Species at Risk Act
Action Plan Series

Action Plan for the Paxton Lake and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada

Paxton Lake and Vananda Creek Stickleback Species Pairs

2020

Canada

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For copies of the action plan, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, recovery strategies, and other related recovery documents, please visit the Species at Risk Public Registry.

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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 effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of action plans for species listed as Extirpated, Endangered, and Threatened for which recovery has been deemed feasible. They are also required to report on progress five years after the publication of the final document on the Species at Risk Public Registry.

The Minister of Fisheries and Oceans is the competent minister under SARA for the Paxton Lake and Vananda Creek Stickleback Species Pairs and has prepared this action plan to implement the Amended Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada (DFO 2019), as per section 47 of SARA. In preparing the action plan, the competent minister has considered, as per section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. To the extent possible, it has been prepared in cooperation with the Province of British Columbia as per section 48(1) of SARA.

As stated in the preamble to SARA, success in the recovery of these species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions and actions set out in this action plan and will not be achieved by Fisheries and Oceans Canada, or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this action plan for the benefit of the Paxton Lake and Vananda Creek Stickleback Species Pairs and Canadian society as a whole.

Under SARA, an action plan provides the detailed recovery planning that supports the strategic direction set out in the recovery strategy for the species. The plan outlines recovery measures to be taken by Fisheries and Oceans Canada and other jurisdictions and/or organizations to help achieve the population and distribution objectives identified in the recovery strategy. Implementation of this action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

This action plan was updated by Erin Gertzen with input from Martin Nantel (Fisheries and Oceans Canada; DFO) to reflect changes made in the amended Recovery Strategy for Paxton Lake, Enos Lake and Vananda Creek Stickleback Species Pairs in Canada (DFO 2019).

The initial proposed action plan (DFO 2016a) was co-authored by Eric Chiang, Jonathan Thar, Alyssa Gerick, and Chelsey Cameron (DFO). DFO wishes to acknowledge the contributions made by those that have supported the development of the Action Plan for the Paxton Lake and Vananda Creek Stickleback Species Pairs. Recovery measures were first identified in the recovery strategy for these species (NRTSSP 2007), and were further discussed and refined using updated information gained during a March 2011 workshop held by DFO in the community of Van Anda, on Texada Island, British Columbia. The valuable ideas generated during the workshop were first used by Acroloxus Wetlands Consultancy Ltd. and subsequently by DFO to guide the development of this action plan. These ideas will also be used to help guide the implementation of the actions identified in the plan wherever possible.

Executive summary

The Paxton Lake and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) were listed as Endangered under the *Species at Risk Act* (SARA) in 2003. This action plan is considered one in a series of documents 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 2010a, b) and the amended recovery strategy (DFO 2019).

An initial proposed Action Plan for the Paxton Lake and Vananda Creek Stickleback Species Pairs was posted on the Species at Risk Public Registry in 2016. This 2020 action plan updates the 2016 proposed action plan to reflect changes made in the amended Paxton Lake, Enos Lake and Vananda Creek Stickleback Species Pairs recovery strategy (DFO 2019). Specifically, critical habitat and residence descriptions were moved from the initial action plan (DFO 2016a) to the amended recovery strategy (DFO 2019), and minor changes were made to the measures to be taken and implementation schedule section.

The Paxton Lake and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) are endemic to Texada Island, British Columbia. Each pair consists of a surface-feeding “Limnetic” species adapted for a zooplankton-consuming lifestyle and a bottom-feeding “Benthic” species adapted to prey on benthic invertebrates in the littoral zone. These small, sympatric freshwater fish are thought to have evolved from the marine Threespine Stickleback (*Gasterosteus aculeatus*). The four species’ recent and unique evolutionary history has been of considerable scientific interest and value.

This action plan addresses all four species making up the Paxton Lake and Vananda Creek Stickleback Species Pairs. It outlines measures that provide the best chance of achieving the population and distribution objectives for the species, including the measures to be taken to address the threats and monitor the recovery of the species. The population and distribution objectives outlined in the amended recovery strategy (DFO 2019) are:

- population objectives: maintain, or where possible increase, abundance relative to the 2016 observed population sizes of each species pair[1]
- distribution objectives: maintain the current spatial distribution of each species pair

It is likely that these species will always remain at some risk owing to their extremely limited distributions.

Section 1.2 outlines: measures to be undertaken by Fisheries and Oceans Canada (table 1); measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners, other agencies, organizations or individuals (table 2); and, measures that represent opportunities for other jurisdictions, organizations or individuals to lead (table 3). Section 1.2 measures fall under the following broad strategies, as per the amended recovery strategy (DFO 2019):

- develop and implement monitoring programs
- conduct research on the Paxton Lake and Vananda Creek Stickleback Species Pairs
- develop an Aquatic Invasive Species management plan

[1] The 2016 abundances are thought to be near historical levels and self-sustaining (DFO 2019).

- establish baseline water quality parameters for the Paxton Lake and Vananda Creek Stickleback Species Pairs
- develop a comprehensive water management plan for each basin
- develop land management strategies
- develop protocols for scientific investigations of the Paxton Lake and Vananda Creek Stickleback Species Pairs
- develop and implement outreach and stewardship projects for the Paxton Lake and Vananda Creek Stickleback Species Pairs

For the Paxton Lake and Vananda Creek Stickleback Species Pairs, critical habitat was identified to the extent possible, using the best available information, in section 8 of the amended recovery strategy (DFO 2019). As per section 2.3, it is anticipated that the protection of the species' critical habitat from destruction will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

An evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation is provided in section 3.

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1. Recovery actions

1.1 Context and scope of the action plan

The fish known collectively as "Stickleback Species Pairs" are thought to have evolved from the marine Threespine Stickleback (*Gasterosteus aculeatus*). Their recent and unique evolutionary history has been of considerable scientific interest and value. They are considered to be one of the youngest species on earth as strong evidence suggests that the species pairs developed after the last glaciation, less than 13,000 years ago. They are also among the world's best examples of rapid adaptive radiation[2] and parallel evolution[3] (as cited in Wood et al. 2004).

Sympatric[4] Stickleback Species Pairs have only been found in few small lakes in British Columbia. The Paxton Lake and Vananda Creek Stickleback Species Pairs are two such sympatric Stickleback Species Pairs. They each consist of a pair of species that are genetically and morphologically distinct from each other. Even though they live in the same lake, they are reproductively isolated. Each species pair includes a surface-feeding "Limnetic" species adapted for a zooplankton-consuming lifestyle, and a bottom-feeding "Benthic" species adapted to prey on benthic invertebrates in the littoral zone.

The two Stickleback Species Pairs that are the focus of this action plan are endemic to the Paxton Lake[5] and Vananda Creek watersheds on Texada Island in southwestern British Columbia. They include the Paxton Lake Benthic Threespine Stickleback and the Paxton Lake Limnetic Threespine Stickleback, which are only found in Paxton Lake (figure 1). The Vananda Creek Benthic Threespine Stickleback and the Vananda Creek Limnetic Threespine Stickleback are found in Spectacle,[6] Priest and Emily[7] Lakes (figure 2). They also move through the shallow marsh between Spectacle and Priest Lakes in both directions (COSEWIC 2010a) and through the stream and marsh between Emily and Priest Lakes (Taylor and McPhail 2000).

The Paxton Lake and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) were first assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in May 2000. This assessment was subsequently re-examined and confirmed in April 2010. The four species were listed as Endangered under the *Species at Risk Act* (S.C. 2002, c.29) (SARA) in June 2003. The Paxton Lake and Vananda Creek Stickleback Species Pairs were assessed as Endangered because they are unique endemic species with a restricted distribution (COSEWIC 2010a, b). They are also highly susceptible to extinction from aquatic invasive species (AIS) introductions, as well as to habitat loss and degradation from water extraction and land use in the surrounding watersheds (COSEWIC 2010a, b). Two other Stickleback Species Pairs on Lasqueti Island[8] and Vancouver Island[9] have been extirpated by invasive species (COSEWIC 2010a, b).

[2] Rapid diversification of two or more species to fill different ecological niches.
[3] Development of similar adaptations in two or more species.
[4] The spatial distribution of the two species is entirely or mostly overlapping.
[5] Paxton Lake lies within the Myrtle Creek watershed (see figure 1).
[6] Spectacle Lake is sometimes referred to as Balkwill Lake.
[7] Emily Lake is sometimes referred to as Turtle Lake.
[8] The Hadley Lake Stickleback Species Pair was assessed as extinct by COSEWIC in May 2000.
[9] While the Enos Lake Benthic Threespine Stickleback and the Enos Lake Limnetic Threespine Stickleback are still listed as Endangered under SARA, recent morphological and genetic analyses of Enos Lake Sticklebacks show no evidence of any "genetically pure" Benthic or Limnetic species

A recovery strategy that addresses the Paxton Lake and Vananda Creek Stickleback Species Pairs, along with the Enos Lake Stickleback Species Pair on Vancouver Island, was posted to the Species at Risk Public Registry in 2007 (NRTSSP 2007). The 2007 Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus spp.*) in Canada identified threats, population and distribution objectives (previously known as recovery goal and objectives) and broad approaches to recovery (previously known as strategies to address threats) for the six species. An Amended Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada was posted to the Species at Risk Public Registry in 2019. The 2019 amended recovery strategy updates biology, recovery feasibility assessments, population abundance information, threats, and population and distribution objectives. It also includes the identification of critical habitat and residence description for Paxton Lake and Vananda Creek Stickleback Species Pairs. For a detailed description of the species and further background information, the reader is encouraged to refer to the amended recovery strategy (DFO 2019).

An initial proposed action plan for the Paxton Lake and Vananda Creek Stickleback Species Pairs was posted on the Species at Risk Public Registry in 2016. This 2020 action plan updates the 2016 proposed action plan to reflect changes made in the amended Paxton Lake, Enos Lake and Vananda Creek Stickleback Species Pairs recovery strategy (DFO 2019). Specifically, critical habitat and residence descriptions were moved from the initial proposed action plan (DFO 2016a) to the amended recovery strategy (DFO 2019), and minor changes were made to the measures to be taken and implementation schedule section.

This action plan addresses the entire distribution of the four species that make up the Paxton Lake and Vananda Creek Stickleback Species Pairs.

This action plan identifies recovery measures to implement the broad approaches to recovery identified in the amended recovery strategy (DFO 2019) that relate to Paxton Lake and Vananda Creek Stickleback Species Pairs. These measures are intended to support progress towards the population and distribution objectives for the Paxton Lake and Vananda Creek Stickleback Species Pairs:

- population objectives: maintain, or where possible increase, abundance relative to the 2016 observed population sizes of each species pair[10]
- distribution objectives: maintain the current spatial distribution of each species pair

Please refer to section 6 of the amended recovery strategy (DFO 2019) for further information on the population and distribution objectives and broad approaches to recovery for the Paxton Lake and Vananda Creek Stickleback Species Pairs.

Under section 47 of SARA, the competent minister must prepare one or more action plans based on the recovery strategy. Therefore, action planning for species at risk recovery is an iterative process. The Implementation Schedule in this action plan may be modified in the future depending on the progression towards recovery.

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remaining in the lake (Taylor and Piercey 2016; DFO 2019). This provides strong evidence that Enos Lake now contains a single breeding population of sticklebacks that constitutes a hybrid population of the former Benthic and Limnetic species.

[10] The 2016 abundances are thought to be near historical levels and self-sustaining (detailed in the recovery strategy (DFO 2019)).

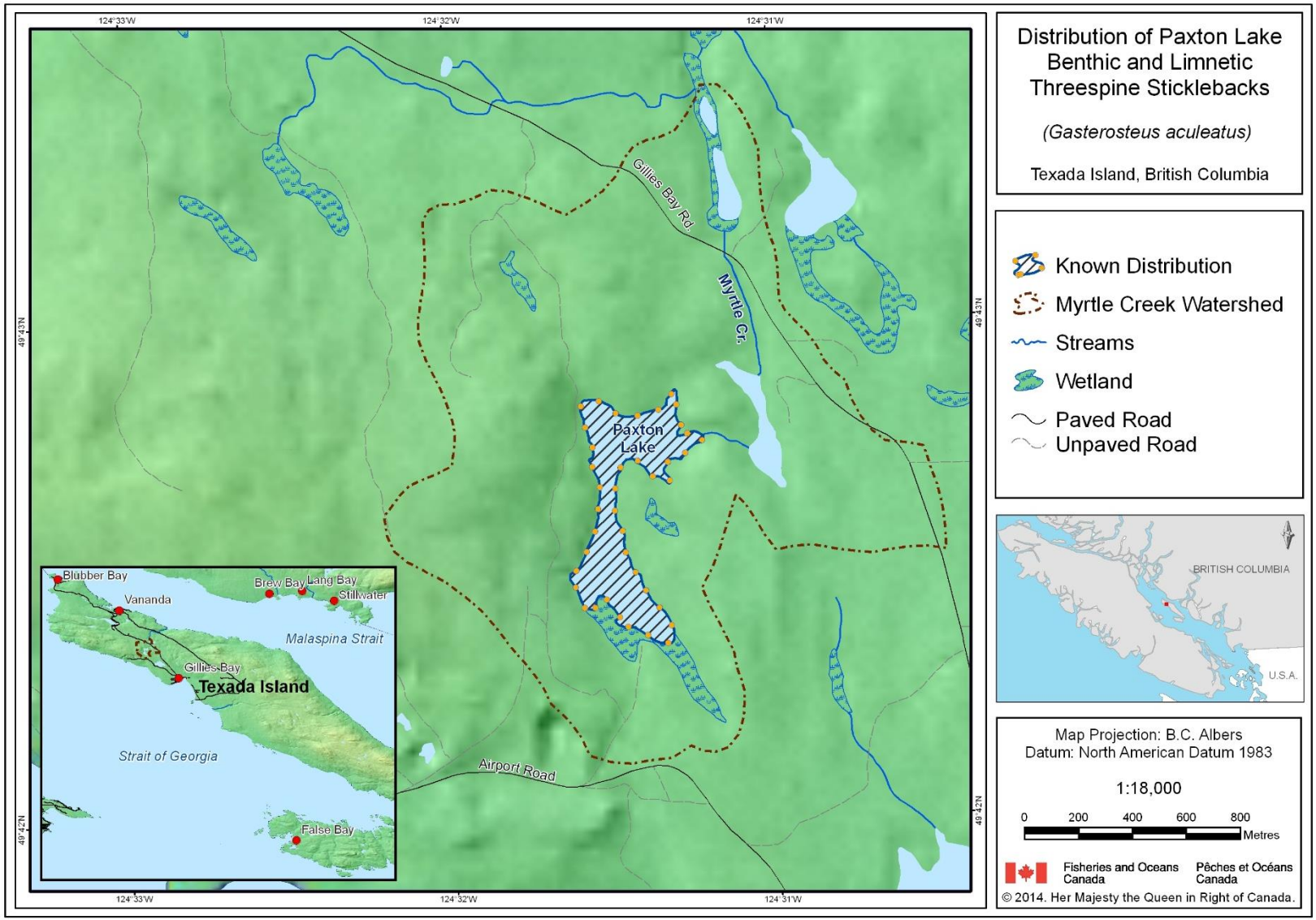

Figure 1. Distribution of the Paxton Lake Benthic and Limnetic Threespine Sticklebacks.

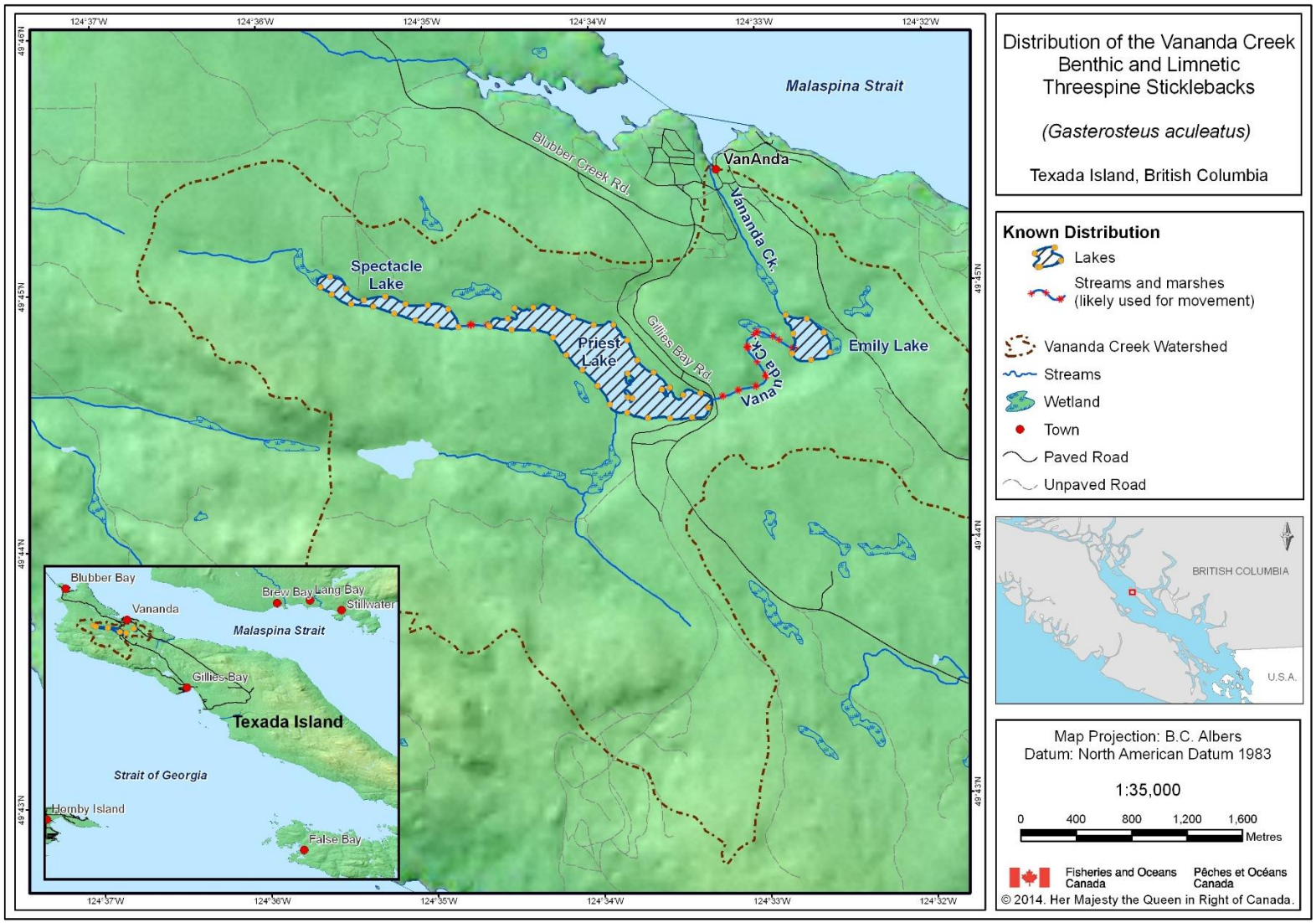

Figure 2. Distribution of the Vananda Creek Benthic and Limnetic Threespine Sticklebacks.

1.2 Measures to be taken and implementation schedule

Success in the recovery of the Paxton Lake and Vananda Creek Stickleback Species Pairs is dependent on the actions of many different jurisdictions; it requires the commitment and cooperation of the constituencies that will be involved in implementing the directions and measures set out in this action plan.

This action plan provides a description of the measures that provide the best chance of achieving the population and distribution objectives for the Paxton Lake and Vananda Creek Stickleback Species Pairs, including measures to be taken to address threats to the species and monitor its recovery, to guide not only activities to be undertaken by Fisheries and Oceans Canada, but those for which other jurisdictions, organizations and individuals have a role to play. As new information becomes available, these measures and the priority of these measures may change. Fisheries and Oceans Canada strongly encourages all Canadians to participate in the conservation of the Paxton Lake and Vananda Creek Stickleback Species Pairs through undertaking recovery measures outlined in this action plan.

Section 1.2 measures fall under the following broad strategies, as per the amended recovery strategy (DFO 2019):

1. develop and implement monitoring programs
2. conduct research on the Paxton Lake and Vananda Creek Stickleback Species Pairs
3. develop an Aquatic Invasive Species management plan
4. establish baseline water quality parameters for the Paxton Lake and Vananda Creek Stickleback Species Pairs
5. develop a comprehensive water management plan for each basin
6. develop land management strategies
7. develop protocols for scientific investigations of the Paxton Lake and Vananda Creek Stickleback Species Pairs
8. develop and implement outreach and stewardship projects for the Paxton Lake and Vananda Creek Stickleback Species Pairs

Table 1 identifies the measures to be undertaken by Fisheries and Oceans Canada to support the recovery of the Paxton Lake and Vananda Creek Stickleback Species Pairs.

Table 2 identifies recovery measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners, other agencies, organizations or individuals. Implementation of these measures will be dependent on a collaborative approach, in which Fisheries and Oceans Canada is a partner in recovery efforts, but cannot implement the measure alone. As all Canadians are invited to join in supporting and implementing this action plan, table 3 identifies remaining measures that represent opportunities for other jurisdictions, organizations or individuals to lead for the recovery of the species.

These recovery measures were informed by the Amended Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada (DFO 2019). These measures were discussed and refined using information gained during a March 2011 workshop held by DFO in the community of Van Anda, Texada Island, British Columbia. If your organization is interested in participating in one of these measures, please contact the Species at Risk Pacific Region office at sara@pac.dfo-mpo.gc.ca.

A summary of actions that have already been completed to benefit the Paxton Lake and Vananda Creek Stickleback Species Pairs can be found in section 3 below and in the Report on the Progress of Recovery Strategy Implementation for the Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada for the Period 2007 to 2015 (DFO 2016b).

Implementation of this action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Table 1. Measures to be undertaken by Fisheries and Oceans Canada.

#	Recovery measures	Broad strategy	Priority[11]	Threats addressed	Timeline
1	Develop a monitoring plan for the Paxton Lake and Vananda Creek Stickleback Species Pairs. The long-term monitoring plan should be sufficiently robust to provide a clear indication of the progress towards the population and distribution objectives for the Paxton Lake and Vananda Creek Stickleback Species Pairs.	Develop and implement monitoring programs.	High	AIS; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); scientific collections/*in situ* research; disease.	2019 to 2021

[11] "Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the population and distribution objectives for the species. Medium priority measures may have a less immediate or less direct influence on reaching the population and distribution objectives, but are still important for recovery of the populations. Low priority recovery measures will likely have an indirect or gradual influence on reaching the population and distribution objectives, but are considered important contributions to the knowledge base and/or public involvement and acceptance of the species.

Table 2. Measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners, other agencies, organizations or individuals.

#	Recovery measures	Broad strategy	Priority[12]	Threats addressed	Timeline[13]	Collaborators
2	Implement the monitoring plan for the Paxton Lake and Vananda Creek Stickleback Species Pairs.	Develop and implement monitoring programs.	High	AIS; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); scientific collections/*in situ* research; disease.	Short-term[14]	Academia, consultants, local or provincial governments, stewardship groups.
3	Develop and implement initiatives to prevent AIS from entering and becoming established in lakes containing the Paxton Lake and Vananda Creek Stickleback Species Pairs. Such initiatives could include actions directed at: - gathering increased knowledge about AIS in order to prevent their arrival - developing and implementing a system of monitoring and communications to ensure early detection, as well as a rapid response in the event that AIS are detected	Develop an Aquatic Invasive Species (AIS) management plan.	High	AIS; land use (including habitat loss or degradation); recreation.	Short-term	Academia, consultants, local or provincial governments, stewardship groups, other groups or individuals.

[12] Ibid.
[13] Short-term: 2019 to 2023; medium-term: 2024 to 2028; long-term: 2029+.
[14] Timeline is dependent on completion of Recovery Measure 1.

#	Recovery measures	Broad strategy	Priority[12]	Threats addressed	Timeline[13]	Collaborators
4	Research potential impacts of recreational lake usage on the Paxton Lake and Vananda Creek Stickleback Species Pairs, including: - impacts of gas-operated power boats on water quality - impacts of lake stocking or use of live bait	Develop an Aquatic Invasive Species (AIS) management plan.	Low	AIS; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); recreation.	Long-term	Academia, consultants, local or provincial governments, stewardship groups.
5	Develop mitigation measures to address potential impacts from recreational lake usage, and engage relevant agencies regarding the adoption of these measures.	Develop an Aquatic Invasive Species (AIS) management plan.	Low	AIS; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); recreation.	Long-term	Academia, consultants, local or provincial governments, stewardship groups.

#	Recovery measures	Broad strategy	Priority[12]	Threats addressed	Timeline[13]	Collaborators
6	Conduct scientific research that contributes to recovery and/or addresses knowledge gaps affecting management of the Paxton Lake and Vananda Creek Stickleback Species Pairs. Examples of potential areas for research include: - developing robust population estimates for Paxton, Priest, Spectacle and Emily Lakes - evaluating impacts on eggs and larvae caused by temporarily removing males from nests - monitoring hybridization rates, particularly as it relates to impacts of removing pure sticklebacks for research - confirming that the Vananda Creek Stickleback Species Pair is ecologically similar to the Paxton Lake Stickleback Species Pair (that is, similar life histories and timing) - learning more about dispersal and migration linkages between Emily, Priest and Spectacle Lakes (Vananda Creek Stickleback Species Pair) - determining the effects of lake level fluctuations - investigating the potential water quality implications and effects on the species pairs from the use of explosives for exploration and mining activities within the Paxton Lake and Vananda Creek Stickleback Species Pairs' watersheds	Conduct research on the Paxton Lake and Vananda Creek Stickleback Species Pairs.	High	AIS; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); disease.	Short-term	Academia, consultants, industry, local or provincial governments, stewardship groups.

#	Recovery measures	Broad strategy	Priority[12]	Threats addressed	Timeline[13]	Collaborators
7	Assess the technical risk of potential long-term impacts from future quarry operations on the Paxton Lake and Vananda Creek Stickleback Species Pairs. This assessment should identify projections for quarry expansion, potential pathways and processes of impacts, likelihood of impacts, and potential mitigation options.	Conduct research on the Paxton Lake and Vananda Creek Stickleback Species Pairs.	Medium	Water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation).	Medium-term	Academia, consultants, industry, local or provincial governments, stewardship groups.
8	Establish baseline parameters for turbidity, temperature, pH and dissolved oxygen for all lakes and streams containing the Paxton Lake and Vananda Creek Stickleback Species Pairs to better understand the species' biological needs and the parameters that affect habitat quality.	Establish baseline water quality parameters for the Paxton Lake and Vananda Creek Stickleback Species.	High	Water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation).	Medium-term	Academia, consultants, local or provincial governments, stewardship groups.
9	Identify and evaluate water management options to satisfy both conservation and stakeholder needs (for example, timing maximum water extraction during periods of least sensitivity) in the following ways: - share information on the Paxton Lake and Vananda Creek Stickleback Species Pairs - address impacts of changes in lake water levels - review the number and extent of water use licenses - engage relevant agencies about conservation and water management options	Develop a comprehensive water management plan for each basin.	High	Water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation).	Medium-term	Academia, consultants, industry local or provincial governments, stewardship groups.

#	Recovery measures	Broad strategy	Priority[12]	Threats addressed	Timeline[13]	Collaborators
10	Identify and evaluate land use planning and management options in the following ways: - share information about the Paxton Lake and Vananda Creek Stickleback Species Pairs, land use-related threats, and mitigation measures and management practices to address these threats - encourage relevant agencies or governments to consider the Paxton Lake and Vananda Creek Stickleback Species Pairs in developing and modifying land use plans, official community plans, management guidelines and by-laws	Develop land management strategies.	High	Water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation).	Medium-term	Academia, consultants, industry, local or provincial governments, private landowners, stewardship groups.
11	Develop a list of mitigation measures and best management practices to address and mitigate the potential impacts of land use activities in the Paxton Lake and Vananda Creek Stickleback Species Pairs' watersheds.	Develop land management strategies.	High	Water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation).	Medium-term	Academia, consultants, industry local or provincial governments, stewardship groups.
12	Evaluate the impacts of an established Wildlife Habitat Area in the Vananda Creek watershed.	Develop land management strategies.	Medium	Water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation).	Medium-term	Academia, consultants, local or provincial governments, stewardship groups.

#	Recovery measures	Broad strategy	Priority[12]	Threats addressed	Timeline[13]	Collaborators
13	Update the protocols for scientific investigations related to the collection and use of *in situ* studies to increase scientific understanding of the Paxton Lake and Vananda Creek Stickleback Species Pairs (Rosenfeld 2008).	Develop protocols for scientific investigations of the Paxton Lake and Vananda Creek Stickleback Species.	Medium	AIS; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); scientific collections/*in situ* research.	Medium-term	Academia, consultants, local or provincial governments.

Table 3. Measures that represent opportunities for other jurisdictions, organizations or individuals to lead.

#	Recovery measures	Broad strategy	Priority[15]	Threats addressed	Contributors
14	Participate in AIS removal or prevention programs.	Develop an Aquatic Invasive Species (AIS) management plan	High	AIS.	Academia, consultants, stewardship groups, other groups or individuals.
15	Adopt and promote practices to reduce potential impacts of recreational lake use.	Develop an Aquatic Invasive Species (AIS) management plan.	Low	AIS; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); recreation.	Recreational users, local or provincial governments, stewardship groups, groups or individuals.
16	Promote and adopt best management practices to mitigate potential effects of land use on water quality (for example, turbidity and nutrient levels in lakes).	Establish baseline water quality parameters for the Paxton Lake and Vananda Creek Stickleback Species Pairs.	High	Water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation).	Academia, consultants, industry, local or provincial governments, private landowners, stewardship groups, other groups or individuals.
17	Develop and implement projects to promote water conservation and the adoption of best practices for water use in the Paxton Lake and Vananda Creek Stickleback Species Pairs' watersheds.	Develop a comprehensive water management plan for each basin.	Medium	Water management (including water pollution and/or sedimentation).	Industry, local or provincial governments, stewardship groups, other groups.

[15] "Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the population and distribution objectives for the species. Medium priority measures may have a less immediate or less direct influence on reaching the population and distribution objectives, but are still important for recovery of the populations. Low priority recovery measures will likely have an indirect or gradual influence on reaching the population and distribution objectives, but are considered important contributions to the knowledge base and/or public involvement and acceptance of the species.

#	Recovery measures	Broad strategy	Priority[15]	Threats addressed	Contributors
18	Promote and adopt best management practices for land use in the Paxton Lake and Vananda Creek Stickleback Species Pairs' watersheds and/or mitigation measures to reduce potential impacts of land use on the Paxton Lake and Vananda Creek Stickleback Species Pairs.	Develop land management strategies.	High	Land use (including habitat loss or degradation).	Industry, local and provincial governments, private landowners.
19	Incorporate considerations regarding the conservation and protection of the Paxton Lake and Vananda Creek Stickleback Species Pairs, as well as their habitat, in local planning processes and by-laws.	Develop land management strategies.	High	Land use (including habitat loss or degradation).	Local governments.
20	Participate in a group that supports recovery of the Paxton Lake and Vananda Creek Stickleback Species Pairs by implementing actions, initiatives, studies and/or other activities to benefit and increase understanding and awareness of the species.	Develop and implement outreach and stewardship projects for the Paxton Lake and Vananda Creek Stickleback Species Pairs.	High	AIS; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); recreation.	Academia, consultants, local or provincial governments, stewardship groups, other groups or individuals.

#	Recovery measures	Broad strategy	Priority[15]	Threats addressed	Contributors
21	Develop outreach and stewardship projects in support of recovery measures identified in this action plan. Target audiences should include local community members, landowners, industry, recreational groups, and local schools. For example: - promote best management practices to minimize the effects of various land use practices - promote lake riparian area conservation - promote stewardship practices, such as riparian planting by private landowners; - develop, install, and maintain educational signage (for example, at ferry terminals, specific lake access points) about the species and its threats, particularly AIS - where appropriate, participate in water management and land use planning processes - share information at relevant workshops or symposia	Develop and implement outreach and stewardship projects for the Paxton Lake and Vananda Creek Stickleback Species Pairs.	Medium	All.	Academia, consultants, industry, local or provincial governments, stewardship groups, other groups or individuals.

2. Critical habitat

2.1 Identification of the species' critical habitat

2.1.1 General description of the species' critical habitat

Critical habitat is defined in SARA as "…*the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or in an action plan for the species*." [section 2(1)]

Also, SARA defines habitat for aquatic species as "… *spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced*." [section 2(1)]

Critical habitat for Paxton Lake and Vananda Creek Stickleback Species Pairs is identified to the extent possible in section 8.1 of the amended recovery strategy (DFO 2019). The amended recovery strategy (DFO 2019) also contains details about the identified critical habitat including geographic location and biophysical functions, features and attributes.

2.2 Activities likely to result in the destruction of critical habitat

Examples of activities likely to result in destruction of critical habitat may be found in section 8.2 of the amended recovery strategy (DFO 2019).

2.3 Measures to protect critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a final recovery strategy or action plan and included in the Species at Risk Public Registry. For the Paxton Lake and Vananda Creek Stickleback Species Pairs critical habitat, this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

3. Evaluation of socio-economic costs and of benefits

SARA requires that an action plan include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA 49(1)(e), 2003). This evaluation addresses only the incremental socio-economic costs of implementing this action plan from a national perspective as well as the social and environmental benefits that would occur if the action plan were implemented in its entirety, recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. It does not address cumulative costs of species recovery in general nor does it attempt a cost-benefit analysis. Its intent is to inform the public and to guide decision making on implementation of the action plan by partners.

The protection and recovery of species at risk can result in both benefits and costs. SARA's Preamble recognizes that "wildlife, in all its forms, has value in and of itself and is valued by Canadians for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological and scientific reasons" (SARA, S.C. 2003, c.29). Self-sustaining and healthy ecosystems with their various elements in place, including species at risk, contribute positively to the livelihoods and the quality of life of all Canadians. A review of the literature confirms that Canadians value the preservation and conservation of species in and of themselves. Actions taken to preserve a species, such as habitat protection and restoration, are also valued. In addition, the more an action contributes to the recovery of a species, the higher the value the public places on such actions (Loomis and White 1996; DFO 2008). Furthermore, the conservation of species at risk is an important component of the Government of Canada's commitment to conserving biological diversity under the International *Convention on Biological Diversity*. The Government of Canada has also made a commitment to protect and recover species at risk through the *Accord for the Protection of Species at Risk*. The specific costs and benefits associated with this action plan are described below.

This evaluation does not address the socio-economic impacts of protecting critical habitat for Paxton Lake and Vananda Creek Stickleback Species Pairs. Under SARA, DFO must ensure that critical habitat identified in a recovery strategy or action plan is legally protected from destruction within 180 days of the final posting of the recovery strategy or action plan. Where a SARA Critical Habitat Protection Order will be used for critical habitat protection, the development of the Order will follow a regulatory process in compliance with the *Cabinet Directive on Regulatory Management*, including an analysis of any potential incremental impacts of the SARA Critical Habitat Protection Order that will be included in the Regulatory Impact Analysis Statement. As a consequence, no additional analysis of the critical habitat protection has been undertaken for the assessment of costs and benefits of the action plan.

Recovery actions to date

Actions to support recovery implemented prior to this action plan include DFO-funded research to support critical habitat identification as well as education, outreach and stewardship projects supported by DFO through the Habitat Stewardship Program. Further, the Texada Stickleback Group has implemented a number of education and stewardship projects to support the recovery of the Paxton Lake and Vananda Creek Stickleback Species Pairs. Researchers from the University of British Columbia and other universities have also conducted a number of research projects to learn more about these species pairs. Most recently in 2015, under the federal *Fisheries Act*, DFO developed AIS regulations which will benefit the Paxton Lake and Vananda Creek Stickleback Species Pairs and other species at risk affected by AIS.

Benefits of implementing this action plan

The benefits of maintaining the Paxton Lake and Vananda Creek Stickleback Species Pairs are unknown but likely positive. As indicated above, Canadians value the species for a number of reasons, including non-market benefits (that is, bequest, existence and option values[16]). Activities that positively affect the recovery of these species may result in positive benefits to Canadians. The recent and unique evolutionary history of the Paxton Lake and Vananda Creek Stickleback Species Pairs has been of considerable scientific interest. Recovery will preserve this research value and could provide insights that benefit other species that are similarly isolated in their distribution.

While the specific impacts of recovery measures under the various strategies and plans that will be implemented in the longer-term are unknown, it is likely that there will also be broader ecosystem benefits associated with conservation, stewardship, research, and monitoring actions to other species within the Paxton Lake and Vananda Creek watersheds.

Socio-economic costs of implementing this action plan

Measures to protect and recover the species in the action plan fall into five broad, complementary categories: research; monitoring; education, awareness, and stewardship; development of best practice approaches and mitigation options; and, cooperation and engagement. The cost of longer-term activities, in particular implementation of plans yet to be developed, could not be assessed. Additionally, while it is recognized that the actions in table 2 and 3 are important to the recovery of the Paxton Lake and Vananda Creek Stickleback Species Pairs, the level of uncertainty in terms of participants, timelines and project specifics precludes a full assessment of the costs to collaborators and contributors, and the distribution of those costs in this evaluation.

The action outlined in table 1 is short-term (<5 years) related to the development of a monitoring plan. DFO financial contribution is expected to be under $50,000 for action 1. While DFO is identified as the lead for the activity analyzed in table 1, a number of potential collaborators may participate or are already involved. These collaborators may include other government agencies, academic institutions, researchers, local stewardship organizations, private citizens, and industry groups. Such participation may include in-kind support in terms of staff time and resources for discussion and to attend meetings. The overall costs of table 1 are expected to be minimal.

The actions in table 2 mainly involve research to fill knowledge gaps, implementation of monitoring activities and identification of threat mitigation options through engagement and cooperation. These activities depend on either financial and/or in-kind support from collaborators. The majority of DFO financial costs in this table are related to one-time research costs, ongoing monitoring costs, and one-time costs to develop mitigation guidelines/options. In-kind support costs from DFO are also anticipated for engagement activities. Further, an unknown level of collaborator financial or in-kind contribution costs for cooperation and

[16] Non-market benefits include bequest values (the value placed on conservation for future generations), existence values (the value people place on the existence of a species) and option values (the amount someone is willing to pay to keep open the option of future use of the species).

engagement activities is likely to be incurred for table 2 activities. The overall costs (financial and in-kind) for table 2 to both DFO and collaborators would likely be low.[17]

Table 3 activities focus on implementation of plans to (1) increase awareness through education and outreach activities; and (2) mitigate AIS threats, land use, water quality/use and recreational use threats through stewardship and adoption of best practices. Costs associated with the implementation of plans and mitigation strategies cannot be assessed as these will depend on design, which has yet to be undertaken and may be informed by research activities. It is anticipated that stewardship activities would be supported by existing government sources, although in-kind and financial support from contributors may also be possible. Education and outreach plans are likely low cost to implement. The cost to recreational users, local or provincial government, stewardship groups and other groups or individuals from adoption of best practices are largely unknown at this time, as in some cases, these actions will need to be informed by research activities to set objectives. The distribution of costs cannot be determined as responsibilities of those that may choose to voluntarily participate have not been identified. However, if these mitigation strategies and plans are developed cooperatively with interested parties, cost considerations may be incorporated in the design.

In summary, while the long term financial and in-kind costs of table 1 and table 2 are likely to be low for DFO and collaborators, table 3 costs cannot be assessed as the plans and strategies have not yet been drafted. Therefore, the overall costs and benefits of this action plan are unknown, although the benefits are likely to be positive and costs, while unknown, are likely to be low.

4. Measuring progress

The performance indicators presented in the amended recovery strategy (DFO 2019) provide a way to define and measure progress toward achieving the population and distribution objectives.

Reporting on implementation of the action plan (as required by section 55 of SARA) will be done by assessing progress towards implementing the broad strategies outlined in the amended recovery strategy (DFO 2019).

Reporting on the ecological and socio-economic impacts of the action plan (as required by section 55 of SARA) will be done by assessing the results of monitoring the recovery of the species and its long term viability, and by assessing the implementation of the action plan.

[17] Treasury Board of Canada Secretariat (2014) guidance provides scales in terms of present values, as well as annualized values. The annualized scale is: Low $0 to $1 million, Medium $1 to $10 million, High >$10 million.

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Appendix A: effects on the environment and other species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals. The purpose of an SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that implementation of action plans may inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the action plan itself, but are also summarized below in this statement.

This action plan will benefit the environment by promoting the recovery of the Paxton Lake and Vananda Creek Stickleback Species Pairs in the wild, thereby contributing to FSDS Theme III (Protecting Nature and Canadians), Goal 4 (Conservation and Restoring Ecosystems, Wildlife and Habitat, and Protecting Canadians). Specifically, it will help to attain the associated target of 4.1 which is to have populations of federally listed species at risk exhibit trends that are consistent with the objectives of recovery strategies and management plans. In addition, it could help to meet the target associated with 4.6, whereby pathways of AIS introductions are identified, and risk-based intervention or management plans are in place for priority pathways and species.

The actions identified in this plan address threats from water management (including water pollution and sedimentation), land use (including habitat loss or degradation) and AIS, all of which typically negatively affect other aquatic species and wildlife. By addressing these threats, the actions will contribute to the overall ecosystem health, which may provide benefits to other species, such as Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*), as well as ecological services to Canadians living in the area. No adverse effect on other species is anticipated as the result of the implementation of this action plan.

The Paxton Lake and Vananda Creek Stickleback Species Pairs co-exist with Coastal Cutthroat Trout as the only other fish species documented to exist in the lakes. Species-specific and predatory interactions may occur with carnivorous benthic invertebrates or piscivorous birds, but they are not thought to be a threat to species pairs. AIS, such as Brown Bullhead are thought to have caused the extinction of the species in Hadley Lake due to predation or nesting interference leading to recruitment failure (Hatfield 2001). The collapse of the Enos Lake pair occurred following the appearance of the American Signal Crayfish, which is thought to have affected the macrophyte community leading to species hybridization.

Given the considerations outlined above, the benefits of this action plan to the environment and other species are expected to outweigh any adverse effects that may occur.

Appendix B: record of cooperation and consultation

The Paxton Lake and Vananda Creek Stickleback Species Pairs were listed as Endangered under SARA in June 2003. A final recovery strategy was posted to the Species at Risk Public Registry in 2007. The Minister of Fisheries and Oceans (DFO) is the competent Minister under SARA for the Paxton Lake and Vananda Creek Stickleback Species Pairs and prepared this action plan, as per section 47 of SARA. To the extent possible, it has been prepared in cooperation with the Province of British Columbia (B.C.) as per section 48(1) of SARA. Processes for coordination and consultation between the federal and B.C. governments on management and protection of species at risk are outlined in the *Canada-British Columbia Agreement on Species at Risk*. The draft document was also sent to the Parks Canada Agency and Environment and Climate Change Canada for review and comment in 2014.

On March 19, 2011 a community workshop on Texada Island was held to seek comments and input on the draft action plan, and ensure the document incorporated the best technical and scientific expertise on these species. Participants included the Texada Stickleback Group, local citizens, academia, Texada Logging (now JMG Logging), Texada Quarry Ltd. (LaFarge North America aggregate operations), scientific experts, and representatives from the Province of British Columbia.

The draft action plan was posted to the DFO Pacific Region Consultation website for a public comment period from August 19 to September 17, 2014. A draft of the action plan, along with background information and a comment form, was made available on the website. Letters were mailed, e-mailed and faxed to Indigenous organizations in the species' range requesting input on this draft action plan and offering an opportunity to meet with DFO for further discussions. E-mail notifications of the consultation were also sent to the Province of British Columbia, Environment and Climate Change Canada, environmental interest groups, academia, industry and other stakeholder groups in the species' range. As well, letters were sent to private landowners proximate to the draft critical habitat notifying them of the consultation. The general public was notified by social media tweets and newspaper advertisements.

Comments on the 2014 draft action plan were received from 6 respondents in the form of emails, phone calls, and online comment forms. Primary topics discussed included: existing protection mechanisms; additional threats; critical habitat identification (scientific rationale) and protection (implications for landowners and natural resource management); additional activities likely to destroy critical habitat; socio-economic costs; and, the importance of stewardship.

Additional Indigenous, stakeholder, and public input was sought through the publication of the initial proposed 2016 action plan on the Species at Risk Public Registry for a 60-day public comment period. No comments were received.

This 2020 action plan updates the 2016 proposed action plan to reflect changes made in the amended Paxton Lake, Enos Lake and Vananda Creek Stickleback Species Pairs recovery strategy (DFO 2019). Additional Indigenous, stakeholder, and public input was sought through a second 60-day public comment period in 2018 when this proposed action plan was posted on the Species at Risk Public Registry. No feedback was received.