouth Bass. Suppression of Northern Pike and other invasive predators and competitors is ongoing within the range of Upper Columbia River White Sturgeon NSP in Canada and US (Baxter and Neufeld 2015, 2018; Duncan et al. 2019; Smith et al 2020), including a Northern Pike bounty program.	BC MFLNRORD, CCT, industry, ONA, STI, WDFW

Strategy	Activity	Descriptions and results	Participants[31]
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-4 Dialogue with regulatory agencies that have influence or jurisdiction over White Sturgeon prey species	No actions taken during this reporting period.	N/A

Table 4. Details of activities supporting the recovery of the Kootenay River White Sturgeon nationally significant population (NSP) from 2014 to 2020.

Strategy	Activity	Descriptions and Results	Participants[37]
A. Meet or exceed recovery population targets within specified timeframe	A-1 Set up conservation aquaculture where needed	Conservation aquaculture was initiated for the Kootenay River White Sturgeon NSP in 1990 at the Kootenai Tribe of Idaho (KTOI) Tribal Sturgeon Hatchery in Idaho (ID); hatchery releases began in 1992 and are ongoing (KTOI 2021[38]). • KTOI contracted FFSBC's Kootenay Trout and Sturgeon Hatchery (Wardner, British Columbia (BC)) between 1999 and 2015 to raise a portion of fertilized eggs from the Tribal Sturgeon Hatchery (Idaho) as a failsafe strategy; up to 5 families were produced annually in BC (BPA 2013) • Twin Rivers Hatchery (Idaho) opened in 2015 to increase annual numbers of broodstock families (USFWS 2019) As of 2019, the KTOI conservation aquaculture program has released over 286,000 hatchery-origin juvenile White Sturgeon into the Kootenai River[39] basin (KTOI 2021), with approximately 18% of juveniles released at sites on the Canadian portion of the Kootenay River and approximately 7% of juveniles released into Kootenay Lake. Annual White Sturgeon Program Reviews (APR) convened by the KTOI, with participation from all co-managers, aim to adaptively manage the conservation aquaculture program based on information collected through annual monitoring efforts (refer to A-2; KTOI APR 2019). • Shifts in hatchery operations to maximize post-release survival include releasing juveniles at larger sizes and releases in the spring instead of summer (Dinsmore et al. 2015) • In 2019, KTOI and co-managers reduced the annual release number to 5,000 (KTOI 2021)	BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC MFLNRORD), Bonneville Power Association (BPA), Freshwater Fisheries Society of British Columbia (FFSBC), Idaho Department of Fish and Game (IDFG), KTOI, Montana Fish, Wildlife and Parks (MFWP), US Fish and Wildlife Service (USFWS)

[37] When more than 1 participant is associated with an activity, they are listed in alphabetical order.
[38] Work was completed within the reporting period.
[39] The Kootenay River is spelled Kootenai in the United States (US).

Strategy	Activity	Descriptions and Results	Participants[37]
		• Wild egg and larvae collection was attempted; however, the quantity collected was not sufficient to support the aquaculture program. • Efforts to develop a parental-based tagging protocol are underway (KTOI 2021) The conservation aquaculture programs screen for diseases, ploidy and deformities (KTOI 2021).	
A. Meet or exceed recovery population targets within specified timeframe	A-2 Monitor population trends	Wild adult Kootenay River White Sturgeon (Canada and United States (US)) abundance estimates have declined from 2,072 individuals in 2011 to 1,744 individuals (95% confidence interval 1,232 to 2,182) in 2017; annual survival was estimated at ~96% (Hardy et al. 2020). Previous studies estimated the population to be at lower abundance (for example, ~1,000 individuals in 2007; Beamesderfer et al. 2009). A standardized monitoring program, led by IDFG and BC MFLNRORD (with sporadic sampling in Montana conducted by MFWP), began in 2003, was completed annually during the reporting period, and is ongoing. This adult and juvenile monitoring program includes periodic stock assessment surveys, spawn monitoring (in the US), juvenile indexing, and movement studies (including juvenile and adult telemetry; Hardy et al. 2020; Stephenson et al. 2020; Sylvester et al. 2020). • Hatchery-origin juvenile abundance levelled off after 2005 and was estimated at ~14,000 to 16,000 individuals in 2018 (Hardy et al. 2020) • Age-1 survival has decreased to less than 10% in the last 20 years and growth of juveniles caught in the river has decreased, suggesting density-dependence effects are occurring (Hardy et al. 2020) • Sampling in Canada suggests higher growth rates and higher representation of the older hatchery individuals in the lake habitat compared to the river (Stephenson and Evans 2018)	BC MFLNRORD, BPA, IDFG, KTOI, MFWP

Strategy	Activity	Descriptions and Results	Participants[37]
		Co-managers in BC, Idaho and Montana have developed, and continue to update, relational databases for mark-recapture and telemetry data for the Kootenay River White Sturgeon NSP. Data is shared among all international co-managers.	
A. Meet or exceed recovery population targets within specified timeframe	A-3 Establish parameters for beneficial use	Beneficial use parameters have not been established as natural recruitment rates are not sufficient to support beneficial use at this time (refer to table 12, strategy A).	N/A
B. Protect critical habitats	B-1: Identify habitat requirements for all life stages	Data on habitat use has been collected as part of ongoing population monitoring efforts (refer to A-2). • Annual spawn monitoring at the spawning reach near Bonners Ferry, Idaho provides information on early life stage habitat requirements (Hardy et al. 2020) • Ongoing adult telemetry studies focus on tagging adults (with a priority on tagging females) in Idaho and BC to evaluate spawn migration, periodicity, and spawning habitat use, and to assess spawning habitat restoration projects (Hardy et al. 2020) • BC MFLNRORD initiated a juvenile telemetry study in 2014, which included 50 hatchery-origin juveniles caught in Kootenay Lake (10 of which have depth tags), to provide information on hatchery-origin juvenile movements within Kootenay Lake and Kootenay River (Stephenson et al. 2020) US Geological Survey (USGS) and IDFG completed bathymetry mapping to characterize the physical habitat occupied by Kootenai River White Sturgeon during spawning and early life stages (Fosness 2014). IDFG and USGS are developing a particle drift model to determine locations with high particle concentrations with the goal to better	BC MFLNRORD, BPA, IDFG, KTOI, MFWP, USFWS, USGS

Strategy	Activity	Descriptions and Results	Participants[37]
		understand how larval Kootenai White Sturgeon drift downstream; this will inform larval sampling design (Hardy pers. comm. 2020).	
B. Protect critical habitats	B-2 Define critical habitat (including related ecological processes)	Geographic locations of critical habitats for White Sturgeon were identified in section 8.5 of the recovery strategy (DFO 2014); ongoing research and monitoring may inform critical habitat refinement, especially for early life stages (refer to B-1 and table 8). A critical habitat order was put in place in 2016.	BC MFLNRORD, DFO, IDFG, KTOI, MFWP
B. Protect critical habitats	B-3 Identify critical habitats for designation and protection	Refer to B-2.	BC MFLNRORD, DFO, IDFG, KTOI, MFWP
B. Protect critical habitats	B-4 Protect, maintain and enhance critical habitat for White Sturgeon	A critical habitat order was put in place in 2016 (refer to B-2). Nutrient addition programs have been implemented in Canada and the US to enhance biological productivity in the Kootenay system. • In Canada, the Kootenay Lake Nutrient Restoration Program has been successful in partially offsetting nutrient declines and increasing biological productivity in the lake, including increases in zooplankton (Basset et al. 2018a, 2018b; Schindler et al. 2020) • In the US, the Ecosystem Restoration Program, which started in 2005 and is managed by the KTOI and IDFG, releases nutrients in the US portion of the Kootenai River (Gidley et al. 2019). Nutrient additions in the river have increased phytoplankton and zooplankton density (Kruse et al. 2020) Two restoration projects are underway that are expected to benefit Kootenay River White Sturgeon in Canada: • Creston Valley Wildlife Management Area (CVWMA)'s Six Mile Slough Wetland Restoration Project will restore up to 1,260 hectares of wetlands and is expected to benefit White Sturgeon and other native species (Biebighauser and Annschild 2016). Pre-restoration monitoring was completed in 2020 (Quamme et al. 2020)	BC MFLNRORD, BPA, CVWMA, DFO, FFSBC, IDFG, Indigenous organizations, industry, KTOI, LKB, US Army Corps of Engineers (USACE), USFWS

Strategy	Activity	Descriptions and Results	Participants[37]
		• Yaqan Nuʔkiy (Lower Kootenay Band (LKB)) has secured funding to restore over 500 hectares of wetlands, streams, and riparian habitat along the Kootenay and Goat River The Kootenai River Restoration Program Master Plan, developed by KTOI in 2009, provides a framework for implementing large-scale, ecosystem-based restoration in Idaho and focuses on enhancing habitat for White Sturgeon through addressing changes in river morphology, as well as reduction in floodplain access, riparian habitat and nutrients (KTOI 2009). KTOI has completed 11 habitat restoration projects in Idaho under this program, including 8 projects in the braided reach of the Kootenai River and 1 project in the meander reach (IDFG and KTOI 2020). ○ Completed projects include the construction of islands, and restoration and reconnection of riparian/floodplain areas to enhance hydraulic and food web complexity, and prevent erosion (USFWS 2019) ○ The Nimz Ranch flood plain reconnection project was initiated in 2016 (completion expected in 2024) to improve ecological productivity and enhance off-channel habitats (IDGF and KTOI 2020[40]); recent experimental Burbot (*Lota lota*) release studies indicated pre-feeding larvae survive and grow in the constructed off-channel habitats (Hardy et al. 2020) ○ Completed restoration efforts to address White Sturgeon recruitment failure include a spawning substrate enhancement pilot project and resting pool enhancements and additions (refer to C-4)	
B. Protect critical habitats	B-5 Ensure habitat diversity, connectivity and productivity	There are a number of completed and ongoing initiatives in the Kootenay River to ensure habitat diversity and productivity, including: restoration activities (refer to B-4 and C-4); nutrient additions into Kootenay Lake and Kootenai River (refer to B-4); and management of	BC MFLNRORD, CVWMA, DFO, IDFG, Indigenous organizations, industry, KTOI,

[40] Work was completed within the reporting period.

Strategy	Activity	Descriptions and Results	Participants[37]
		hydroelectric facility operations to protect sturgeon habitat (refer to C-4).	LKB, MFWP, USACE
B. Protect critical habitats	B-6 Work cooperatively to develop plans to protect habitat	The USFWS worked with co-managers to develop the "Revised Recovery Plan for the Kootenai River Distinct Population Segment of the White Sturgeon" (USFWS 2019), which includes a number of strategies to mitigate habitat threats. KTOI is actively promoting Kootenai River White Sturgeon habitat restoration through: ○ hosting annual meetings with the International Kootenai Ecosystem Restoration Team on the ongoing nutrient addition program (Ecosystem Restoration Program; refer to B-4) ○ co-chairing the Kootenai Valley Resource Initiative, which facilitates community involvement in restoring and enhancing resources in the Kootenai Valley (refer to B-4 for details on White Sturgeon habitat restoration) ○ hosting annual meetings and joint workshops with co-managers USACE hosts annual public meetings in Canada and the US regarding White Sturgeon flow operations at Libby Dam (USFWS 2019).	BC MFLNRORD, BPA, DFO, FFSBC, IDFG, industry, KTOI, Kootenai White Sturgeon Recovery Team (KWSRT)[41], USACE, USFWS
C. Restore natural recruitment	C-1 Determine accuracy of recruitment index time series	No new analyses were completed during this reporting period. Previous analyses showed that natural recruitment has been inconsistent for Kootenay River White Sturgeon since the mid-1950s (Paragamian et al. 2005), with no significant recruitment of wild juveniles since 1974 (Paragamian 2012).	Academia, IDFG

[41] KWSRT is chaired by USFWS. Voting members include BC FLNRORD, BPA, IDFG, KTOI, MFWP, and USFWS.

Strategy	Activity	Descriptions and Results	Participants[37]
C. Restore natural recruitment	C-2 Identify temporal correlations between significant recruitment shifts (peaks or drops) and environmental changes	Ongoing monitoring (refer to A-2 and B-1) informs analyses on relationships between recruitment and environmental variables. Libby Dam Flow Plan operations test experimental flows annually to enhance White Sturgeon spawning; analysis to identify best practices is ongoing (refer to C-4). Recent analysis shows long periods of high flows during the spring spawning period. Combined with KTOI's resting pool restorations (refer to C-4), this increased the presence of tagged adult White Sturgeon in areas with suitable spawning habitat (Golder Associates Ltd. 2020).	BC MFLNRORD, BPA, DFO, IDFG, industry, KTOI, MFWP, USACE, USFWS
C. Restore natural recruitment	C-3 Examine potential mechanism of recruitment effect	A leading recruitment failure hypothesis is that development of the Kootenay River has led to environmental changes (for example, altered hydrograph due to the construction of the Libby Dam and habitat alterations through dyke construction) that have modified White Sturgeon behaviour, causing selection of unsuitable spawning substrates (Anders et al. 2014). Post-spawning egg and embryo suffocation, and predation from being deposited in unsuitable substrates, have been identified as prominent mortality factors and contribute to recruitment failure ("spatial mismatch hypothesis"; Anders et al. 2014).	Academia, BC MFLNRORD, IDFG, industry, KTOI, MFWP, USACE, USFWS
C. Restore natural recruitment	C-4 Undertake meso-scale field trials	Through the Kootenai River Ecosystem Function Restoration Flow Plan Implementation Protocol, USACE experimentally operates the flows at Libby Dam to support Kootenay River White Sturgeon spawning. The Kootenai River Restoration Program has completed 11 habitat restoration projects (refer to B-4), including: • Rocky substrate was placed in 2 locations in the spawning reach in Idaho in 2014 to evaluate the potential of using substrate enhancement to address factors limiting egg and larval survival (IDFG and KTOI 2020). Post-enhancement monitoring suggests adults use the enhanced substrate (Golder Associates Ltd. 2020) but no increase in egg deposition and larval production rates has been detected (Hardy et al. 2020)	BPA, IDFG, KTOI, USACE, USFWS

Strategy	Activity	Descriptions and Results	Participants[37]
		• A series of deep pools were constructed or enhanced to provide holding and spawning staging habitat to encourage upstream migration. Recent telemetry analysis indicated that the duration of high flows in combination with the added pools increased the number of spawners migrating above Bonners Ferry (Golder Associates Ltd. 2020) No actions specific to restoring natural recruitment have been undertaken in Canada as Kootenay River White Sturgeon spawn in the US. There is potential to conduct habitat restoration for early life stages (0 to 1 years) in Canada.	
C. Restore natural recruitment	C-5 Undertake larger scale field trials	Restoration efforts completed that aim to address recruitment failure include a spawning substrate enhancement pilot project and resting pool construction / enhancement (refer to C-4). Larger scale restoration efforts through KTOI's plan are ongoing (refer to B-4).	BPA, IDFG, KTOI, USACE, USFWS
C. Restore natural recruitment	C-6 Design and implement longer term restoration program	Multiple activities are being implemented simultaneously in an attempt to restore natural recruitment, including: identification of the leading recruitment failure hypothesis (refer to C-3); experimental operations to assess flow and temperature management techniques at Libby Dam (refer to C-4); spawning substrate enhancement and resting pool construction and enhancement (refer to C-4); a large scale restoration plan (refer to B-4); and ongoing monitoring to assess recovery efforts (refer to A-2). No actions specific to restoring natural recruitment have been undertaken to date in Canada as Kootenay River White Sturgeon spawn in the US; however, wetland restoration projects in BC are expected to benefit White Sturgeon through increasing juvenile foraging habitat and providing habitat for early life stages (0 to 1 years; refer to B-4).	BC MFLNRORD, BPA, CVWMA, IDFG, Indigenous organizations, KTOI, LKB, USACE, USFWS

Strategy	Activity	Descriptions and Results	Participants[37]
C. Restore natural recruitment	C-7 Determine the habitat requirements for dam affected population enhancement or recovery	Multiple activities are ongoing to determine the habitat requirements for enhancement or recovery of the Kootenay River White Sturgeon, including: annual monitoring which includes collecting information on habitat use and movement (refer to A-2 and B-1); habitat restorations that aim to enhance habitat diversity and productivity for all White Sturgeon life stages (refer to B-4); experimental operations to assess flow and temperature management techniques at Libby Dam (refer to C-4); identification of leading recruitment failure hypothesis (refer to C-3); and experimental spawning substrate enhancement and resting pool construction and enhancement (refer to C-4).	BC MFLNRORD, BPA, CVWMA, DFO, IDFG, Indigenous organizations, KTOI, LKB, MFWP, USACE, USFWS
C. Restore natural recruitment	C-8 Initiate, within 5 years, pilot studies towards restoration of natural recruitment for each population that is affected by dams	Multiple activities are being implemented simultaneously in an attempt to restore natural recruitment, including: identification of the leading recruitment failure hypothesis (refer to C-3); experimental operations to assess flow and temperature management techniques at Libby Dam (refer to C-4); spawning substrate enhancement and resting pool construction and enhancement (refer to C-4); a large scale restoration plan (refer to B-4); and ongoing monitoring to assess recovery efforts (refer to A-2). No actions specific to restoring natural recruitment have been undertaken to date in Canada as spawning habitat is located in the US (refer to C-4).	Academia, BC MFLNRORD, BPA, IDFG, industry, KTOI, MFWP, USACE, USFWS
C. Restore natural recruitment	C-9 Within 10 years, identify methods for each population that, if and when implemented, can restore recruitment to a level sufficient to achieve the other recovery	Refer to C-8. Natural recruitment has not been restored to necessary levels. Conservation aquaculture is ongoing as a measure to prevent the extirpation of the Kootenay River White Sturgeon NSP (refer to A-1) until natural recruitment is restored.	Academia, BC MFLNRORD, BPA, IDFG, industry, KTOI, MFWP, USACE, USFWS

Strategy	Activity	Descriptions and Results	Participants[37]
	measures listed herein		
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: a. fishing	Risks associated with fishing were assessed as moderate for the Kootenay River White Sturgeon NSP; however, the amount of illegal harvest is unknown (DFO 2014).	DFO
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: b. pollution	Early life stage White Sturgeon are highly sensitive to particular toxins (for example, copper) relative to other fish (Calfee et al. 2014; Vardy et al. 2014, 2015; Wang et al. 2014); in lab studies, below lethal concentrations, contaminants resulted in sublethal effects such as altered movement, diminished hiding, disruption in sodium uptake, and loss of equilibrium (Calfee et al. 2014; Little et al. 2014; Wang et al. 2014; Shekh et al. 2019). Selenomethionine (bioavailable form of selenium) had toxic effects on juvenile White Sturgeon (De Rui et al. 2014; Zee et al. 2016). Selenium concentrations in the US portion of the Kootenai River have been increasing over time due to outputs into the river from a coal mining operation in Elk River, BC (Mebane and Schmidt 2019). During annual KTOI broodstock collection, there is ongoing testing of White Sturgeon egg tissues for 23 contaminants of concern, including selenium and copper (Hoyle pers. comm. 2020). Potential contaminant sources in the Kootenay River include pulp mill and mine effluent, wastewater treatment plants, and spills from railway crossings. A number of water quality monitoring programs exist within the range of Kootenay River White Sturgeon in Canada and the US, including stewardship led efforts (for example, Friends of Kootenay Lake-led Lake-Wide Citizen Science Water Quality Monitoring Data Collection program) and government led efforts (for example, BC ENV and	Academia, BC ENV, BC MFLNRORD, BPA, DFO, ECCC, IDFG, Indigenous organizations, industry, KTOI, MFWP, stewardship groups, USFWS

Strategy	Activity	Descriptions and Results	Participants[37]
		Environment and Climate Change Canada (ECCC) led Canadian Aquatic Biomonitoring Network program and the US National Water Quality Initiative). Regular monitoring provides baseline water quality data and can identify changes and allow for management response to benefit resident species, including White Sturgeon.	
D. Clarify and mitigate threats	D-1 Clarify threats and relative risks: c. predation	No actions taken during this reporting period.	N/A
D. Clarify and mitigate threats	D-2 Clarify threats to: a. food supply	Monitoring of resident fish species (which White Sturgeon may prey upon) in the Kootenay River and Kootenay Lake is ongoing. BC monitors Kokanee (*Oncorhynchus nerka*), Burbot and important predator species including Gerrard Rainbow Trout (*Oncorhynchus mykiss*) and Bull Trout (*Salvelinus confluentus;* for example, McPherson 2018; Bassett et al. 2018a, 2018b; Evans et al. 2019). Idaho monitors Kokanee, Burbot, Mountain Whitefish (*Prosopium williamsoni*), Rainbow Trout and Largescale Sucker (*Catostomus macrocheilus*; for example, Rust et al. 2017). The Kokanee population in Kootenay Lake, which collapsed in 2012 (McPherson 2018), is closely monitored as an indicator of food web health (Bassett et al. 2018a, 2018b). No studies directly linking White Sturgeon survival and condition to Kokanee have been conducted. Development of the Kootenay River has altered nutrient transport, thereby reducing biological production. Nutrient addition programs in Kootenay Lake and River aim to increase system productivity (refer to B-4).	BC MFLNRORD, BPA, IDFG, Indigenous organizations, industry, KTOI, MFWP
D. Clarify and mitigate threats	D-2 Clarify threats to: b. habitat (including effects	A leading recruitment failure hypothesis is that development of the Kootenay River has led to changes in White Sturgeon behaviour which results in spawning in unsuitable locations (refer to C-3).	Academia, BC MFLNRORD, IDFG, industry, KTOI, MFWP, USACE

Strategy	Activity	Descriptions and Results	Participants[37]
	of flow regulation)		
D. Clarify and mitigate threats	D-3 Undertake specific actions to: a. protect, maintain, and enhance critical habitat	Refer to B-2 to B-5 and table 8. DFO developed critical habitat information packages and distributed them to landowners located near Kootenay River White Sturgeon critical habitat. Annually, USACE experimentally operates the flows at Libby Dam to support Kootenay River White Sturgeon spawning (refer to C-4).	BC MFLNRORD, BPA, DFO, IDFG, Indigenous organizations, industry, KTOI, MFWP, USFWS
D. Clarify and mitigate threats	D-3 Undertake specific actions to: b. address illegal harvest	Year-round compliance patrols are conducted by DFO and Fishery Guardians (refer to table 3: D-3b) to enforce *Species at Risk Act* prohibitions and the White Sturgeon fishing closure.	DFO, Ktunaxa Nation Council (KNC)
D. Clarify and mitigate threats	D-3 Undertake specific actions to: c. minimize bycatch and mitigate impacts from fisheries through regulation and best practices	In BC, there is a recreational fishing closure at the mouth of the Kootenay River to eliminate potential bycatch of White Sturgeon as this is an area of known high concentration and an important holding location. Patrols are conducted by DFO and Fishery Guardians (refer to D-3b).	DFO, KNC
D. Clarify and mitigate threats	D-3 Undertake specific actions to: d. limit and address pollutant discharges and contaminant	The Elk Valley Water Quality Plan (Teck 2015) aims to reduce contaminant (for example, selenium) inputs. Threats related to pollution are mitigated through protections by provincial and federal regulatory reviews. Refer to D-1b for details on threat of pollution for Kootenay River White Sturgeon NSP.	BC ENV, BC MFLNRORD, DFO, ECCC, industry, KTOI, USFWS

Strategy	Activity	Descriptions and Results	Participants[37]
	loading, especially adjacent to important or critical habitats		
D. Clarify and mitigate threats	D-3 Undertake specific actions to: e. protect, maintain, and enhance water quality	Refer to D-3d.	BC ENV, BC MFLNRORD, DFO, ECCC, industry, KTOI, USFWS
D. Clarify and mitigate threats	D-3 Undertake specific actions to: f. mitigate interactions of White Sturgeon with industrial structures and activities	Provincial and federal regulatory review of projects that may impact White Sturgeon and/or its habitat is ongoing. There is ongoing adaptive management of Libby Dam operations to enhance White Sturgeon spawning (refer to C-4). A 2018 voluntary Protocol for Deceased White Sturgeon aims to collect biological information from deceased White Sturgeon and provide an avenue to notify regulatory agencies of any mortalities. Several hydroelectric operators within the Canadian range of Kootenay River White Sturgeon adhere to these protocols.	BC ENV, BC MFLNRORD DFO, industry, USACE

Strategy	Activity	Descriptions and Results	Participants[37]
D. Clarify and mitigate threats	D-3 Undertake specific actions to: g. manage risks from conservation hatchery introductions	The aquaculture program has been adaptively managed over time. Key adaptations include changing release season and releasing fewer fish, and the opening of the Twin Rivers Hatchery to increase the annual number of broodstock families (refer to A-1). The programs screen for diseases, ploidy, and deformities. The broodstock program has captured 96% of natural genetic variation over all years (Schreier et al. 2012); however, variability in post-release survival reduces genetic diversity (Schreier et al. 2015). Annual hatchery operations include autopolyploidy assessments and the removal of families with high instances of autopolyploidy (KTOI APR 2019). Research is being conducted on the potential causes of spontaneous autopolyploidy (Van Eenennaam et al. 2020), methods to efficiently detect polyploids (Fiske et al. 2019), and potential reproductive impairment in 10N individuals (Schreier and Van Eenennaam 2019).	Academia, BC MFLNRORD, BPA, IDFG, KTOI, MFWP, USFWS
D. Clarify and mitigate threats	D-3 Undertake specific actions to: h. better understand, maintain, and enhance food availability for all life stages of each population	Threats associated with prey species are described in D-2a. Annual nutrient addition programs (refer to B-4) aim to increase system productivity, thereby enhancing prey availability for White Sturgeon. Habitat restoration projects are being undertaken and aim to enhance food availability. For example, results of post-restoration monitoring indicate Burbot larvae are surviving and growing in the restored Nimz Ranch floodplain (refer to B-4). There are a number of habitat restoration-focused groups within the range of Kootenay River White Sturgeon NSP (for example, the Friends of Kootenay Lake and the Kootenay Conservation Program) that work towards conserving and maintaining important habitats for resident species, including White Sturgeon.	BC MFLNRORD, BPA, IDFG, Indigenous organizations, industry, KTOI, MFWP, stewardship groups, USFWS

Strategy	Activity	Descriptions and Results	Participants[37]
D. Clarify and mitigate threats	D-4 Monitor threat indicators and population trends	Monitoring population trends is ongoing (refer to A-2). Monitoring threat indicators is ongoing (refer to D-1b and D-2a).	Academia, BC ENV, BC MFLNRORD, BPA, ECCC, IDFG, Indigenous organizations, industry, KTOI, MFWP, USFWS
D. Clarify and mitigate threats	D-5 Work cooperatively to develop plans to mitigate threats to White Sturgeon	KTOI hosts a number of meetings to inform Kootenai White Sturgeon recovery and provides a forum for discussion regarding threat mitigation. Annual Program Review meetings provide a forum for co-manager input into adaptive management of the conservation aquaculture program (refer to A-1). Annual meetings and periodic workshops with various groups review, evaluate, and adaptively manage the recovery and habitat restoration initiatives that KTOI leads (refer to B-6). USACE hosts annual public meetings in Canada and the US regarding White Sturgeon flow operations at Libby Dam (refer to B-6). The KWSRT was established in 1994 to coordinate recovery and guide development of the recovery plan and recovery implementation strategy under the US *Endangered Species Act*. There is representation from each basin that contains White Sturgeon on the National White Sturgeon Recovery Team (NWSRT)[42], providing an avenue to coordinate recovery and management efforts for White Sturgeon in Canada.	BC MFLNRORD, BPA, DFO, IDFG, industry, KTOI, KWSRT, MFWP, NWSRT, USACE, USFWS

[42] NWSRT membership: DFO and BC ENV co-chairs, chairs for each basin-level TWG, and Indigenous organizations.

Strategy	Activity	Descriptions and Results	Participants[37]
E. Address information gaps that inhibit the conservation of White Sturgeon	E-1 Address basic biological data gaps	Work has been conducted to address basic biological gaps for Kootenay River White Sturgeon, including: population monitoring to address demographic gaps (for example, population abundance and structure; refer to A-2); spawn monitoring to address life history and ecology gaps (for example, spawn periodicity; refer to B-1); and studies to assess genetic diversity (refer to D-3g). Refer to C-4 for work conducted to address knowledge gaps specific to recruitment failure. Refer to table 8 for information on knowledge gaps related to critical habitat.	BC MFLNRORD, BPA, DFO, IDFG, industry, KTOI, MFWP, USACE, USFWS
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-1 Maintain and where possible increase awareness and stewardship of White Sturgeon throughout its natural range	Kootenay White Sturgeon co-managers and partners advocate for White Sturgeon recovery and communicate scientific research findings through a variety of forums including conferences, guest lectures at academic institutions, and through media coverage. Kootenay White Sturgeon co-managers and partners engage the public through a number of outreach initiatives. • Annual public education events, including White Sturgeon hatchery release events which engage local elementary schools, are carried out by BC MFLNRORD and KTOI • FFSBC delivers a Kootenay White Sturgeon education program to up to 12 elementary school classes reaching 500 students annually in the Creston, Nelson, and Cranbrook areas • KTOI has open house tours for the conservation aquaculture facilities Media coverage for Kootenay River White Sturgeon is ongoing. • Gale Force Films produced "The Fish Between the Falls" documentary in 2015, which outlines the history of collaborative Kootenai White Sturgeon research, management and restoration (USFWS 2019)	BC ENV, BC MFLNRORD, BPA, DFO, FFSBC, IDFG, Indigenous organizations, industry, KTOI, MFWP, stewardship groups, USACE, USFWS, USGS

Strategy	Activity	Descriptions and Results	Participants[37]
		• National Geographic Television included Kootenai White Sturgeon in an episode of their "Megafishes Project" • Kyle and Rob productions released "A Natural Balance: Partners in Restoration" in 2017, highlighting the Kootenai River Habitat Restoration Program In 2020, DFO developed critical habitat information packages for landowners located near Kootenay River White Sturgeon critical habitat (refer to D-3a).	
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-2 Engage in effective public education of the species and its conservation needs	Refer to F-1.	BC ENV, BC MFLNRORD, BPA, DFO, FFSBC, IDFG, Indigenous organizations, industry, KTOI, MFWP, stewardship groups, USACE, USFWS, USGS
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-3 Support learning and communication across all working groups	Refer to D-5. The NWSRT co-chairs participate in the UCWSRI TWG and provide exchange of information between basin-level working groups and Indigenous groups. Periodic meetings between the Upper Columbia and Kootenay River White Sturgeon NSP working groups at basin-wide conferences (for example, at the Lake Roosevelt Forum Conference in 2016) promote information exchange on knowledge gaps and recovery efforts (UCWSRI OP 2018).	BC ENV, BC MFLNRORD, BPA, DFO, IDFG, Indigenous organizations, industry, KTOI, MFWP, stewardship groups, USACE, USFWS, USGS

Strategy	Activity	Descriptions and Results	Participants[37]
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	F-4 Ensure participation from community and technical experts	Refer to D-5, F-1 and F-3.	BC ENV, BC MFLNRORD, BPA, DFO, IDFG, Indigenous organizations, industry, KTOI, MFWP, stewardship groups, USACE, USFWS, USGS
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-1 Incorporate the needs of healthy White Sturgeon populations into the management of White Sturgeon prey species, especially salmon and resident sportfish	No actions taken during this reporting period.	N/A
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-2 Accommodate other species' needs during recovery of White Sturgeon	Various restoration projects have been completed or are underway that aim to support all life stages of Kootenay River White Sturgeon (refer to B-4). These projects are designed to benefit other native species as well (for example, Burbot).	BC MFLNRORD, BPA, DFO, IDFG, industry, Indigenous organizations, KTOI, MFWP
G. Maintain and where	G-3 Closely manage non-	Invasive species data is recorded in White Sturgeon monitoring programs (refer to A-2), but studies assessing the effects of non-native	BC MFLNRORD, IDFG, MFWP

Strategy	Activity	Descriptions and Results	Participants[37]
necessary, restore ecosystem functions relevant to White Sturgeon	native predatory fish species	species on Kootenay River White Sturgeon survival and recruitment have not been completed.	
G. Maintain and where necessary, restore ecosystem functions relevant to White Sturgeon	G-4 Dialogue with regulatory agencies that have influence or jurisdiction over White Sturgeon prey species	No actions taken during this reporting period.	N/A

3.2 Activities supporting the identification of critical habitat

Tables 5 to 8 provide information on the implementation of the studies outlined in the schedule of studies to identify critical habitat found in the recovery strategy (DFO 2014). Each study has been assigned 1 of 4 statuses:

1) completed: the activity has been carried out and concluded
2) in progress: the activity is underway and has not concluded
3) not started: the activity has been planned but has yet to start
4) cancelled: the activity will not be started or completed

List of tables in this section:

Table 5. Status and details of the implementation of the schedule of studies outlined in the recovery strategy for the Upper Fraser River White Sturgeon nationally significant population (NSP).

Study	Status	Descriptions and results	Participants[43]
Confirm locations of spawning sites.	In progress	The spawn monitoring program (refer to table 1 A-2) includes adult telemetry which showed an aggregation of adults at the Willow River, Bowron (tributaries of the Upper Fraser River), and Nechako River confluences during spawning season; however, egg matting efforts have not confirmed spawning use (refer to table 1 B-1). Monitoring to confirm spawning sites is ongoing and includes periodic egg matting (Lheidli T'enneh 2020).	Fisheries and Oceans Canada, Lheidli T'enneh First Nation
Initiate lab and/or *in situ* studies to investigate habitat use by eggs (for example, survival), yolk sac larvae (for example, survival), and feeding larvae (for example, cover and food availability).	Not started	Specific *in situ* studies on habitat use by eggs, yolk sac larvae and feeding larvae cannot be conducted for the Upper Fraser River White Sturgeon NSP until spawning sites are confirmed. No laboratory studies have been completed for the Upper Fraser River White Sturgeon NSP during this reporting period, but refer to table 7 for studies completed or underway on the Nechako River White Sturgeon NSP which may be relevant due to similar geographic range.	N/A

[43] Participants are listed in alphabetical order.

Table 6. Status and details of the implementation of the schedule of studies outlined in the recovery strategy for the Nechako River White Sturgeon nationally significant population (NSP).

Study	Status	Descriptions and results	Participants[44]
Confirm locations of spawning sites.	Completed	The Nechako spawning reach near Vanderhoof, British Columbia (BC) was confirmed and identified as critical habitat in the recovery strategy; current evidence suggests additional spawning sites are possible, but unlikely (EDI 2016).	BC Ministry of Environmental and Climate Change Strategy (BC ENV), BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC MFLNRORD), Carrier Sekani Tribal Council (CSTC), Nechako White Sturgeon Recovery Initiative Technical Working Group (NWSRI TWG)[45]
Initiate lab and/or *in situ* studies to investigate habitat use by eggs (for example, survival), yolk sac larvae (for example, survival), and feeding larvae (for example, cover and food availability).	In progress	Multiple laboratory studies have been completed or are underway including studies examining the effects of temperature, substrate, and alarm cues on growth and survival (refer to table 2 B-4); these studies provide information on habitat requirements and inform experimental in-river enhancements and cleaning of spawning habitat (refer to table 2 C-4).	Academia, BC ENV, BC MFLNRORD, CSTC, NWSRI TWG
Undertake pre-requisite studies in support of spawning	In progress	Ongoing flow and sediment transport research and modelling aim to clarify habitat requirements and inform future restoration efforts (refer to table 2 C-3).	Academia, BC ENV, BC MFLNRORD, CSTC, NWSRI TWG

[44] When more than 1 participant is associated with an activity, they are listed in alphabetical order.
[45] The NWSRI supports recovery for the Nechako River White Sturgeon NSP and the Upper Fraser River White Sturgeon NSP due to similar geographic location and endangered status. NWSRI TWG membership includes: BC ENV, BC MFLNRORD, DFO, Lheidli T'enneh First Nation, Tl'azt'en First Nation, CSTC, Freshwater Fisheries Society of BC (FFSBC), University of BC and Rio Tinto Alcan. Note: Rio Tinto Alcan participates in Nechako River White Sturgeon NSP recovery measures only and Lheidli T'enneh First Nation participates in Upper Fraser River White Sturgeon NSP recovery measures only.

Study	Status	Descriptions and results	Participants[44]
habitat restoration. Investigate hydraulic conditions required to sustain preferred incubation substrates.		Experimental restoration through substrate placement occurred in 2011 and substrate cleaning occurred in 2016 and 2020 through mechanical and manual techniques, respectively, in an effort to enhance spawning and early life stage habitats (refer to table 2 C-4). Experimental releases of over 300,000 and 250,000 fertilized eggs occurred in 2011 and 2016, respectively, and aimed to provide a method to assess the success of spawning substrate enhancements and cleaning. A recruitment event was detected in 2011; investigations into causality are ongoing. A habitat restoration plan is being developed to identify data gaps that limit implementation of substrate restoration. The plan will help set the direction for future restoration efforts (refer to table 2 B-6).	
Investigate biological determinants of spawning micro habitat selection. This would include evaluation of physical conditions (for example, hydraulics), social/chemical cues (for example, presence of other fish, pheromones), as well as investigation of manipulating habitat attributes to attract/deter spawning at specific locations.	In progress	Ovarian fluid pheromone testing was conducted in the Nechako River in 2015. Results indicated ovarian fluid acted as a potential attractant to adult White Sturgeon in a river environment (Beardsall et al. 2017). Studies using acoustic Virtual Positioning System were conducted from 2015 to 2017 in the Nechako spawning reach and aimed to further refine spawning location(s) and timing, but were unsuccessful in detecting fine-scale interactions (NWSRI 2016, 2018). Ongoing sediment transport research and geomorphology work are being conducted to provide information on bedload movements and site selection to inform future restoration efforts (refer to table 2 C-4).	Academia, BC MFLNRORD, NWSRI TWG

Table 7. Status and details of the implementation of the schedule of studies outlined in the recovery strategy for the Upper Columbia River White Sturgeon nationally significant population (NSP).

Study	Status	Descriptions and results	Participants[46]
Confirm use of the Kinnaird area of Columbia River by spawning adults, identify egg and larval rearing habitats, and describe habitats used by juveniles and adults for feeding and overwintering.	In progress	The monitoring program has documented spawning annually at the Kinnaird area since 2007 (British Columbia [BC] Hydro 2020), but the exact location of egg deposition remains unknown. Annual monitoring includes telemetry, egg matting and larval driftnetting to confirm egg and larval rearing habitats (BC Hydro 2020).	BC Hydro
Confirm locations of spawning sites.	Completed	Annual spawn monitoring occurs at 4 identified spawning sites in Canada and larval sampling occurs at 1 location in the United States (US) (BC Hydro 2020; Golder Associates Ltd. and ONA 2020; Miller et al. 2020). Annual monitoring has not identified any additional spawning locations.	BC Hydro, Colville Confederated Tribes (CCT), Okanagan Nation Alliance (ONA), Spokane Tribe of Idaho (STI), Upper Columbia White Sturgeon Recovery Initiative
Initiate lab and/or *in situ* studies to investigate habitat use by eggs (for example, survival), yolk sac larvae (for example, survival), and feeding larvae (for example, cover and food availability).	In progress	Laboratory studies are ongoing to evaluate the effects of substrate, temperature, and other environmental factors on early life stage growth, development, and survival; results show substrate presence is important for growth and survival (refer to table 3 B-1). Hydrodynamic and individual-based early life stage (embryo to early larvae) models were developed for the US portion of the range (Bellgraph et al. 2015; Garavelli et al. in prep*)*. Larvae translocation experiments were conducted from	Academia, BC Hydro, British Columbia Ministry of Environmental and Climate Change Strategy (BC ENV), CCT, STI

[46] Participants are listed in alphabetical order.

Study	Status	Descriptions and results	Participants[46]
		2017 to 2019 to research larval drift behaviour and habitat use, but results are unclear due to limited recaptures (refer to table 3 C-4; Howell and McLellan 2018b, 2019b, 2020b).	
Undertake pre-requisite studies in support of spawning habitat restoration. Investigate hydraulic conditions required to sustain preferred incubation substrates.	In progress	An experimental initiative to restore habitat in Revelstoke spawning area was completed in 2014 (refer to table 3 C-4). Prerequisite studies are ongoing and a study to determine feasibility of spawning substrate restoration at Keenleyside, Kinnaird, and Waneta was completed in 2020 (refer to table 3 C-4).	Academia, BC ENV, BC Hydro
Investigate biological determinants of spawning micro habitat selection. This would include evaluation of physical conditions (for example, hydraulics), social/chemical cues (for example, presence of other fish, pheromones), as well as investigation of manipulating habitat attributes to attract/deter spawning at specific locations.	In progress	A study on the effects of flows on White Sturgeon spawning at Revelstoke identified that White Sturgeon select specific flow regimes (BC Hydro 2015). No studies have been completed on social and chemical cues, or on manipulating habitat attributes to attract spawners to specific locations for Upper Columbia River White Sturgeon.	BC Hydro

Study	Status	Descriptions and results	Participants[46]
Initiate experimental spawning habitat restoration (one location minimum) in the Transboundary reach.	In progress	An experimental initiative to restore habitat in Revelstoke spawning area was completed in 2014 (refer to table 3 C-4). A study to determine feasibility of spawning substrate restoration at Keenleyside, Kinnaird, and Waneta was completed in 2020 (refer to table 3 B-4); implementation of restoration at Keenleyside is planned for 2022.	Academia, BC ENV, BC Hydro

Table 8. Status and details of the implementation of the schedule of studies outlined in the recovery strategy for the Kootenay River White Sturgeon nationally significant population (NSP).

Study	Status	Descriptions and results	Participants[47]
Initiate lab and/or *in situ* studies to investigate habitat use by yolk sac larvae (for example, survival) and feeding larvae (for example, cover and food availability).	In progress	No laboratory studies were completed for Kootenay River White Sturgeon during this reporting period. Kootenai Tribe of Idaho (KTOI) completed a spawning substrate enhancement pilot project in 2014 (refer to C-4). Post-restoration telemetry showed tagged adults used the enhanced areas (Golder Associates Ltd. 2020); however, there was no clear evidence of increased egg deposition rates or larval recruitment (Hardy et al. 2020). Idaho Department of Fish and Game (IDFG) and United States Geological Survey (USGS) are developing a particle drift model to determine locations with high particle concentrations with the goal to better understand how larval Kootenai River White Sturgeon drift downstream and inform larval sampling design (Hardy pers. comm. 2020).	IDFG, KTOI, USGS

[47] Participants are listed in alphabetical order.

3.3 Summary of progress towards recovery

3.3.1 Status of performance measures

Tables 9 to 12 provide a summary of the progress made toward meeting the performance measures outlined in the recovery strategy. Each performance measure has been assigned 1 of 4 statuses:

1) not met: the performance measure has not been met, and little to no progress has been made
2) partially met, underway: moderate to significant progress has been made toward meeting 1 or more elements of the performance measure, and further work is ongoing or planned
3) met: the performance measure has been met and no further action is required
4) met, ongoing: the performance measure has been met, but efforts will continue until such time the population is considered to be recovered

List of tables in this section:

Table 9. Progress and details of the progress made toward meeting the performance measures outlined in the recovery strategy for the Upper Fraser River White Sturgeon nationally significant population (NSP).

Strategy	Performance measure	Status	Details
A. Meet or exceed recovery population targets within specified timeframe	Have targets been achieved?	met	The Upper Fraser River White Sturgeon NSP is near historical abundance and has a stable age structure (refer to table 1 A-2).
B. Protect critical habitats	Has critical habitat been identified?	met, ongoing	Geographic locations of critical habitats for White Sturgeon were identified in section 8.5 of the recovery strategy (DFO 2014), and a critical habitat order was put in place in 2016. Research and monitoring efforts are ongoing and may further refine critical habitat (refer to table 1 A-2 and B-1); these efforts include periodic egg matting to confirm spawning sites (refer to table 1 B-1 and table 5).
C. Restore natural recruitment	Have experimental trials been initiated to restore natural recruitment?	N/A	Not applicable. The Upper Fraser River White Sturgeon NSP is not experiencing recruitment failure.
C. Restore natural recruitment	Have experimental results shown that natural recruitment can be restored to necessary levels?	N/A	Not applicable. The Upper Fraser River White Sturgeon NSP is not experiencing recruitment failure.
C. Restore natural recruitment	Has recruitment been restored in dam-affected populations?	N/A	Not applicable. The Upper Fraser River White Sturgeon NSP is not experiencing recruitment failure.

Strategy	Performance measure	Status	Details
D. Clarify and mitigate threats	Have the most serious threats been defined?	met, ongoing	Effects of small population size and reduced or altered food supply were identified as high risk threats to the Upper Fraser River White Sturgeon NSP in section 4 of the recovery strategy (DFO 2014) and 2016 recovery potential assessment (DFO 2016). Work has been conducted and is ongoing to clarify and define threats to the Upper Fraser White Sturgeon NSP, including: pollution (through laboratory studies; refer to table 1 D-1b), predation (predominately in Nechako River; refer to table 1 D-1c); hatchery and aquaculture effects on health and population (through identifying hatchery-origin juveniles straying from Nechako; refer to table 1 D-3g); prey supply (refer to table 1 D-2a); and ongoing monitoring of threat indicators and population trends (refer to table 1 D-4). A key outcome from this reporting period is: • Recent declines in Pacific salmon were further impacted by the Big Bar landslide, which restricted upstream access by salmon (refer to table 1 D-2a); this indicates the threat of reduced or altered food supply remains high for the Upper Fraser White Sturgeon NSP
D. Clarify and mitigate threats	Have these threats been sufficiently mitigated?	partially met, underway	All threats have not been sufficiently mitigated; however, multiple initiatives are underway to mitigate threats to Upper Fraser River White Sturgeon NSP, including: • Projects to enhance salmon abundance and restore habitats are underway and may mitigate the threat of reduced or altered food supply (refer to table 1 D-3h) • The Emergency Boat Kit Program includes community outreach and awareness to mitigate by-catch mortalities associated with First Nation Food, Social, and Ceremonial (FSC) salmon fisheries (refer to table 1 D-3c) • The collaborative juvenile monitoring program identifies hatchery-origin juveniles from the Nechako River straying into the Upper Fraser River White Sturgeon range. This program provides data to

Strategy	Performance measure	Status	Details
			assess the potential threat of hatchery and aquaculture effects (refer to table 1 D-3g)
E. Address information gaps that inhibit conservation of White Sturgeon	Have key information gaps been filled?	partially met, underway	Work has been conducted to address basic biological gaps for Upper Fraser River White Sturgeon, including: population monitoring to address demographic gaps (for example, population abundance and structure; refer to table 1 A-2); spawn monitoring to address life history and ecology gaps (for example, spawn periodicity; refer to table 1 B-1); and studies to assess prey preferences (refer to table 1 D-2a). Genetic stock identification studies are underway to examine levels of distinctness and exchange between Nechako, Middle and Upper Fraser River White Sturgeon NSPs (refer to table 1 E-1).
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	Has general awareness of sturgeon conservation been increased?	met, ongoing	Awareness of Upper Fraser River White Sturgeon NSP and its conservation has increased through: • many ongoing outreach and education initiatives are led by the Nechako White Sturgeon Recovery Initiative (NWSRI) and Fraser River Sturgeon Conservation Society (for example, educational materials for schools; refer to table 1 F-1 and F-3) • NWSRI Technical Working Group members share research through media, conferences, and guest lectures (refer to table 1 F-1 and F-3) • the Emergency Boat Kit Program includes community outreach and awareness to mitigate by-catch mortalities associated with First Nation FSC salmon fisheries (refer to table 1 F-1)
G. Maintain and where necessary restore ecosystem functions relevant to White Sturgeon	Is the ecosystem “healthy” for White Sturgeon?	partially met, underway	Although the Upper Fraser River White Sturgeon NSP is believed to be at or near its historical distribution and abundance (refer to strategy A in table 9), there are a variety of threats identified and activities are underway to address these threats (refer to strategy D in table 9).

Table 10. Progress and details of the progress made toward meeting the performance measures outlined in the recovery strategy for the Nechako River White Sturgeon nationally significant population (NSP).

Strategy	Performance measure	Status	Details
A. Meet or exceed recovery population targets within specified timeframe	Have targets been achieved?	not met	The natural recruitment target has not been achieved. Low capture rates of wild-origin juveniles (125 between 2009 and 2019) suggest some degree of natural spawning success; however, natural recruitment is not occurring in sufficient numbers to sustain population levels (refer to table 2 A-2). Conservation aquaculture and habitat restoration are ongoing (refer to table 2 A-1 and B-6). The population target of 1,000 mature individuals has not yet been achieved. Recent estimates indicate the adult population consists of ~630 individuals (Carruthers et al. unpublished as reported in DFO 2016; refer to table 2 A-2).
B. Protect critical habitats	Has critical habitat been identified?	met, ongoing	Geographic locations of critical habitats for White Sturgeon were identified in section 8.5 of the recovery strategy (DFO 2016), and a critical habitat order was put in place in 2016 (refer to table 2 B-1). Ongoing research and monitoring may further refine critical habitat (refer to table 2 A-2 and B-1 and table 6).
C. Restore natural recruitment	Have experimental trials been initiated to restore natural recruitment?	partially met, underway	Multiple activities are being implemented simultaneously in an attempt to restore natural recruitment, including: laboratory studies that provide information on early life stage requirements (refer to table 2 B-4); research to identify cause(s) of recruitment pulses (refer to table 2 C-2) and recruitment failure (refer to table 2 C-3); experimental spawning substrate enhancement and cleaning (refer to table 2 C-4); and ongoing monitoring to assess recovery efforts (refer to table 2 A-2).
C. Restore natural recruitment	Have experimental results shown that natural recruitment can be restored to necessary levels?	not met	Experimental results to restore natural recruitment have not yet shown that natural recruitment can be restored to necessary levels; efforts are ongoing to restore recruitment (see row above).

Strategy	Performance measure	Status	Details
C. Restore natural recruitment	Has recruitment been restored in dam-affected populations?	not met	The natural recruitment target has not been achieved. Extremely low capture rates of wild-origin juveniles suggest some degree of natural spawning success but natural recruitment has yet to be restored to necessary levels (refer to table 2 A-2). Conservation aquaculture and habitat restoration are ongoing (refer to table 2 A-1 and B-6).
D. Clarify and mitigate threats	Have the most serious threats been defined?	partially met, underway	Anthropogenic factors causing recruitment failure, reduced or altered food supply, loss of habitat quality or quantity, and altered hydrograph components were identified as high risk threats to the Nechako White Sturgeon population in section 4 of the recovery strategy (DFO 2014) and in the 2016 recovery potential assessment (DFO 2016). Work has been conducted and is ongoing to clarify and define threats to the Nechako River White Sturgeon NSP, including: identifying the cause(s) of recruitment failure (refer to table 2 C-3 and D-2b); pollution (through laboratory studies; refer to table 2 D-1b); predation (predominately by River Otter (*Lontra canadensis*); refer to table 2 D-1c); prey supply (refer to table 2 D-2a); and ongoing monitoring of threat indicators and population trends (refer to table 2 D-4). Some key outcomes from this reporting period are: • substrate change in spawning locations has been identified as a leading hypothesis for recruitment failure (refer to table 2 C-3 and D-2b) • studies have identified predation (especially by River Otters) as a major cause of mortality that significantly reduces survival of hatchery-origin juveniles (refer to table 2 D-1c), indicating predation is a higher threat than originally thought • recent declines in Pacific salmon were further impacted by the Big Bar landslide which restricted upstream access of salmon (table 2 D-2a); this indicates the threat of reduced or altered food supply remains high for the Nechako River White Sturgeon NSP

Strategy	Performance measure	Status	Details
D. Clarify and mitigate threats	Have these threats been sufficiently mitigated?	not met	Threats have not been sufficiently mitigated; however, multiple initiatives are underway to mitigate threats to the Nechako River White Sturgeon NSP, including: • restoration efforts to address anthropogenic threats causing recruitment failure (refer to table 2 C-4) • development of a plan to address the threat of predation (refer to table 2 D-1c) • projects to enhance salmon abundance and restore habitats, which may mitigate the threat of reduced or altered food supply (refer to table 2 D-3h) • the Emergency Boat Kit Program, which includes community outreach and awareness to mitigate by-catch mortalities associated with the First Nations Food, Social, and Ceremonial (FSC) salmon fisheries (refer to table 2 D-3c) • adaptive management of the conservation aquaculture program to mitigate the threat of hatchery and aquaculture effects (refer to table 2 D-3g)
E. Address information gaps that inhibit conservation of White Sturgeon	Have key information gaps been filled?	partially met, underway	Work has been conducted to address basic biological gaps for Nechako River White Sturgeon, including: population monitoring to address demographic gaps (for example, population abundance and structure; refer to table 2 A-2); spawn monitoring to address life history and ecology gaps (for example, spawn periodicity; refer to table 2 B-1); laboratory studies to address early life stage knowledge gaps (refer to table 2 B-1); and studies to assess prey preferences (refer to table 2 D-2a). Genetic stock identification studies are underway to examine levels of distinctness and exchange between Nechako, Middle and Upper Fraser River White Sturgeon NSPs (refer to table 2 E-1).

Strategy	Performance measure	Status	Details
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	Has general awareness of sturgeon conservation been increased?	met, ongoing	Awareness of Nechako River White Sturgeon NSP and its conservation has increased through: ○ ongoing outreach and education is led by the Nechako White Sturgeon Recovery Initiative (NWSRI) Community Working Group and Nechako White Sturgeon Conservation Centre (for example, juvenile sturgeon release events, public hatchery tours, education in schools, and website and social media presence; refer to table 2 F-1) ○ NWSRI Technical Working Group members share research through media, conferences, and guest lectures (refer to table 2 F-1) ○ the Emergency Boat Kit Program includes community outreach and awareness to mitigate by-catch mortalities associated with First Nations FSC salmon fisheries (refer to table 2 D-3c)
G. Maintain and where necessary restore ecosystem functions relevant to White Sturgeon	Is the ecosystem “healthy” for White Sturgeon?	not met	The ecosystem is not healthy for White Sturgeon, as evidenced by the fact that population targets have not been achieved (refer to strategy A in table 10). There are a variety of threats identified for the Nechako White Sturgeon population, and activities are underway to address these threats (refer to strategy D in table 10).

Table 11. Progress and details of the progress made toward meeting the performance measures outlined in the recovery strategy for the Upper Columbia River White Sturgeon nationally significant population (NSP).

Strategy	Performance measure	Status	Details
A. Meet or exceed recovery population targets within specified timeframe	Have targets been achieved?	partially met, underway	The natural recruitment target has not been achieved; wild-origin juveniles represent <1% of captures in the juvenile monitoring program (refer to table 3 A-2). The abundance target of 1,000 mature individuals has been met. Recent estimates indicate the population consists of 1,042 individuals (95% confidence interval 743 to 1,461; mostly adults) for the Canadian portion of the range (refer to table 3 A-2). The conservation aquaculture program has prevented extirpation in the short-term through replacement of 19 juvenile year classes that would not have been produced naturally.
B. Protect critical habitats	Has critical habitat been identified?	partially met, underway	Geographic locations of critical habitats for White Sturgeon were identified in section 8.5 of the recovery strategy (DFO 2014), and a critical habitat order was put in place in 2016. Ongoing research and monitoring may further refine critical habitat (refer to table 3 A-2 and B-1 and table 7). Monitoring identified the Kinnaird area as important habitat for all life stages, including spawning; however, it is not currently designated as critical habitat (refer to table 3 B-2 and table 7).
C. Restore natural recruitment	Have experimental trials been initiated to restore natural recruitment?	partially met, underway	Multiple activities are being implemented simultaneously in an attempt to restore natural recruitment, including: reviewing recruitment failure hypotheses (refer to table 3 C-3); experimental spawning substrate enhancement and sediment trapping to guide future restoration (refer to table 3 C-4); and larval release studies (refer to table 3 C-4). A study to determine feasibility of spawning substrate restoration at Keenleyside, Kinnaird, and Waneta was completed in 2020. Planning of

Strategy	Performance measure	Status	Details
			a larger scale restoration at Keenleyside is underway; implementation is anticipated for 2022 (refer to table 3 C-5).
C. Restore natural recruitment	Have experimental results shown that natural recruitment can be restored to necessary levels?	not met	Experimental results to restore natural recruitment have not yet shown that natural recruitment can be restored to necessary levels; efforts are ongoing to restore recruitment (see row above).
C. Restore natural recruitment	Has recruitment been restored in dam-affected populations?	not met	The natural recruitment target has not been achieved. Wild-origin juveniles have been captured in the juvenile monitoring program, suggesting some degree of natural spawning success. However, wild origin juveniles represent <1% of captures in the program, indicating natural recruitment has yet to be restored to necessary levels (refer to table 3 A-2). Conservation aquaculture and habitat restoration are ongoing (refer to table 3 A-1 and C-8).
D. Clarify and mitigate threats	Have the most serious threats been defined?	met, ongoing	Work has been conducted and is ongoing to clarify and define threats to the Upper Columbia River White Sturgeon NSP, including: identifying the cause(s) of recruitment failure (refer to table 3 C-3 and D-2b); pollution (through laboratory studies; refer to table 3 D-1b); predation (through experimental trials on early life stage predation; refer to table 3 D-1c); and ongoing monitoring of threat indicators and population trends (refer to table 3 D-4). A key outcome from this reporting period is: • Substrate change in spawning locations has been identified as a leading hypothesis for recruitment failure (refer to table 2 C-3 and D-2b).
D. Clarify and mitigate threats	Have these threats been sufficiently mitigated?	partially met, underway	Threats have not been sufficiently mitigated; however, multiple initiatives are underway to mitigate threats to Upper Columbia River White Sturgeon NSP, including: • restoration efforts to address anthropogenic threats causing recruitment failure (refer to table 3 C-4)

Strategy	Performance measure	Status	Details
			• nutrient addition programs and projects to restore passage for salmon and other native species, which may mitigate the threat of reduced or altered food supply (refer to table 3 D-3h) • adaptive management of the conservation aquaculture program to mitigate the threat of hatchery and aquaculture effects (refer to table 3 D-3g)
E. Address information gaps that inhibit conservation of White Sturgeon	Have key information gaps been filled?	partially met, underway	Work has been conducted to address basic biological gaps for Upper Columbia River White Sturgeon, including: population monitoring to address demographic gaps (for example, population abundance and structure; refer to table 3 A-2); gastric lavage to clarify juvenile diets (refer to table 3 D-2a); and spawn monitoring to address life history and ecology gaps (for example, spawn periodicity; refer table 3 to B-1).
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	Has general awareness of sturgeon conservation been increased?	met, ongoing	Awareness of Upper Columbia River White Sturgeon NSP and its conservation has increased through: • ongoing outreach and education led by the Upper Columbia White Sturgeon Recovery Initiative and BC Hydro (for example, sturgeon release events, educational resources for schools, and website materials; refer to table 3 F-1 and F-3)
G. Maintain and where necessary restore ecosystem functions relevant to White Sturgeon	Is the ecosystem “healthy” for White Sturgeon?	not met	The ecosystem is not healthy for White Sturgeon, as evidenced by the fact that population targets have not been achieved (refer to strategy A in table 11). There are a variety of threats identified for the Upper Columbia River White Sturgeon NSP, and activities are underway to address these threats (refer to strategy D in table 11).

Table 12. Progress and details of the progress made toward meeting the performance measures outlined in the recovery strategy for the Kootenay River White Sturgeon nationally significant population (NSP).

Strategy	Performance Measure	Status	Details
A. Meet or exceed recovery population targets within specified timeframe	Have targets been achieved?	partially met, underway	Population targets for natural recruitment have not been achieved; wild juvenile recruits are not produced in sufficient numbers to sustain the population (refer to table 4 A-2). Conservation aquaculture and habitat restoration are ongoing (refer to table 4 A-1 and B-4). The population target of 1,000 mature individuals has been met; the wild adult population was estimated at 1,744 in 2017 for the entire Kootenay population (that is, US and Canada; refer to table 4 A-2). The conservation aquaculture program maintains the population and, as of 2019, has released over 286,000 hatchery-origin juveniles into the Kootenai River basin (Kootenai Tribe of Idaho 2021a[48]).
B. Protect critical habitats	Has critical habitat been identified?	partially met, underway	Geographic locations of critical habitats for White Sturgeon were identified in section 8.5 of the recovery strategy (DFO 2014), and a critical habitat order was put in place in 2016. Future research is needed to refine attributes of critical habitat in Canada, especially for early life stages. Ongoing research and monitoring may further refine critical habitat (refer to table 4 A-2 and B-1 and table 8).
C. Restore natural recruitment	Have experimental trials been initiated to restore natural recruitment?	partially met, underway	Multiple activities are being implemented simultaneously in an attempt to restore natural recruitment, including: experimental operations of Libby Dam to support White Sturgeon life processes and to assess flow and temperature management techniques (refer table 4 to C-2); spawning substrate enhancement and resting pool construction and enhancement (refer to table 4 to C-4); and a large scale restoration plan (refer to table 4 B-4),

[48] Work was completed within the reporting period.

Strategy	Performance Measure	Status	Details
C. Restore natural recruitment	Have experimental results shown that natural recruitment can be restored to necessary levels?	not met	Experimental results to restore natural recruitment have not yet shown that natural recruitment can be restored to necessary levels; efforts are ongoing to restore recruitment (see row above).
C. Restore natural recruitment	Has recruitment been restored in dam-affected populations?	not met	The natural recruitment target has not been achieved. Extremely low capture rates of wild-origin juveniles suggest some degree of natural spawning success; however, natural recruitment has yet to be restored to necessary levels (refer to table 4 A-2). Conservation aquaculture and habitat restoration are ongoing (refer to table 4 A-1 and B-4).
D. Clarify and mitigate threats	Have the most serious threats been defined?	met, ongoing	Work has been conducted and is ongoing to clarify and define threats to the Kootenay River White Sturgeon NSP, including: identifying the cause(s) of recruitment failure (refer to table 4 C-3 and D-2b); pollution (through laboratory studies; refer to table 4 D-1b); prey supply (refer to table 2 D-2a); and ongoing monitoring of threat indicators and population trends (refer to table 3 D-4). Some key outcomes from this reporting period are: • alteration of White Sturgeon behaviour resulting in the selection of unsuitable spawning locations was identified as a leading hypothesis for recruitment failure (refer to table 4 C-3 and D-2b) • Selenium was found to have toxic effects on juvenile White Sturgeon and concentrations have been increasing within the range of Kootenay White Sturgeon due to a coal mine in British Columbia (BC; refer to table 4 D-1a)

Strategy	Performance Measure	Status	Details
D. Clarify and mitigate threats	Have these threats been sufficiently mitigated?	partially met, underway	Threats have not been sufficiently mitigated; however, multiple initiatives underway to mitigate threats to Kootenay River White Sturgeon NSP, including: • restoration efforts to address anthropogenic threats causing recruitment failure (refer to table 4 C-4) • nutrient addition programs and restoration projects that target other native species, which may mitigate the threat of reduced or altered food supply (refer to table 4 D-3h) • adaptive management of the conservation aquaculture program to mitigate the threat of hatchery and aquaculture effects (table 4 D-3g)
E. Address information gaps that inhibit conservation of White Sturgeon	Have key information gaps been filled?	partially met, underway	Work has been conducted to address basic biological gaps for Kootenay River White Sturgeon, including: population monitoring to address demographic gaps (for example, population abundance and structure; refer to table 4 A-2); spawn monitoring to address life history and ecology gaps (for example, spawn periodicity; refer to table 4 B-1); and studies to assess genetic diversity (refer to table 4 D-3g). However, significant information gaps for Kootenay River White Sturgeon remain, particularly for the Canadian portion of the range.
F. Increase stakeholder and general public awareness of White Sturgeon and its conservation needs	Has general awareness of sturgeon conservation been increased?	met, ongoing	Awareness of Kootenay River White Sturgeon NSP and its conservation has increased through: • annual outreach and education led by Kootenai Tribe of Idaho and Freshwater Fisheries Society of BC (for example, sturgeon release events, education in schools, media coverage, tours of the conservation aquaculture facilities; refer to table 4 F-1 and F-3)

Strategy	Performance Measure	Status	Details
G. Maintain and where necessary restore ecosystem functions relevant to White Sturgeon	Is the ecosystem “healthy” for White Sturgeon?	not met	The ecosystem is not healthy for White Sturgeon, as evidenced by the fact that population targets have not been achieved (refer to strategy A in table 12). There are a variety of threats identified for the Kootenay River White Sturgeon NSP, and activities are underway to address these threats (refer to strategy D in table 12).

3.3.2 Completion of action plan

The proposed version of the “Action Plan for the White Sturgeon (*Acipenser transmontanus*) in Canada” was published in 2022 (DFO 2022). The action plan outlines the measures that provide the best chance of meeting the recovery goal and population and distribution objectives for the 4 SARA-listed nationally significant populations (NSPs) of White Sturgeon, including measures to be taken to address threats and monitor recovery of the NSPs. A summary of the action plan was published in 2020 (DFO 2020).

3.3.3 Critical habitat identification and protection

Critical habitat for the 4 SARA-listed White Sturgeon NSPs was identified, to the extent possible and using the best available information, in section 8 of the recovery strategy (DFO 2014). Protection of each listed NSP’s critical habitat from destruction was achieved in 2016 through 4 SARA critical habitat orders under subsections 58(4) and (5), which invoked the subsection 58(1) prohibition against the destruction of identified critical habitat (SOR/2016-83 to 86).

The schedule of studies (section 8.8 in the recovery strategy) outlined the research required to identify additional critical habitat and refine the understanding of the functions, features and attributes of existing critical habitat necessary to support survival and recovery of the species and protect the critical habitat from destruction. Since publication of the recovery strategy, progress has been made towards completing the schedule of studies and detailed progress has been reported on in section 3.2 of this progress report.

3.3.4 Recovery feasibility

Based on the best current available information, recovery of the 4 SARA-listed White Sturgeon NSPs is determined to be feasible. No new information has been gathered that would suggest that the 4 SARA-listed White Sturgeon NSPs no longer meet the feasibility criteria laid out in the recovery strategy (DFO 2014).

4. Concluding statement

Progress has been made towards recovery of all 4 SARA-listed White Sturgeon nationally significant populations (NSPs) within the reporting period of this progress report (2014 to 2020). Progress has been achieved through the implementation of activities identified in the recovery strategy (DFO 2014).

Protection of critical habitat for all SARA-listed NSPs occurred through SARA critical habitat orders in 2016. Monitoring programs are underway for each of the SARA-listed White Sturgeon NSPs and data from these programs support management, provide a method to measure success of implemented recovery activities, and inform progress towards meeting the recovery goal and population and distribution objectives. The monitoring programs for the dam-affected NSPs in the Nechako, Columbia and Kootenay rivers have documented the success of the conservation aquaculture programs and allowed for identification of natural recruitment events.

Progress has been made towards clarifying the most serious threats to each of the 4 SARA-listed White Sturgeon NSPs. Monitoring programs have identified emerging and important threats for each population (for example, high predation of hatchery-origin juveniles in the Nechako River NSP and high survival of hatchery release year-classes in the Upper Columbia

River NSP). Mitigation measures are in place to address some threats (for example, the Emergency Boat Kit Program mitigates bycatch mortalities in the range of Nechako and Upper Fraser River NSPs) and mitigation measures to address other threats are being developed. Progress has been made towards completing research on the mechanisms of recruitment failure in the dam-affected NSPs. Many pre-requisite studies for restoring natural recruitment have been completed or are underway, and pilot experimental spawning restorations have been completed for each dam-affected NSP. Planning for larger-scale restoration to support natural recruitment in the Nechako River and Upper Columbia River is underway. In the Kootenay system, the Kootenai Tribe of Idaho has started to implement large-scale restoration to enhance habitat for all life stages of Kootenay River White Sturgeon.

Progress has been made towards increasing stakeholder and general public awareness of White Sturgeon and its conservation needs. Many outreach and education initiatives are underway through basin-level working groups, DFO, Indigenous organizations and other partners working on White Sturgeon recovery. Public outreach initiatives include annual hatchery-origin juvenile release events, education in schools, media coverage, critical habitat information packages, and web and social media presence.

The status of the Upper Fraser River White Sturgeon NSP remains stable. The 3 dam-affected NSPs in Nechako, Columbia, and Kootenay rivers continue to experience natural recruitment failure; however, recruitment into these populations has been maintained through conservation aquaculture.

While there has been measurable progress towards meeting the recovery goal and population and distribution objectives, further work is required to support recovery of the 4 SARA-listed White Sturgeon NSPs. Priority next steps include: continuing research to clarify and mitigate threats to all SARA-listed NSPs with a focus on understanding and mitigating the mechanism(s) of recruitment failure of the 3 dam-affected populations; continued monitoring and research; and, maintaining and restoring ecosystem functions relevant to White Sturgeon.

White Sturgeon recovery has been a collaborative effort, with many participants from both Canada and the United States involved in basin-level working groups. Canadian partners include, but are not limited to: BC Hydro, British Columbia Ministry of Environment and Climate Change Strategy, British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Carrier Sekani Tribal Council, Columbia Power Corporation/Columbia Basin Trust, Columbia River Inter-Tribal Fisheries Commission, Fortis BC, Freshwater Fisheries Society of British Columbia, Ktunaxa Nation Council, Lheidli T'enneh First Nation, Okanagan Nation Alliance, Rio Tinto Alcan, Teck Metals Ltd., Tl'azt'en First Nation, University of British Columbia, academia, industry, stewardship groups and private consultants. American members include: Bonneville Power Administration, Colville Confederated Tribes, Idaho Department of Fish and Game, Kootenai Tribe of Idaho, Montana Fish, Wildlife and Parks, Northwest Power and Conservation Council, Spokane Tribe of Idaho, United States (US) Army Corps of Engineers, US Fish and Wildlife Service, US Geological Survey, Washington Department of Fish and Wildlife, academia, industry, stewardship groups and private consultants.

DFO remains committed to recovering Upper Fraser River, Nechako River, Upper Columbia River, and Kootenay River White Sturgeon NSPs. The work started and completed to date has built a strong foundation for continued research and management of the 4 SARA-listed NSPs of White Sturgeon over the next reporting period. Progress made to date would not have been achieved without the significant contributions of our partners. DFO looks forward to continuing this successful collaboration and welcomes the participation of additional partners.

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