Nechako White Sturgeon Predation and Survival – Compendium of Options 2022

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A Technical Report Prepared by

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With input from and for the

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Executive Summary

White Sturgeon (*Acipenser transmontanus*) in the Nechako River, British Columbia (BC), Canada have experienced ongoing recruitment failure related to alterations to the river. Changes to river characteristics and habitats as a result of impoundment, diversion, and regulation of flow may have altered predator-prey dynamics in the Nechako River. Recent evidence suggests predation of early life stages and juvenile sturgeon is a potential limiting factor in the success of Nechako White Sturgeon recovery actions. This includes predation of juvenile White Sturgeon released as part of a conservation aquaculture program. This compendium provides a framework for prioritization and implementation of potential monitoring programs and mitigations that address predation pathways of eggs, larvae, and juvenile Nechako White Sturgeon in the Nechako River and Upper Fraser River (i.e., Nechako White Sturgeon population range).

Previous literature reviews and risk analyses identified mammalian, avian, and fish predators; and developed risk ratings for each predator species. Sections of this document are organized by risk rating, taxonomy, and priority of actions. Part 1 pertains to High-risk predators (i.e., North American River Otter, Bald Eagle, Osprey, and fish predators). Part 2 addresses Moderate-risk predators (i.e., American mink, Great Blue Heron, and American White Pelican). Part 3 contains complementary actions that are not predator-specific, including broad hatchery and environmental mitigations. Part 4 addresses the need to prioritize actions that pertain to different predator species within each priority ranking.

This compendium divides potential actions into four general objectives, and associated research and management activities:

- A. Confirm Predation and Determine Spatial/Temporal Extent
- B. Monitor Levels of Predation
- C. Reduce Predation
- D. Determine Drivers of Predation Interaction

For each action, it is indicated if successful implementation would benefit wild-origin fish, hatchery-origin fish, or both, as well as the range of sturgeon sizes that would most likely benefit. Tables in this compendium indicate if there is a confirmed link between predation and recruitment, and each action is assigned a priority ranking, a timeline for implementation, and partner groups. This document was prepared based on information available until April of 2022, however, is an adaptive document and therefore it is recommended that the options presented in this compendium be reviewed bi-annually by the NWSRI TWG Predation Sub-Committee (or TWG as a whole) to ensure it incorporates the most up to date scientific information.

Table of Contents

List of Tables

Background and Context

White Sturgeon (*Acipenser transmontanus*) in the Nechako River, British Columbia (BC), Canada have experienced recruitment failure since 1967 (McAdam et al. 2005). In 2000, the recovery planning process was initiated for the Nechako River White Sturgeon population based on the results of age class analyses and apparent lack of recruitment. A formal recovery plan was developed in 2004 and this population was listed as endangered under the *Species at Risk Act* (SARA) in 2006 (Nechako White Sturgeon Recovery Initiative [NWSRI] 2004; Fisheries and Oceans Canada [DFO] 2014).

The ongoing recruitment failure of the Nechako White Sturgeon population is related to alterations to the Nechako River as a result of the impoundment, diversion, and regulation of river flow (McAdam et al. 2005). Mean annual discharge in the "middle river" (i.e., Nautley River confluence to Stuart River confluence) has been estimated to be 46% of pre-impoundment levels since 1980, with highly altered seasonality. These alterations have resulted in changes in the processes of spawning bed material erosion, transport, and deposition (McAdam et al. 2005). Corresponding changes to river characteristics and habitats may have altered fish community composition and abundance, as well as predator-prey dynamics.

Conservation aquaculture was identified as a priority recovery action and pilot aquaculture efforts to release juvenile Nechako White Sturgeon into the Nechako River took place from 2006 to 2009, with an experimental embryo release in 2011. Larger scale releases from the Nechako White Sturgeon Conservation Center (NWSCC), a specially designed aquaculture facility, began in 2015 (Hildebrand et al. 2016). Sturgeon released from the hatchery were at least 16 cm fork length (FL), but depending on the year (i.e., 2015–2019), average FL was 25–42 cm. A shift in rearing and release strategy in recent years has resulted in fewer and larger sturgeon released, averaging 68.5 cm FL in 2020 and 74.6 cm FL in 2021. Annual sampling of juvenile sturgeon in the Nechako River was initiated prior to pilot hatchery operations and has provided a comprehensive monitoring record of wild and hatchery juvenile survival. Monitoring suggests survival rates are lower than anticipated for both wild and hatchery juveniles and sub-adult sized sturgeon (Carrier Sekani Tribal Council [CSTC], 2021). Radio telemetry and River Otter (*Lontra canadensis*) latrine investigations from 2019-2021 have confirmed that otters are predating on large numbers of juvenile and sub-adult sized Nechako White Sturgeon (Babey et al. 2020).

In early 2021, the Nechako White Sturgeon Recovery Initiative's Technical Working Group (NWSRI TWG) formed a Predation/Survival sub-committee to develop a Predation/Survival Plan. This was in response to recent evidence and increasing concerns about predation as a potential limiting factor in the success of Nechako White Sturgeon recovery actions. The sub-committee consists of four NWSRI TWG members and two observers who volunteered to contribute to the group. Through 2021/22, the sub-committee jointly developed two documents: the Predation Risk Review (Breault et al. 2022) summarized below, and this compendium of options regarding White Sturgeon Predation and Survival.

In this compendium, actions are proposed to better understand and mitigate predation of both wild and hatchery-raised Nechako White Sturgeon. Three main points should be acknowledged when deciding which of these actions to undertake:

1. Predation is a natural ecological interaction; however, the dynamics of predator-prey interactions can be altered through many pathways in ways that adversely impact the persistence of some species.
2. Predation that limits recruitment and success of recovery should be prioritized for mitigation.
3. Predator-prey dynamics are complex, and it may be difficult to determine how specific predators may contribute to limiting recruitment. Within the context of this document, actions to mitigate the impacts of specific predators must be revisited as more information is developed.

River Otter predation has been studied specifically for Nechako White Sturgeon and results show River Otters have impacted the survival and recruitment of hatchery-raised juvenile Nechako White Sturgeon (Babey et al. 2020; Babey 2022). Therefore, the actions to mitigate River Otter predation of White Sturgeon are prioritized here. However, this document captures actions to address all potential High-risk and medium-risk predators of wild and hatchery Nechako White Sturgeon, with priority given to predators and actions based on available information. While this compendium focuses on the Nechako River, actions may also be applicable to the Upper Fraser River as both wild and hatchery-origin Nechako White Sturgeon are known to be present there.

Results from Risk Review

A systematic investigation of predation of sturgeon by mammalian and avian species was conducted by Breault et al. (2022) to inform this compendium. The investigation identified North American River Otter, Bald Eagle (*Haliaeetus leucocephalus*), and Osprey (*Pandion haliaetus*) as High-risk predators. American Mink (*Mustela vison*), Great Blue Heron (*Ardea Herodias*), and American White Pelican (*Pelecanus erythrorhynchos*) were classified as Moderate-risk, and Common Loon (*Gavia immer*), Belted Kingfisher (*Megaceryle alcyon*), Common Merganser (*Mergus merganser*), and Red-necked Grebe (*Podiceps grisegena*) were considered Low-risk. Mammalian and avian predators were rated as High-risk if there was physical evidence of Nechako White Sturgeon consumption, or evidence of White Sturgeon consumption elsewhere in North America. Moderate and Low-risk predators were rated based on four criteria: the range of size classes of White Sturgeon likely affected, preferred foraging depth, as well as spatial and temporal overlap (Breault et al. 2022). A previous review classified Northern Pikeminnow (*Ptychocheilus oregonensis*), Prickly Sculpin (*Cottus asper*), Peamouth Chub (*Mylocheilus caurinus*), Largescale Sucker (*Catostomus macrocheilus*), and Burbot (*Lota lota*) as High-risk, adult White Sturgeon, Bull Trout (*Salvelinus confluentus*), Longnose Sucker (*Catostomus catostomus*), Redside Shiner (*Richardsonius balteatus*), Mountain Whitefish (*Prosopium williamsonil*), and Slimy Sculpin (*Cottus cognatus*) as Moderate-risk, and Rainbow Trout (*Oncorhynchus mykiss*) and juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) as Low-risk (EDI 2016). Fish predators were ranked based on current research of food habits, habitat preferences, and average body length of each predator, as well as bycatch data collected during juvenile White Sturgeon assessments in the Nechako River between 2007–09 (NWSRI 2021). Kernel density estimation based on public observations indicated high risk of predation within the Nechako juvenile sturgeon core area, as well as areas surrounding Vanderhoof, Prince George, Quesnel, and Williams Lake. This likely reflects significant observation bias; however, areas with relatively high densities of predator occurrence should be given priority for predation monitoring and mitigation programs.

The review found differential predation risk to hatchery and wild individuals, as sturgeon reared at the NWSCC are released at a size (i.e., >15 cm FL) that surpasses their vulnerability to many fish predators and most mammalian and avian predators. Up to 13 fish species may consume sturgeon eggs and larvae in the Nechako River, but there are no known mammal or bird predators of egg and larval stages. A total of 16 species of fish, mammals, and birds were identified as possible predators (all native species) of juvenile sturgeon from 2–15 cm FL in the Nechako and Upper Fraser Rivers. Based on the predator presence in the Nechako and Upper Fraser River, as well as data available for size of prey in predator diets, overall predation risk appears to be greatest for wild juvenile sturgeon from 2–15 cm FL (Table 1). The presence of wild individuals during both the vulnerable egg/larvae (i.e., 0–2 cm FL) to early juvenile stages (i.e., 2–15 cm FL) makes them susceptible to a much broader collection of predators. However, the vulnerability of hatchery fish may also be increased as the hatchery environment may suppress important anti-predator behaviours and promote development of maladaptive behaviours that make fish more vulnerable to mammalian and avian predators.

Table 1. Confirmed or potential predators of Nechako White Sturgeon by size (cm), age (years), and origin (wild [W] or hatchery [H]), based on published sizes of fish captured by predators. High and Moderate-risk predators in bold. Modified from Breault et al. 2022.

White Sturgeon Fork Length (cm)	Origin of Affected WS	Fish Predators (EDI 2016)	Avian and Mammalian Predators
Egg–Larvae (0–2)	W	**Northern Pikeminnow, Prickly Sculpin, Peamouth Chub, Largescale Sucker, Burbot**, White Sturgeon, Bull Trout, Longnose Sucker, Redside Shiner, Mountain Whitefish, Slimy Sculpin, Rainbow Trout, Chinook Salmon (juvenile)	Unknown
2–15	W	**Northern Pikeminnow, Prickly Sculpin, Burbot**, White Sturgeon, Bull Trout, Redside Shiner, Rainbow Trout	**American Mink, Great Blue Heron**, Belted Kingfisher, Common Merganser, Common Loon, **American White Pelican**, Red-necked Grebe, **Osprey, Bald Eagle**
15–40	W-H	White Sturgeon	**River Otter, American Mink, Great Blue Heron, American White Pelican, Osprey, Bald Eagle**
40–70	W-H	Unknown	**River Otter, Osprey, Bald Eagle**
>70	W-H	Unknown	**River Otter***

*Evidence of River Otter predation on Nechako White Sturgeon 15–70 cm FL; however, predation of smaller and larger sizes is plausible.

Objectives and Scope

This compendium of options provides a description of the potential actions that address predation pathways of eggs, larval, and juvenile Nechako White Sturgeon in the Nechako River and Upper Fraser River. Actions in this document are meant to specifically address predation mortality that would limit early life stage and juvenile survival. There is some overlap in the objectives and scope of this doucment with a Habitat Restoration Plan aimed at improving survival of early life stages <2 cm FL (i.e., eggs, larvae) (McAdam et al 2022).

Actions recommended in this compendium should be preceded by field surveys to evaluate baseline mortality rates of both hatchery-reared and wild juvenile Nechako White Sturgeon. Empirical data from targeted monitoring are crucial for outlining effective single-species predator mitigation plans with any certainty. Actions consider the conservation status of predator species, broad ecosystem implications of mitigations, the feasibility of maintaining measures long-term, monitoring plans to evaluate efficacy, and adaptive management strategies. Mitigation and monitoring actions are designed to reduce predation of hatchery-reared sturgeon, wild sturgeon, or both.

Knowledge of predation and recruitment varies among the different size classes of juvenile Nechako White Sturgeon. Due to the low catchability of sturgeon below 30 cm FL using current capture methods, our current understanding of survival and recruitment below this size is limited. Therefore, it is difficult to characterize limitations on survival of these smaller sturgeon due to predation. Survival and recruitment of Nechako White Sturgeon above 30 cm FL is better understood, although there has been an apparent decline of these juveniles since 2017 seen in conjunction with a shift to releases of fewer, larger (i.e. >70 cm FL) hatchery sturgeon (Babey 2022). Because of this, the links between predation and the recruitment of sturgeon greater than 30 cm FL may be better understood. For example, there is evidence that River Otter predation is limiting recruitment of hatchery-released juvenile sturgeon 15–70 cm FL (mean = 31.5 cm) (Babey et al. 2020; Babey 2022). However, predation and links to recruitment have not been studied among other mammalian and avian predators of juvenile sturgeon >2 cm FL. The habitat restoration plan includes improvements to larval rearing habitat for White Sturgeon on the Nechako River to enable rapid interstitial hiding and increase survival of early life stages (McAdam 2011). Restoration of larval rearing habitat may increase recruitment of sturgeon >2 cm FL and allow monitoring of predation and survival among these understudied size classes.

How to Read Action Tables

Tables in Part 1 pertain to species that were identified in the risk review as High-risk (i.e., confirmed predators of White Sturgeon in the Nechako River or elsewhere in North America). These tables are divided by general taxonomic group, with Table 2 pertaining to River Otter, Table 3 to avian predators (i.e., Bald Eagle and Osprey), and Table 4 to fish predators. Part 2 addresses species identified as Moderate-risk predators during the risk review, and includes species that were unconfirmed, but likely, predators of Nechako White Sturgeon. Table 5 deals with American Mink, and Table 6 covers avian predators (i.e., Great Blue Heron and American White Pelican). In Part 3, Table 7 contains complementary actions to reduce predation risk across a range of species. These actions are not predator-specific and include broad scale hatchery and environmental mitigations. In Part 4, Tables 8–10 address the need to prioritize actions that pertain to different predator species within each priority ranking.

Objectives, Outcomes, and Actions

This compendium divides actions into four general objectives and their associated research and management activities. Objectives are defined here as overarching monitoring and mitigation goals that relate to addressing predators of the Nechako White Sturgeon population. It should be acknowledged that objectives do not necessarily need to be addressed sequentially, and that a single action may address multiple objectives. The identified objectives and types of actions related to each are as follows:

A. **Confirm Predation and Determine Spatial/Temporal Extent**
   ○ For example: Identify Nechako White Sturgeon in the diet of unconfirmed predators, expand empirical knowledge of species-specific predation risk, and/or document foraging behavior and dietary composition of confirmed and unconfirmed predators.
B. **Monitor Levels of Predation**
   ○ For example: Document predator-specific mortality rates and other effects of predation (e.g. behavioral changes, physiological stress responses, and demographic changes) n Nechako White Sturgeon, measure temporal and spatial variation in predator foraging behavior and predation rates (would link with objective A), and/or monitor and evaluate effectiveness of implemented actions.
C. **Reduce Predation**
   ○ For example: Relocate or remove predators from High-risk areas (e.g., juvenile core area), manage or alter habitat conditions including in-river and denning/nesting sites, manage populations of alternate prey species, and/or adjust proposed actions via an adaptive management approach.
D. **Determine Drivers of Predation Interaction**
   ○ For example: Improve knowledge of population size and habitat of predators, investigate importance of sturgeon in the diet of predators, and/or understand the influence of environmental conditions and predator population dynamics on species-specific predation risk.

The 'outcome' column in Tables 2–7 describes more specifically what the desired result of addressing a particular objective is. The 'action' column provides the most detailed information on the actions to be undertaken to achieve a particular outcome.

Priority

Each action is assigned a priority ranking, which reflects the degree to which the action contributes directly or indirectly to the recovery of Nechako White Sturgeon. Priority rankings also reflect information gaps and consequently, the level of certainty that an action will be effective. If an action is included in a table, it is assumed to have a high likelihood to meet a stated objective/strategy.

● *High priority* actions have a high likelihood of being effective and should have an immediate or high influence on recovery. High priority actions also include critical monitoring and research actions which can be implemented immediately.
● *Medium priority* actions are important to consider long-term but are likely to have a less immediate influence on recovery. Further, medium priority actions contain considerable uncertainty related to ecological impacts (e.g., predator removal, predator den/nest destruction) and require monitoring and research activities (e.g., High priority) prior to implementation.
● *Low priority* actions are considered important contributions to the knowledge base about the threat of predation to Nechako White Sturgeon recovery. These actions include mitigations considered to have an indirect influence on recovery and require further research to fill large information gaps.

Sturgeon Origin and Size Class

For each action, it is indicated if achieving the outcome of that action would benefit wild-origin fish ("W"), hatchery-origin fish ("H"), or both. Each action is given a range of sturgeon sizes that would most benefit if the outcome of that action was achieved. In the River Otter table (Table 2), sizes range includes all sturgeon larger than the smallest hatchery sturgeon released (15 cm FL). In Tables 3–6, size ranges are based on the size of fish those predators are documented to consume, as indicated in the risk review (Breault et al. 2022). Size ranges in Table 7 combine confirmed and documented in the literature.

Link to Recruitment

Among native species, predation is a natural ecological interaction, and it is important to acknowledge that not all predation limits the recruitment of wild and hatchery Nechako White Sturgeon. Therefore, implementing actions to address predators that are not likely to influence recruitment beyond normal levels would be unproductive. Instead, decisions regarding which actions to implement should reflect the link between predation and recruitment of Nechako White Sturgeon. This includes predation that limits the success of the Nechako White Sturgeon conservation aquaculture program. Therefore, for each action, it is indicated if the predator it addresses has a confirmed link to limiting recruitment (Given a "Y" for "Yes"), a potential link to limiting recruitment (given an "M" for "Maybe"), or an unlikely link to limiting recruitment (given an "N" for "No").

River Otter is the only predator that has been studied in relation to Nechako White Sturgeon. Data suggest otters impact recruitment success of hatchery sturgeon; therefore, otters are the only predator given a "Y" for link to recruitment. Predators given an "M" are those that were identified as High-risk in the risk review, and predators given an "N" are those that were identified as Medium-risk predators and for which no predation data on the Nechako River exists. Table 7 includes actions addressing multiple predators;

therefore, the value for link to recruitment limitation is based on the most limiting predator (e.g., if one of the predators addressed is River Otter, then link to recruitment is "Y").

Timeline

Each action is assigned a timeline indicating an approximate timing window during which the action should be initiated.

- Ongoing actions are currently initiated or underway.
- Immediate actions are urgently needed and should be implemented as soon as possible.
- Short-term actions should be initiated within the next 5 years (2023–2027).
- Medium-term actions should be initiated within 6–10 years (2028–2033)
- Long-term actions should be initiated >10 years from now (2034+)

Timelines of Short-, Medium-, and Long-term actions are subject to change as information is developed from Ongoing and Immediate actions.

Considerations

The actions described and prioritized in this document are meant to provide guidance towards their planning and implementation. Several considerations should be acknowledged when choosing, planning, and implementing an action. These action tables do not consider the feasibility of the action, including costs, logistical constraints, resource requirements, or policy implications. Therefore, each action will require further discussion and review prior to implementation. Furthermore, these action tables do not consider the order in which actions should be implemented. In some cases, one action will need to be completed prior to implementing others and in other cases, actions can be implemented simultaneously. Additionally, in most cases proposed wildlife control actions such as removal of individuals or a population, may follow a stepwise progression with preference for non-lethal measures such as translocation over legal harvest or lethal control measures (Province of BC 2006).

Results from the NWSRI juvenile monitoring program suggest the numbers of both wild and hatchery juvenile White Sturgeon present in the Nechako River are low. In addition, a recent change in release strategy starting in 2020 has resulted in low numbers of larger hatchery sturgeon released into the Nechako River. This leads to two considerations when planning for implementation. First, studies of predation of juvenile sturgeon are limited by the low number of sturgeon available to predators. Second, if alternative prey is suitably abundant and available to predators, then the relatively few sturgeon in the Nechako River may experience low risk of predation.

Predation is natural and as such is expected to occur in the Nechako River and Upper Fraser River from early life stages throughout the juvenile size categories. The scope of present and past predation monitoring in the Nechako River has been limited to river otters and studies demonstrated high predation rates of hatchery juveniles 15–70 cm FL (Babey et al. 2020). Sturgeon monitoring in the Nechako River is limited to annual set line sampling methods that reliably catch sturgeon >30 cm FL (NWSRI 2021). Therefore, it will be challenging to infer the impacts of mitigation actions on predation and recruitment of sturgeon <30 cm FL given the uncertainty around survival bottlenecks from egg/larval life stages through juvenile stages.

Policy review

This section is not comprehensive of all provincial and federal ministry policies and procedures that may apply to the implementation of the mitigation and management actions outlined in this compendium. This section is intended to acknowledge that proposed actions may follow principles guided by existing policies for the management and protection of ecosystems, habitat, wildlife, water, and fisheries (Province of BC 2021). This section should be expanded upon and revised as an action plan develops and actions are implemented, and as ministry policies and procedures continue to be updated.

Actions that may impact endangered or threatened species and their residences and critical habitats are regulated federally under the *Species at Risk Act* (Government of Canada 2002), provincially under the Provincial *Wildlife Act* (Government of British Columbia 1996), and/or the *Forest and Range Practices Act* (Government of British Columbia 2002). Habitat restoration actions that involve in-stream modifications and require activities within a stream channel are regulated federally under the *Fisheries Act* (Government of Canada 2019) and provincially under the *Water Sustainability Act* (Government of British Columbia 2014). Alterations to riparian habitat may also be regulated by the *Water Sustainability Act* and/or the *Forest and Range Practices Act* (Government of British Columbia 2002) and may be required to follow Provincial Environmental Mitigation Procedures (BC Ministry of Environment 2014). Actions that take place within a critical wildlife area or include removing/altering wildlife dens or bird nests are regulated federally under the *Migratory Birds Convention Act* (Government of Canada 1994) and provincially under the *Wildlife Act* (Government of British Columbia 1996). Actions including translocation or removal of wildlife may be guided by the policies for *Translocations of Wildlife and Non-Native Species* (Province of BC 2015), as well as *Control of Species* (Province of BC 2006). Other policies and procedures may apply and should be consulted as an action plan is developed and actions are implemented.

Several important considerations relevant to the actions described in this compendium arose after an initial policy discussion with a FLNRORD Wildlife Management Specialist. In general, managers considering actions that involve the removal of a species or their habitat need to: 1. Lay down groundwork with a feasible removal plan, 2. Be confident the removal will work, and 3. Develop a strong monitoring plan to measure the success of the removal. Predator removal is typically a last priority; however, if it is deemed the best management option, the removal of furbearer predators should first be done in collaboration with local trappers where possible. Relevant to some actions outlined in this compendium, protections under the *Wildlife Act* include: 1. Beaver and Muskrat dens, 2. Bald Eagle, Osprey, and Great Blue Heron nests during all times of year, and 3. Nests of other birds when occupied. These all need to be considered when identifying which actions to pursue.

A Management Implication Review of this document by Ministry of Forests Omineca managers in 2022 resulted in the adoption of the term 'compendium of options' in the title and body of this report, and the recommendation that the NWSRI TWG further prioritize options presented here into a future Action Plan.

Part 1. Confirmed priority predators – direct interactions

Table 2. River Otter - (rows are ranked by objectives alphabetically).

#	Objectives	Outcome	Action for River Otters	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
1.1	A, B	Expand knowledge of spatial and temporal extent of otter predation.	Latrine site identification surveys and subsequent sampling for PIT tags in previously unsurveyed areas, including the identification and sampling of latrine sites in Fraser Lake.	H, W	>15	Y	M–H	Ongoing/Short-term	
1.2	B	Understand movement and mortality of radio tagged hatchery sturgeon.	Fine-scale (i.e. boat and foot) radio telemetry surveys to identify status of radio-tagged hatchery juvenile sturgeon. ● Use helicopter-based telemetry results to identify potential tags that are lacking observable movement (LOM) and confirm their status with boat surveys. ● Identify if LOM tags are likely to be a result of otter predation. ● Monitor status of radio tagged fish in Fraser Lake and identify tags on shore.	H	>15	Y	H	Ongoing/Short-term	
1.3	B	Identify trends in otter predation on sturgeon.	Monitor level of predation via continued monitoring of known latrine sites (i.e., collect PIT tags from latrines). ● Analyze predation rates over time to determine potential impact of mitigation actions on otter predation of sturgeon.	H, W	>15	Y	M–H	Ongoing/Short-term	
1.4	C	Remove/relocate otters from high-	River Otter removal program plan that involves collaboration with wildlife professionals.	H, W	>15	Y	M	Short-term	

#	Objectives	Outcome	Action for River Otters	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
		risk areas (e.g., core area).	• Identify feasibility and most effective methods of removal (preferred) or relocation (with a plan to deter returning). • Understand potential effects of predator removal to the ecological community. • Develop post-removal monitoring plan to assess program success (e.g., effect size, reduction in PIT in latrines) including monitoring for re-populations of otters.						
1.5	C	Reduce habitat use of otters in high-risk areas (e.g., core area).	Deter River Otters from high-risk areas (e.g., core area) by targeting denning sites. • Identify River Otter denning sites, including the dens of beavers and muskrat which may be used by otters. • Consider ecological effects of removing muskrats, beavers, and their active and/or inactive dens. • If deemed beneficial, implement a muskrat and beaver removal program, and subsequently destroy dens to prevent further use by otters. • Develop post-removal monitoring plan to assess program success including monitoring for re-population.	H, W	>15	Y	L–M	Long-term	
1.6	C	Increase in-river escape cover.	Survey escape cover currently available to juvenile sturgeon in the Nechako River and determine areas where increased cover may be beneficial. • Investigate otter use of foraging sites that coincide with juvenile sturgeon habitat (see 1-9).	H, W	>15	Y	M	Short-term	

#	Objectives	Outcome	Action for River Otters	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
			• Increase cover in these areas by deploying anchored brush piles and woody debris.						
1.7	C	Exclude River Otters from high-risk areas (e.g., core area).	Determine practicality and feasibility of electric fence construction to deter otters from certain areas of river.	H, W	>15	Y	L	Long-term	
1.8	C	Increase availability of alternative River Otter food sources.	Identify preferred (non-sturgeon) fish prey species of otters in the Nechako River and work towards determining the possibility and ecological feasibility of increasing the populations of these species.	H, W	>15	Y	L	Long-term	
1.9	D	Improve knowledge of otter ecology in the Nechako River.	River Otter-specific research to study otter population and habitat ecology. • Estimate population size in high-risk areas. • Determine fine and broad-scale movements and habitat use, and how they coincide with juvenile sturgeon movement and habitat use. • Investigate diet preferences and how they may change with changes in availability of sturgeon.	H, W	>15	Y	H	Immediate	
1.10	D	Understand role of flow and turbidity in otter predation.	Research how flow and turbidity influences otter predation (e.g., is predation higher during periods of low flow?).	H, W	>15	Y	H	Short-term	

Table 3. High-risk avian predators.

#	Objectives	Outcome	Action for High-risk Avian Predators	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
2.1	A	Determine extent of Bald Eagle predation on sturgeon.	Research to confirm presence of juvenile sturgeon in Bald Eagle diet. ● Identify sturgeon remains at Bald Eagle nest sites (e.g., using remote camera monitoring, aerial drones, and/or work platform sampling). ● Determine size of sturgeon captured. ● Identify proportional contribution of sturgeon to Bald Eagle diet. ● Determine Bald Eagle dietary niche (i.e., stable isotope analysis of Bald Eagle and prey tissues). ● Conduct DNA metabarcoding of Bald Eagle stomach contents or feces.	H, W	12–69	M	H	Immediate	
2.2	A	Determine extent of Osprey predation on sturgeon.	Research to confirm presence of juvenile sturgeon in Osprey diet. ● Identify sturgeon remains at Osprey nest sites. ● Determine size of sturgeon captured. ● Identify proportional contribution of sturgeon to Osprey diet. ● Determine Osprey dietary niche (i.e., stable isotope analysis of Osprey and prey tissues). ● Conduct DNA metabarcoding of Osprey stomach contents or feces.	H, W	10–51	M	H	Immediate	
2.3	B	Monitor levels of Bald Eagle	Measure Bald Eagle predation rates in high-risk areas (e.g., core area).	H, W	12–69	M	M	Short-term	

#	Objectives	Outcome	Action for High-risk Avian Predators	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
		predation on sturgeon.	● Document foraging sites (locations where prey were captured). ● Estimate predation success rates. ● PIT tag surveys.						
2.4	B	Monitor levels of Osprey predation on sturgeon.	Measure Osprey predation rates in high-risk areas (e.g., core area). ● Document foraging sites (locations where prey were captured). ● Estimate predation success rates. ● PIT tag surveys.	H, W	10–51	M	M	Short-term	
2.5	B	Determine influence of Bald Eagle predation on sturgeon population dynamics.	Estimate mortality rates of sturgeon due to Bald Eagle predation. ● Set up control areas with predator excluders. ● Estimate juvenile sturgeon survival and mortality rates at foraging sites compared to control areas.	H, W	12–69	M	M	Medium-term	
2.6	B	Determine influence of Osprey predation on sturgeon population dynamics.	Estimate mortality rates of sturgeon due to Osprey predation. ● Set up control areas with predator excluders. ● Estimate juvenile sturgeon survival and mortality rates at foraging sites compared to control areas.	H, W	10–51	M	M	Medium-term	
2.7	C	Reduce Bald Eagle predation on sturgeon.	Reduce number of Bald Eagle nesting locations in high-risk areas (e.g., core area). ● Determine locations of Bald Eagle nests.	H, W	12–69	M	L	Long-term	

#	Objectives	Outcome	Action for High-risk Avian Predators	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
			• Where practicable, remove largest trees within 16 km of overwintering pools. • Turn nest trees into wildlife trees.						
2.8	C	Reduce Osprey predation on sturgeon.	Reduce number of Osprey nesting locations in high-risk areas (e.g., core area). • Determine locations of Osprey nests. • Where practicable, remove artificial nest sites within 10 km of high-risk areas.	H, W	10–51	M	L	Long-term	
2.9	C	Reduce Bald Eagle predation on sturgeon.	Exclude Bald Eagles from foraging in high-risk areas (e.g., core area). • Monitor Bald Eagle foraging sites and determine branches/trees used as foraging perches. • Remove branches used as foraging perches adjacent to overwintering pools. • Install bird excluders (e.g., wire spike strips) on foraging perches. • Install heavy nets over foraging sites to prevent diving.	H, W	12–69	M	L	Long-term	
2.10	C	Reduce Osprey predation on sturgeon.	Exclude Osprey from foraging in high-risk areas (e.g., core area). • Monitor foraging sites and determine branches/trees used as foraging perches. • Remove branches used as foraging perches adjacent to overwintering pools. • Install bird excluders (e.g., wire spike strips) on foraging perches. • Install heavy nets over foraging sites to prevent diving.	H, W	10–51	M	L	Long-term	

#	Objectives	Outcome	Action for High-risk Avian Predators	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
2.11	D	Understand role of flow and turbidity in Bald Eagle predation on sturgeon.	Research how flow and turbidity influence Bald Eagle predation. ● Record abiotic and biotic variables at foraging sites, including turbidity and flow, which may be correlated with hunting success.	H, W	12–69	M	M	Short-term	
2.12	D	Understand role of flow and turbidity in Osprey predation on sturgeon.	Research how flow and turbidity influences Osprey predation. ● Record abiotic and biotic variables at foraging sites, including turbidity and flow, which may be correlated with hunting success.	H, W	10–51	M	M	Short-term	
2.13	D	Understand role of nest productivity in Bald Eagle predation on sturgeon.	Determine locations of Bald Eagle nests in high-risk areas and if Osprey nest productivity effects predation rates. ● Conduct repeated observations to estimate adults returning to the nest with prey, nestling feeding rates, and nest productivity (i.e., number of nestlings fledged).	H, W	10–51	M	M	Short-term	
2.14	D	Understand role of nest productivity in Osprey predation on sturgeon.	Determine locations of Osprey nests in high-risk areas and if Osprey nest productivity effects predation rates. ● Conduct repeated observations to estimate adults returning to the nest with prey, nestling feeding rates, and nest productivity (i.e., number of nestlings fledged).	H, W	10–51	M	M	Short-term	

Table 4. Fish (High-risk).

#	Objectives	Outcome	Actions for High-Risk Fish Predators	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority L / M/ H	Timeline	Partners
3.1	A	Confirm which Nechako River fish species are predators of egg, larval, and young juvenile white sturgeon.	Capture suspected fish predators at times and in locations where vulnerable life stages of sturgeon are most at-risk (ex. post-spawning period near spawning ground). Conduct stomach content analysis to confirm evidence of sturgeon in diets (see EDI 2016 for methods).	W	egg - 20	M	H	Short-term	
3.2	A, B	Quantify extent of predation by high-risk fish predators.	Determine if fish predation is a significant driver of recruitment failure by developing a sampling plan that allows for quantitative research of fish predation on egg, larval, and juvenile white sturgeon.	W	egg - 20	M	H	Short-term	
3.3	A, D	Determine abundance of high-risk fish predators.	Conduct stock assessments on confirmed high-risk fish predators to understand abundance and how this may influence predation rates by these species.	W	egg - 20	M	M	Medium-term	
3.4	C	Control size of high-risk fish populations.	Determine if fish predator removal is a feasible option to decrease fish predation of eggs, larvae, and young juveniles. ● Identifying potential removal options. ● Perform a risk-cost-benefit analysis to determine if any removal options are economically and ecologically feasible. ● Implement an annual predator removal program if necessary, and continued monitoring to determine success of the program.	W	egg - 20	M	L	Long-term	

#	Objectives	Outcome	Actions for High-Risk Fish Predators	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority L / M/ H	Timeline	Partners
3.5	D	Determine abiotic drivers of fish predation on White Sturgeon.	Research abiotic factors contributing to fish predation of young white sturgeon, focusing on: ● Temperature ● Flow rates ● Turbidity ● Rearing habitat conditions and availability	W	egg - 20	M	M - H	Short-term	

Part 2. Unconfirmed predation – direct interactions

Table 5. Mink.

#	Objectives	Outcomes	Actions for Mink	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
4.1	A	Determine extent of mink predation on sturgeon.	Research to confirm presence of juvenile sturgeon in mink diet. ● Identify sturgeon remains in mink scat. ● Identify importance of sturgeon to mink diet. ● Determine mink dietary niche (i.e., stable isotope analysis of mink and prey tissues). ● Conduct DNA metabarcoding of mink stomach contents or feces.	H, W	1–30	N	H	Short-term	
4.2	B	Monitor levels of mink predation on sturgeon.	Measure mink predation rates in high-risk areas (e.g., core area). ● Document foraging sites and mink foraging success rates.	H, W	1–30	N	M	Medium-term	
4.3	B	Determine influence of mink predation on sturgeon population dynamics.	Estimate sturgeon mortality due to mink predation.	H, W	1–30	N	M	Medium-term	
4.4	C	Reduce mink habitat use in important juvenile sturgeon locations.	Riparian habitat modifications. ● Selective thinning and brush clearing within 500 m of critical juvenile sturgeon areas. ● Implement muskrat and beaver removal program.	H, W	1–30	N	L	Long-term	

#	Objectives	Outcomes	Actions for Mink	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
			● Remove beaver dams and muskrat dens within 3.0 river-km of important sturgeon habitat.						
4.5	C	Increase in-river escape cover.	Survey escape cover available to juvenile sturgeon in the Nechako River and determine areas where increased cover may be beneficial. Increase cover in these areas by deploying anchored brush piles and woody debris.	H, W	1–30	N	L	Short-term	
4.6	C	Reduce mink predation on sturgeon through flow regulation.	Regulate river flow to increase velocity and reduce water clarity.	H, W	1–30	N	L	Long-term	
4.7	D	Determine drivers of mink predation interaction.	Understand influence of flow regulation, increased flow, and reduced clarity, on mink predation.	H, W	1–30	N	M	Short-term	
4.8	D	Determine drivers of mink predation interaction.	Improve knowledge of mink ecology in the Nechako River, including population size, habitat use, and diet. ● Model habitat selection using monitoring data from remote cameras and/or PIT tags. ● Estimate population size using DNA hair snagging. ● Research trapper harvest records (e.g., population trends over time). ● Determine mink dietary niche (i.e., stable isotope analysis). ● Conduct DNA metabarcoding to study dietary ecology of mink.	H, W	1–30	N	L	Long-term	

#	Objectives	Outcomes	Actions for Mink	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
4.9	D	Determine competitive interactions between River Otter and mink in the Nechako River.	Compare diets of mink between areas with and without River Otter. ● Estimate level of resource competition between the two species. ● Determine if changes in diet (i.e., increased fish consumption) would likely follow removal of River Otter.	H, W	1–30	N	M	Long-term	

Table 6. Great Blue Heron and American White Pelican (unconfirmed avian predators).

#	Objectives	Outcomes	Actions for Moderate-risk Avian Predators	Origin (Hatchery and/or wild)	Sturgeon Size Class (cm)	Link to Recruitment (Y/N)	Priority (L/M/H)	Timeline	Partners
5.1	A	Determine extent of Great Blue Heron and American White Pelican predation on sturgeon.	Research to confirm presence of juvenile sturgeon in heron and pelican diet. ● Identify sturgeon remains at heron rookeries and pelican colonies. ● Identify importance of sturgeon to heron and pelican diet. ● Determine heron and pelican dietary niches (i.e., stable isotope analysis of predator and prey tissues). ● Conduct DNA metabarcoding of heron and pelican stomach contents or feces.	H, W	1–40	N	H	Short-term	
5.2	B	Monitor levels of heron and pelican predation on sturgeon.	Measure heron and pelican predation rates in high-risk areas. ● Document foraging sites and heron and pelican foraging success rates.	H, W	1–40	N	M	Medium-term	
5.3	B	Determine influence of heron and pelican predation on sturgeon population dynamics.	Estimate sturgeon mortality due to heron and pelican predation.	H, W	1–40	N	M	Medium-term	
5.4	B	Monitor effectiveness of bird excluders at reducing pelican predation on sturgeon.	Locate pelican foraging areas and install bird excluders on perches and roosts. ● Document injuries due to excluders. ● Estimate predation rates before and after installation.	H, W	1–40	N	L	Long-term	
5.5	C	Reduce heron predation through flow regulation.	Regulate river flow to increase water depth.	H, W	1–40	N	L	Long-term	

#	Objectives	Outcomes	Actions for Moderate-risk Avian Predators	Origin (Hatchery and/or wild)	Sturgeon Size Class (cm)	Link to Recruitment (Y/N)	Priority (L/M/H)	Timeline	Partners
5.6	D	Determine influence of water depth on heron predation on sturgeon.	Understand influence of flow regulation and water depth on heron predation. ● Study predation rates at different water depths.	H, W	1–40	N	M	Short-term	
5.7	D	Determine influence of number of heron nests and distance to high-risk areas on heron predation on sturgeon.	Improve knowledge of heron rookeries in the Nechako River. ● Estimate population size, rookery locations, habitat use, and diet. ● Survey number of nests in heron rookeries and their distances to high-risk areas (e.g., core area). ● Document heron foraging and determine relationship between number of nests per rookery and distance of rookeries to river and predation rates.	H, W	1–40	N	L	Long-term	

Part 3. Complementary actions to reduce predation (not predator-specific)

Table 7. Complementary Actions.

#	Objectives	Outcomes	Actions	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
6.1	A, B, C	Determine if releasing hatchery sturgeon into Fraser Lake increases survival.	Monitor population of hatchery-released sturgeon in Fraser Lake. ● Release hatchery sturgeon into Fraser Lake. ● Monitor movement and survival by tracking radio and acoustic tagged sturgeon. ● Research if predation is occurring in the lake and to what extent it is occurring. ● Understand the ecological implications of this experimental approach.	H	15 - 70	Y	H	Ongoing	
6.2	B, C	Understand the immediacy of predation after release.	Assess levels of predation occurring shortly after release. ● Conduct high effort predation monitoring soon after releases (ex. latrine site monitoring). ● If this predation is considerable, investigate potential "soft release" strategies (i.e., fish released into river with protection from predators for some time).	H	15 - 70	Y	M - H	Short-term	
6.3	C	Train predators to avoid sturgeon as component of their diet.	Investigate the option to train the predator to no longer select white sturgeon as a food source. ● Taste aversion experiments on otters, Osprey, and Bald Eagles.	H, W	15 - 70	Y	H	Ongoing	

#	Objectives	Outcomes	Actions	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
			• Offer alternative food sources (e.g., burbot, suckers)						
6.4	C	Increase predator recognition and promote the development of appropriate anti-predator responses in hatchery sturgeon.	Assess the validity of alarm cue-based conditioning to improve the post-release predator recognition and survival of hatchery sturgeon. • Conduct experiments to investigate anti-predator responses of hatchery sturgeon to conspecific alarm cues. • Conduct conditioning experiments pairing conspecific alarm cues with novel predator scents. • Through experimentation, identify at what ages/life stage conditioning is most successful. • Apply knowledge from experiments to formulate and implement a pre-release conditioning program.	H	free swimming larvae - 70	Y	M	Ongoing	
6.5	C	Increase release size to decrease predation risk.	Rear sturgeon to a larger size (~1 m) to reduce vulnerability to predation.	H	> 70	Y	M	Short-term	
6.6	C	Alter hatchery practices to decrease anti-predator deficits in hatchery sturgeon.	Investigate potential changes to hatchery practices at the NWSCC that decrease anti-predator deficits. • Conduct a literature review on identified hatchery practices that improve anti-predator behaviour in hatchery fish (Babey 2021). • Work with NWSCC personnel to identify the feasibility and logistics of potential options.	H	free swimming larvae - 70	Y	M	Medium-term	

#	Objectives	Outcomes	Actions	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
			• If changes to hatchery practices are made, develop post-release monitoring plan to assess if changes improve survival.						
6.7	C, D	Decrease predation by visual predators and increase protective rearing habitat.	Research the role of flow, depth, and turbidity on predation success, on a predator specific basis. • Increase flows and depth during times of high predation vulnerability. • Increase the availability of habitat that can be used for predator evasion. • Increase turbidity to limit predation by visual predators.	H, W	egg - 70	Y	H	Short-term	
6.8	D	Understand influence of altered habitat on predator community.	Research how habitat alteration as a result of dam construction has altered the Nechako predator community. • Investigate influences of habitat alterations on predation of sturgeon. • Compare environmental parameters and predator interactions in the Nechako River with other systems within White Sturgeon range (e.g., Kootenay River, Columbia River systems).	H, W	egg - 70	Y	H	Short-term	
6.9	D	Understand indirect effects of inter- and intra-specific competition on predation.	Investigate the role of competition as an indirect driver of predation. • Identify fish species that have overlapping niches with juvenile sturgeon and their relative population sizes. • Identify if competition with these species and conspecifics pushes juvenile sturgeon into habitats with higher predation risk.	H, W	free swimming larvae - 70	Y	M	Short-term	

#	Objectives	Outcomes	Actions	Origin (Hatchery and/or wild)	Sturgeon Size class (cm)	Link to Recruitment (Y/N/M)	Priority (L/M/H)	Timeline	Partners
6.10	D	Understand interactions among predators.	Investigate the intraguild competition among predators. ● Determine potential limiting effects of competition on population size, habitat use, and diet. ● E.g., potential competition between Bald Eagle and Osprey, or between River Otter and mink. ● Compare fish species assemblages between the Nechako core area with core habitats of other sturgeon populations.	H, W	15 – 70	Y	M	Short-term	

Part 4. Overall Prioritized Actions

Tables in this part address the need to prioritize actions that pertain to different predator species with the same priority ranking. For example, the need to prioritize between a high-priority action for River Otters and a high-priority action for Bald Eagles. Three summary tables were created to group actions into High-Priority (Table 8), Medium-Priority (Table 9), and Low-Priority (Table 10). Therefore, priority decreases with each subsequent table. Within each table, priority depends on the link to recruitment (i.e., Y, M, N) and the risk ranking of the predator (i.e., H, M). The link between predation and recruitment is the most important factor; therefore, actions linked to recruitment-limiting predators take highest priority (i.e., priority of actions decreases with subsequent rows). The risk ranking of the predator then takes next priority (i.e., priority decreases with subsequent columns). Therefore, actions in the top left cell have the highest within-table priority, while actions in the bottom right cell have the lowest. Actions with a range of priority rankings appear in the table corresponding with the highest priority ranking (e.g., actions with M–H priority in the action tables appear in Table 8: High-Priority). Within-cells, actions are listed based on their timeline in the following order: ongoing (O), immediate (I), short-term (S), medium-term (M), then long-term (L). Similar to priority rankings, the timeline in the table corresponds with the most immediate time frame (e.g., actions that are Ongoing/Short-term are listed as Ongoing) for clarity. The purpose of these tables is to indicate the actions that should be given the highest consideration to support Nechako White Sturgeon recovery; however, it should be acknowledged that these tables do not address the feasibility of actions. For example, a high priority action that addresses a High-risk, recruitment-limiting predator may not be feasible to implement. Feasibility of action implementation was out-of-scope for the development of this document, this to not limit the exploration of options and actions presented herein. Therefore, each action within this compendium should be individually assessed for feasibility prior to actioning.

Table 8. Table Summarizing Prioritization of High-Priority Actions.

	Actions Addressing > 1 High-Risk Predators	Actions Addressing 1 High-Risk Predator	Actions Addressing > 1 Medium-Risk Predators	Actions Addressing 1 Medium-Risk Predator
Action Linked to Recruitment-Limiting Predator	6.3(O) 6.1(O) 6.2(S) 6.7(S) 6.8(S)	1.1(O) 1.2(O) 1.3(O) 1.9(I) 1.10(S)		
Action Linked to Potential Recruitment-Limiting Predator		2.1(I) 2.2(I) 3.1(S) 3.2(S) 3.5(S)		
Action Linked to Non-Recruitment-Limiting Predator				4.1(S) 5.1(S)

Table 9. Table Summarizing Prioritization of Medium-Priority Actions.

	Actions Addressing > 1 High-Risk Predators	Actions Addressing 1 High-Risk Predator	Actions Addressing > 1 Medium-Risk Predators	Actions Addressing 1 Medium-Risk Predator
Action Linked to Recruitment-Limiting Predator	6.4(O) 6.5(S) 6.9(S) 6.10(S) 6.6(M)	1.4(S) 1.6(S) 1.5(L)		
Action Linked to Potential Recruitment-Limiting Predator		2.3(S) 2.4(S) 2.11(S) 2.12(S) 2.13(S) 2.14(S) 2.5(M) 2.6(M) 3.3(M)		
Action Linked to Non-Recruitment-Limiting Predator				4.7(S) 5.6(S) 4.2(M) 4.3(M) 5.2(M) 5.3(M) 4.9(L)

Table 10. Table Summarizing Prioritization of Low-Priority Actions.

	Actions Addressing > 1 High-Risk Predators	Actions Addressing 1 High-Risk Predator	Actions Addressing > 1 Medium-Risk Predators	Actions Addressing 1 Medium-Risk Predator
Action Linked to Recruitment-Limiting Predator				
Action Linked to Potential Recruitment-Limiting Predator		1.7(L) 1.8(L) 2.7(L) 2.8(L) 2.9(L) 2.10(L) 3.4(L)		
Action Linked to Non-Recruitment-Limiting Predator				4.5(S) 4.4(L) 4.6(L) 4.8(L) 5.4(L) 5.5(L) 5.7(L)

References

Babey, C. N., Gantner, N., Williamson, C. J., Spendlow, I. E., and Shrimpton, J. M. 2020. Evidence of predation of juvenile white sturgeon (*Acipenser transmontanus*) by North American river otter (*Lontra canadensis*) in the Nechako River, British Columbia, Canada. J. Appl. Ichthyol, 36: 780-784. doi: 10.1111/jai.14114.

Babey, C. N. 2021. Anti-Predator Behavior Deficits in Hatchery Fish. Unpublished.

Babey, C. N. 2022. Fate of hatchery-reared juvenile Nechako white sturgeon (*Acipenser transmontanus*): assessment of predation by river otters (*Lontra canadensis*) (Master's Thesis). University of Northern British Columbia. https://doi.org/10.24124/2022/59276.

BC Ministry of Environment. 2014. Procedures for Mitigating Impacts on Environmental Values. Available from https://www2.gov.bc.ca/assets/gov/environment/natural-resource-policy-legislation/environmental-mitigation-policy/em_procedures_may27_2014.pdf [accessed 12 March 2018].

Breault, D. N., Babey, C. N., Gantner, N. 2021. Nechako River White Sturgeon (*Acipenser transmontanus*) Predation Risk Review. The Juvenile Survival and Predation Subcommittee, NWSRI Technical Working Group. Unpublished.

Carrier Sekani Tribal Council. 2021. 2020 Nechako/Upper-Mid Fraser Watershed Juvenile White Sturgeon Monitoring Summary Report. Draft report.

DFO. 2014. Recovery Strategy for White Sturgeon (*Acipenser transmontanus*) in Canada [Final]. Fisheries and Oceans Canada, Ottawa. Available from https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/rs_esturgeon_blc_wh_sturgeon_0314a_e.pdf [accessed 17 July 2021].

EDI. 2016. Literature Review on Juvenile Nechako White Sturgeon Predation. Environmental Dynamics Inc., Prince George, BC V2L 1R4.

Government of British Columbia. 1996. *Wildlife Act*. In R.S.B.C. 1996, c. 488. Available from http://www.bclaws.ca/civix/document/id/complete/statreg/96488_01 [accessed 27 March 2019].

Government of Canada. 1994. *Migratory Birds Convention Act*, 1994. In S.C. 1994, c. 22. Available from https://laws-lois.justice.gc.ca/eng/acts/m-7.01/ [accessed 14 March 2018].

Government of British Columbia. 2002. *Forest and Range Practices Act*. In SBC 2002, c. 69. Available from https://www.bclaws.ca/civix/document/id/complete/statreg/02069_01 [accessed 11 February 2020].

Government of British Columbia. 2014. *Water Sustainability Act*. In SBC 2014 c. 15. Available from http://www.bclaws.ca/civix/document/id/complete/statreg/14015 [accessed 13 May 2019].

Government of Canada. 2019. *Fisheries Act*. In R.S.C., 1985, c. F-14. Available from https://laws-lois.justice.gc.ca/eng/acts/f-14/FullText.html.

Government of Canada. 2002. *Species at Risk Act*. In S.C. 2002, c. 29. Available from https://laws.justice.gc.ca/eng/acts/S-15.3/ [accessed 16 November 2020].

Hildebrand, L.R., Drauch Schreier, A., Lepla, K., McAdam, S.O., McLellan, J., Parsley, M.J., Paragamian, V.L., and Young, S.P. 2016. Status of White Sturgeon (*Acipenser transmontanus*, Richardson, 1863) throughout the species range, threats to survival, and prognosis for the future. J. Appl. Ichthyol. 32: 261–312. doi:10.1111/jai.13243.

McAdam, S.O., Walters, C.J., and Nistor, C. 2005. Linkages between White Sturgeon Recruitment and Altered Bed Substrates in the Nechako River, Canada. Trans. Am. Fish. Soc. 134(6): 1448–1456. doi:10.1577/T04-199.1.

Province of BC. 2006. 04.07.01.03 - *Control of Species*. Ministry of Environment, Victoria, British Columbia.

Province of BC. 2015. 04.07.13.02 - *Translocations of Wildlife and Non-Native Species* (2001). Ministry of Forests, Lands, Natural Resource Operations and Rural Development. Available from https://www2.gov.bc.ca/assets/gov/environment/natural-resource-policy-legislation/fish-and-wildlife-policy/4-7-1302_-_translocations_of_wildlife_and_non-native_species.pdf [accessed 13 March 2022].

Province of BC. 2021. Wildlife Policy. Province of British Columbia. Available from https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/laws-policies-standards-guidance/environmental-guidance-and-policy/wildlife-policy [accessed 13 March 2022].

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