PROPOSED

Species at Risk Act
Action Plan Series

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

Stickleback Species Pairs

2016

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.

Cover illustration: Stickleback Species Pair from Paxton Lake, British Columbia. Top photo shows gravid Benthic Paxton Stickleback; bottom photo shows gravid Limnetic Paxton Stickleback. Credit: Todd Hatfield (Solander Ecological Research).

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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 *Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (Gasterosteus* spp.*) in Canada* (NRTSSP 2007), 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 this 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

Fisheries and Oceans Canada (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 when the Act came into force. 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 report, and the recovery strategy.

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 goal of the recovery strategy is to secure the long-term viability of all extant populations of stickleback species pairs. It is likely that these species will always remain at some risk due to their extremely limited distributions. The short-term (over the next five years) and long-term (over the next 20 years) population and distribution objectives (previously referred to as recovery goals and objectives) for the Paxton Lake and Vananda Creek Stickleback Species Pairs identified in the recovery strategy are to "Maintain self-sustaining populations of stickleback species pairs in Paxton Lake and the Vananda Creek watershed."

Section 1.2 outlines: the 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:

- develop and implement monitoring programs;
- develop an Aquatic Invasive Species management plan (referred to in the Recovery Strategy as an exotic species management plan);
- conduct research on Stickleback Species Pairs and investigate potential water quality implications from use of explosives for mining activities within the watersheds;[1]
- establish water quality objectives for all lakes containing the species pairs;
- develop a comprehensive water management plan for each basin;
- develop land management strategies (e.g. for Crown and private lands);

[1] Note: This Broad Strategy encompasses three Broad Strategies from the Recovery Strategy: i.) Support development of a Research Action Group to undertake specific research activities to provide detailed technical advice; ii.) Conduct studies to identify critical habitat for the Stickleback Species Pairs; and iii.) Investigate potential water quality implications from use of explosives for mining activities within species pairs' watersheds (NRTSSP 2007).

- establish and support Recovery Implementation Groups (RIGs);
- determine the potential impacts from recreational lake usage in lakes containing the species pairs and develop mitigation measures as required;[2] and
- develop and implement information and education plans for the Stickleback Species Pairs.

For the Paxton Lake and Vananda Creek Stickleback Species Pairs, critical habitat is identified to the extent possible, using the best available information, and provides the functions and features necessary to support the species' life-cycle processes. This Action Plan identifies critical habitat for Paxton Lake and Vananda Creek Stickleback Species Pairs as the entirety of Paxton, Spectacle, Priest and Emily Lakes (each with a 15 metre riparian width surrounding their wetted perimeters) as well as the stream and marsh between Emily and Priest Lakes, and the shallow marsh between Spectacle and Priest Lakes (each with a 30 metre riparian width surrounding their wetted perimeters) (Section 2.2). It is anticipated that the protection of the species' critical habitat from destruction will be accomplished through a SARA Critical Habitat Protection 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 (Section 2.3).

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.

[2] Note this Broad Strategy encompasses two Broad Strategies from the Recovery Strategy: i.) Determine the potential impacts of recreational fishing in species pair lakes and develop mitigation measures as required; and, ii.) Determine potential impacts of gas operated motor boats on water quality in the species pair lakes and develop mitigation measures as required, and discourage impacts from lakeshore development and recreational use (NRTSSP 2007).

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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 and parallel evolution (as cited in Wood et al. 2004).

Sympatric[3] Stickleback Species Pairs have only been found in few small lakes in British Columbia. The two species within each pair 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[4] 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. The Vananda Creek Benthic and Limnetic Threespine Sticklebacks are found in Spectacle,[5] Priest and Emily[6] Lakes. 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). Figures 1 and 2 depict the distribution of the Paxton Lake and Vananda Creek Stickleback Species Pairs.

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 when the Act came into force. 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 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 and Vancouver Island[7] have been extirpated by invasive species (COSEWIC 2010a, 2010b).

A final Recovery Strategy that addresses the Paxton Lake and Vananda Creek Stickleback Species Pairs, along with a species pair in Enos Lake on Vancouver Island (NRTSSP 2007),

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[3] The spatial distribution of the two species is entirely or mostly overlapping.
[4] Paxton Lake lies within the Myrtle Creek watershed (see Figure 1).
[5] Spectacle Lake is sometimes referred to as Balkwill Lake.
[6] Emily Lake is sometimes referred to as Turtle Lake.
[7] The extirpation of the Enos Lake Stickleback Species Pairs has not been confirmed, although it is believed that the two species have collapsed into a hybrid swarm (Taylor et al. 2006; COSEWIC 2010a, 2010b).

was posted to the Species at Risk Public Registry in 2007. The *Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (Gasterosteus* spp.*) in Canada* identifies 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 those six species.

The information in this Action Plan complements information found in the above mentioned Recovery Strategy. For a detailed description of the species and further background information, the reader is encouraged to review the Recovery Strategy.

This Action Plan addresses the entire distribution of the four species that make up the Paxton Lake and Vananda Creek Stickleback Species Pairs. It does not address the Enos Lake Benthic and Limnetic Sticklebacks, as recent research results indicate that these species have likely collapsed into a hybrid swarm[8] (Taylor et al. 2006), nor does it address the Hadley Lake Stickleback Species Pairs as they are not listed under SARA.

This Action Plan identifies recovery measures to implement the broad approaches to recovery identified in the Recovery Strategy that relate to Paxton Lake and Vananda Creek Stickleback Species Pairs. These measures are intended to support progress towards the population and distribution objective for the Paxton Lake and Vananda Creek Stickleback Species Pairs, which is “to maintain self-sustaining populations of Stickleback Species Pairs in Paxton Lake and Vananda Creek watershed” (NRTSSP 2007). Please refer to sections 7, 8 and 9 of the Recovery Strategy for further information on the population and distribution objective and broad approaches to recovery for the Paxton Lake and Vananda Creek Stickleback Species Pairs (NRTSSP 2007).

This Action Plan also describes the residences and identifies the critical habitat of the Paxton Lake and Vananda Creek Stickleback Species Pairs.

[8] The Enos Lake Stickleback Species Pairs are still listed under SARA as Endangered, and were most recently assessed by COSEWIC as Endangered in 2012.

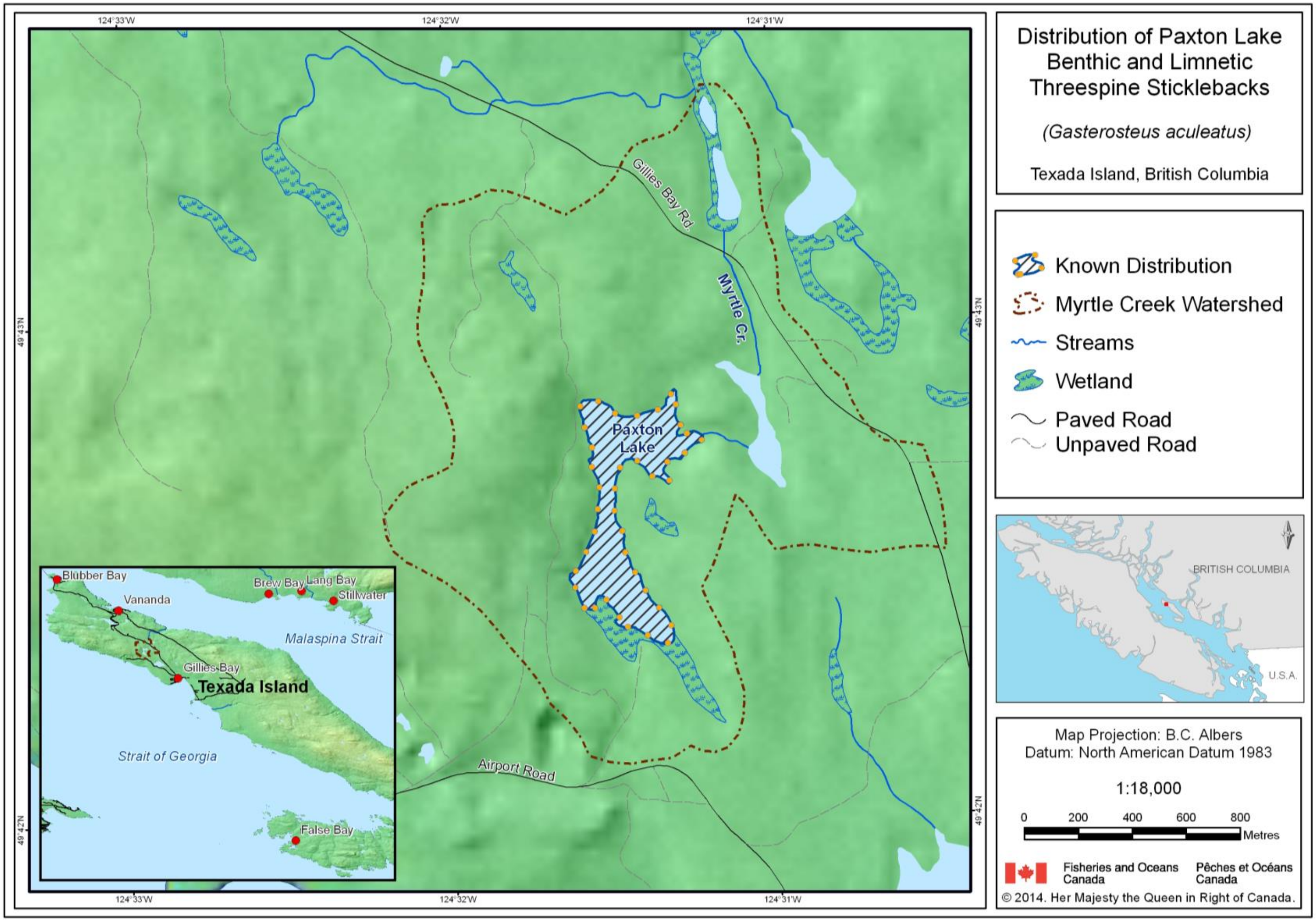


Figure 1. Distribution of the Paxton Lake Benthic and Limnetic Threespine Sticklebacks.

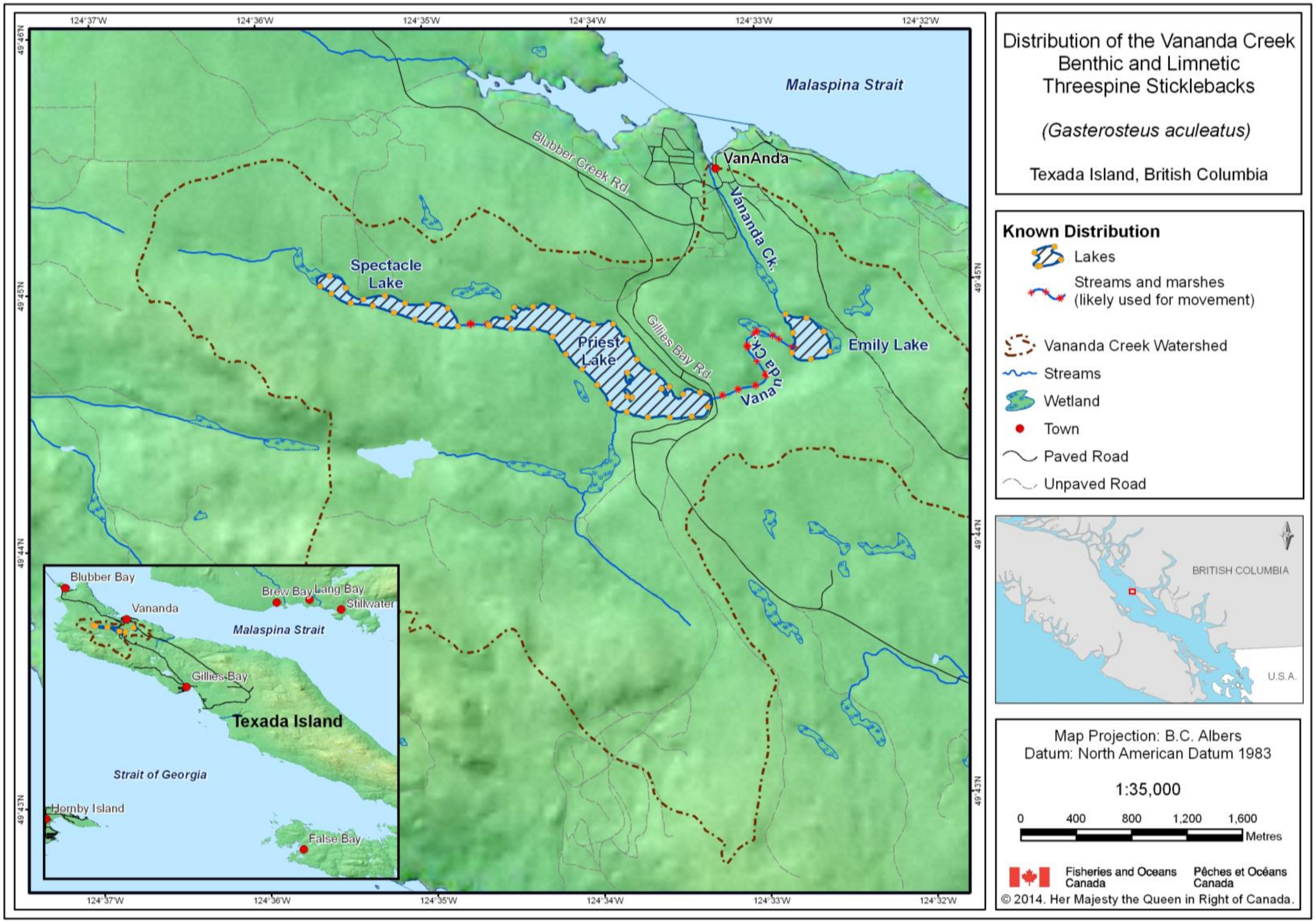


Figure 2. Distribution of the Vananda Creek Benthic and Limnetic Threespine Sticklebacks.

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.

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 initially informed by the *Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (Gasterosteus* spp.*) in Canada* (NRTSSP 2007), then further discussed and refined using updated 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.

DFO has already completed measures that address the broad strategy of developing sound protocols for scientific investigations for Paxton Lake and Vananda Creek Stickleback Species Pairs, so this approach to recovery is not addressed in the table below. 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.

Broad strategies from the Recovery Strategy specific to Enos Lake Stickleback Species Pairs are not addressed in this Action Plan.

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	Priority[9]	Threats addressed	Timeline
Broad Strategy: Develop and implement monitoring programs.				
1	Develop a monitoring plan for the Stickleback Species Pairs. The monitoring plan should be sufficiently robust to provide a clear indication of the progress achieved towards the population and distribution objective of maintaining self-sustaining populations of Stickleback Species Pairs.	H	Exotic species (including invasive and/or introduced species); Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation); Climate change.	2018-2020

[9] "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 ("H") measures are considered those most likely to have an immediate and/or direct influence on attaining the recovery objective for species. Medium priority ("M") measures may have a less immediate or less direct influence on reaching the recovery population and distribution objective, but are still important for recovery of the population. Low priority ("L") recovery measures will likely have an indirect or gradual influence on reaching the recovery objectives, but are considered important contributions to the knowledge base and/or public involvement and acceptance of species.

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

#	Recovery Measures	Priority[10]	Threats addressed	Timeline	Collaborators
Broad Strategy: Develop and implement monitoring programs.					
2	Implement the monitoring plan for Stickleback Species Pairs.	H	Exotic species (including invasive and/or introduced species); Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation); Climate change.	Short-term (dependent on completion of Measure 1; some baseline data already collected).	RIGs, Researchers (e.g. academic institutions, consultants), local or provincial governments, other agencies, stewardship groups
Broad Strategy: Develop an Aquatic Invasive Species management plan (referred to in the Recovery Strategy as an exotic species management plan).					
3	Develop and implement initiatives to prevent exotic, invasive or introduced species from entering and becoming established in lakes containing the Stickleback Species Pairs. Such initiatives could include actions directed at: - gathering increased knowledge about AIS in order to prevent their arrival; and - developing and implementing a system of monitoring and communications to ensure early detection, as well as a rapid response in the event that aquatic invasive species are detected.	H	Exotic species (including invasive and/or introduced species); Land Use (including habitat loss or degradation).	Short-term	RIGs, researchers (e.g. academic institutions, consultants), local or provincial governments, stewardship groups, other agencies, groups or individuals
Broad Strategy: Conduct research on Stickleback Species Pairs and investigate potential water quality implications from use of explosives for mining activities within the watersheds.[11]					

[10] Ibid.

[11] Note: This Broad Strategy encompasses three Broad Strategies from the Recovery Strategy: i.) Support development of a Research Action Group to undertake specific research activities to provide detailed technical advice; ii.) Conduct studies to identify critical habitat for the Stickleback Species Pairs; and iii.) Investigate potential water quality implications from use of explosives for mining activities within species pairs' watersheds (NRTSSP 2007).

#	Recovery Measures	Priority[10]	Threats addressed	Timeline	Collaborators
4	Conduct scientific research that contributes to recovery and/or addresses knowledge gaps. 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 Vananda Creek Stickleback Species Pairs are ecologically similar to Paxton Lake Species Pairs (i.e. similar life histories and timing); - learning more about dispersal and migration linkages between Emily, Priest and Spectacle Lakes (Vananda Creek Stickleback Species Pairs); - determining the effects of lake level fluctuations;[12] - evaluating impacts of changes in water quality parameters such as turbidity (light transmission through the water column), pH, temperature and nutrient levels; and - evaluating the effects of existing land use activities (including the use of explosives for exploration and mining activities) on water quality.	H	Exotic species (including invasive and/or introduced species); Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation).	Short-term	Recovery Implementation Groups (RIGs), researchers (e.g. academic institutions, consultants), industry, local or provincial governments, other agencies, stewardship groups
5	Assess the technical risk of potential long-term impacts from future quarry operations on Stickleback Species Pairs. This assessment should identify projections for quarry expansion, potential pathways and processes of impacts, likelihood of impacts, and potential mitigation options.	M	Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation).	Medium-term	RIGs, researchers (e.g. academic institutions, consultants), industry, local or provincial governments, other agencies, stewardship groups

[12] This is also identified in the Recovery Strategy in Section 6.3 Schedule of Studies Needed to Identify Critical Habitat (NRTSSP 2007).

#	Recovery Measures	Priority[10]	Threats addressed	Timeline	Collaborators
6	Research potential impacts of recreational lake usage on Stickleback Species Pairs, including: - impacts of gas-operated power boats on water quality; and - impacts of lake stocking or use of live bait.	L	Exotic species (including invasive and/ or introduced species); Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation).	Long-term	RIGs, researchers (e.g. academic institutions, consultants), local or provincial governments, stewardship groups, other agencies
7	Develop mitigation measures to address potential impacts from recreational lake usage, and engage relevant agencies regarding the adoption of these measures.	L	Exotic species (including invasive and/ or introduced species); Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation).	Long-term	RIGs, researchers (e.g. academic institutions, consultants), local or provincial governments, stewardship groups, other agencies
Broad Strategies: Establish water quality objectives for all lakes containing the species pairs.					
8	Develop species and/or lake-specific water quality objectives, in order to address the species' biological needs and parameters that affect habitat quality.	H	Water Management (including water pollution and/or sedimentation).	Medium-term (dependent on outcomes of Measures 4, 5, and 6)	RIGs, researchers (e.g. academic institutions, consultants), local or provincial governments, other agencies, stewardship groups
Broad Strategy: Develop a comprehensive water management plan for each basin.					

#	Recovery Measures	Priority[10]	Threats addressed	Timeline	Collaborators
10	Identify and evaluate water management options to satisfy both conservation and stakeholder needs (e.g. timing maximum water extraction during periods of least sensitivity) in the following ways: - Share information on Stickleback Species Pairs; - review the number and extent of water use licenses; - address impacts of changes in lake water levels; and - engage relevant agencies about conservation and water management options.	H	Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation); Climate change.	Medium-term	RIGs, researchers (e.g. academic institutions, consultants), industry local or provincial governments, stewardship groups, other agencies
Broad Strategy: Develop land management strategies (e.g. for Crown and private lands).					
11	Identify and evaluate land use planning and management options in the following ways: - share information about Stickleback Species Pairs, land use-related threats, and mitigation measures and management practices to address these threats; and - encourage relevant agencies or governments to consider Stickleback Species Pairs in developing and modifying land use plans, official community plans, management guidelines and by-laws.	H	Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation); Climate change.	Medium-term	RIGs, researchers (e.g. academic institutions, consultants), industry, local or provincial governments, private landowners, stewardship groups, other agencies
12	Develop a list of mitigation measures and best management practices to address and mitigate the potential impacts of land use activities in the Stickleback Species Pairs' watersheds.	H	Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation).	Medium-term	RIGs, researchers (e.g. academic institutions, consultants), industry local or provincial governments, stewardship groups, other agencies

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

#	Recovery Measures	Priority[13]	Threats addressed	Contributors
Broad Strategy: Establish and support Recovery Implementation Groups (RIGs).				
13	Participate in a group that supports recovery of the Stickleback Species Pairs by implementing actions, initiatives, studies and/or other activities to benefit and increase understanding and awareness.	H	Exotic species (including invasive and/or introduced species); Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation).	Researchers (e.g. academic institutions, consultants), local or provincial governments, stewardship groups, other agencies, groups or individuals
Broad Strategy: Develop an Aquatic Invasive Species management plan (referred to in the Recovery Strategy as an exotic species management plan).				
14	Participate in AIS removal or prevention programs.	H	Exotic species (including invasive and/ or introduced species).	RIGs, researchers (e.g. academic institutions, consultants), stewardship groups, other groups or individuals
Broad Strategies: Establish water quality objectives for all lakes containing the species pairs.				
15	Promote and adopt best management practices to mitigate potential effects of land use on water quality (e.g. turbidity and nutrient levels in lakes).	H	Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation).	RIGs, researchers (e.g. academic institutions, consultants), industry, local or provincial governments, private landowners, stewardship groups, other agencies, groups or individuals
Broad Strategy: Develop a comprehensive water management plan for each basin.				
16	Develop and implement projects to promote water conservation and the adoption of best practices for water use in the Stickleback Species Pairs' watersheds.	M	Water Management (including water pollution and/or sedimentation).	RIGs, industry, local or provincial governments, stewardship groups, other agencies or groups
Broad Strategy: Develop land management strategies (e.g. for Crown and private lands).				
17	Promote and adopt best management practices for land use in Stickleback Species Pairs' watersheds and/or	H	Land Use (including habitat loss or degradation).	Industry, local and provincial governments, private landowners,

[13] "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 ("H") measures are considered those most likely to have an immediate and/or direct influence on attaining the recovery objective for species. Medium priority ("M") measures may have a less immediate or less direct influence on reaching the recovery population and distribution objective, but are still important for recovery of the population. Low priority ("L") recovery measures will likely have an indirect or gradual influence on reaching the recovery objectives, but are considered important contributions to the knowledge base and/or public involvement and acceptance of species.

#	Recovery Measures	Priority[13]	Threats addressed	Contributors
	mitigation measures to reduce potential impacts of land use on the Stickleback Species Pairs.			other agencies
18	Incorporate considerations regarding the conservation and protection of Stickleback Species Pairs, as well as their habitat, in local planning processes and by-laws.	H	Land Use (including habitat loss or degradation).	Local governments
Broad Strategy: Determine the potential impacts from recreational lake usage in lakes containing the species pairs and develop mitigation measures as required.[14]				
19	Adopt and promote practices to reduce potential impacts of recreational lake use.	L	Exotic species (including invasive and/ or introduced species); Water Management (including water pollution and/or sedimentation); Land Use (including habitat loss or degradation).	Recreational users, RIGs, local or provincial governments, stewardship groups, other agencies, groups or individuals
Broad Strategy: Develop and implement information and education plans for the Stickleback Species Pairs.				
20	Develop outreach, education 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:		All.	RIGs, researchers (e.g. academic institutions, consultants), industry, local or provincial governments, stewardship groups, other agencies, groups or individuals
	- 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 (e.g. at ferry terminals, specific lake access points, etc.) about the species and its threats, particularly AIS; - where appropriate, participate in water management and land use planning processes;	H		

[14] Note this Broad Strategy encompasses two Broad Strategies from the Recovery Strategy: i.) Determine the potential impacts of recreational fishing in species pair lakes and develop mitigation measures as required; and, ii.) Determine potential impacts of gas operated motor boats on water quality in the species pair lakes and develop mitigation measures as required, and discourage impacts from lakeshore development and recreational use (NRTSSP 2007).

#	Recovery Measures	Priority[13]	Threats addressed	Contributors
	and			
	- share information at relevant workshops or symposia.	M		

2. Critical Habitat

SARA stipulates that an action plan must include:

> *"an identification of the species' critical habitat, to the extent possible, based on the best available information and consistent with the recovery strategy, and examples of activities that are likely to result in its destruction;"* [ss. 49(1)(a)].

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."* [s. 2(1)]

Also, SARA defines habitat for aquatic species at risk 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."* [s. 2(1)]

Critical habitat for the Paxton Lake and Vananda Creek Stickleback Species Pairs is identified to the extent possible using best available information, and provides the functions and features necessary to support the species' life-cycle processes. The critical habitat identified in this Action Plan is expected to achieve the species' population and distribution objective, which is to maintain self-sustaining populations of Stickleback Species Pairs in Paxton Lake and the Vananda Creek watershed. Additional refinement of the biophysical features and attributes would further enable effective protection of the habitat and its functions that are essential for the species survival or recovery.

The critical habitat identified below is necessary for the survival and recovery of the benthic and limnetic forms of the Paxton Lake and Vananda Creek Stickleback Species Pairs.

2.1 Information and methods used to identify critical habitat

Critical habitat identification for Paxton Lake and Vananda Creek Stickleback Species Pairs has been informed by the publicly available research document *Identification of Critical Habitat for Sympatric Stickleback Species Pairs and the Misty Lake Parapatric Stickleback Species Pair* (Hatfield 2009), which reflects the outcomes of the related peer review process undertaken through DFO's Canadian Science Advisory Secretariat. The identified critical habitat was further refined to align with more recent policy on identifying critical habitat (DFO 2012).

In Hatfield (2009), critical habitat was recommended by applying a three-step framework as suggested in Rosenfeld and Hatfield (2006):

(1) Identification of a population recovery target

Hatfield (2009) considered several different possible population recovery targets for Paxton Lake and Vananda Creek Stickleback Species Pairs, each generated using a different method of analysis or approach to determining the population necessary to ensure genetic viability over the long term.

(2) Determination of a quantitative relationship between habitat and population size

Little information was available to compare habitat availability and abundance for the Paxton Lake and Vananda Creek Stickleback Species Pairs, so a linear relationship between habitat availability and population size was assumed (Hatfield 2009).

(3) Determination of sufficient habitat to meet the recovery target based on the habitat-population relationship.

The results of the analysis of the proportion of existing lake habitat that should be considered critical for each of the different abundance targets identified in step one indicates that the majority or, in some cases, all of the lake habitat is required (Hatfield 2009). Therefore, Hatfield (2009) recommended that the entire lake and a riparian buffer of 15 to 30 metres around the lakes be identified as critical habitat for the Paxton Lake and Vananda Creek Stickleback Species Pairs (Hatfield 2009).

Concerns over potential sediment inputs from activities in areas upstream from the lakes and the risk of hybridization of the two forms of Stickleback in the lakes led Hatfield (2009) to recommend the inclusion of a riparian buffer of 15 to 30 metres in width around all ephemeral and perennial streams flowing into the lakes occupied by the Paxton Lake and Vananda Creek Stickleback Species Pairs.

Recent DFO guidance on critical habitat identification using the bounding box approach, which is described in more detail below, has clarified that critical habitat includes the biophysical features and attributes within an area frequented by the species that provide the functional capacity for the species to carry out its life-cycle processes (DFO 2012). The critical habitat area recommended by Hatfield (2009) was thus adjusted to reflect this new departmental guidance.

2.2 Identification of the species' critical habitat

Critical habitat for Paxton Lake and Vananda Creek Stickleback Species Pairs has been identified using a bounding box approach. This means that critical habitat is not comprised of the entire area within the identified geographic boundaries, but only those areas within the identified boundaries where the described biophysical feature and the function it supports occur.

2.2.1 Biophysical Functions, Features and their Attributes

Table 4 and the narrative below summarize the best available knowledge of the functions, features and attributes for each life stage of the Paxton Lake and Vananda Creek Stickleback Species Pairs. Note that not all attributes in Table 4 must be present for a feature to be identified as critical habitat. If the features as described in Table 4 are present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated by the table.

A key function of critical habitat features and attributes for the Paxton Lake and Vananda Creek Stickleback Species Pairs is to provide reproductive separation and prevent hybridization. Achieving the recovery goal of the sustained viability of populations of both Stickleback Species Pairs depends on:

1) Critical habitat features and attributes that control the abundance of the limnetic and benthic species forms (i.e. population size), and,

2) Critical habitat features and attributes that provide reproductive separation through proper mate recognition[15] (NRTSPP 2007).

As a group, Sticklebacks are relatively hardy species tolerant to a fairly large range of water quality conditions. Until more information becomes available, the British Columbia *Water Quality Guidelines* serve as a general guideline for water quality parameters for lake critical habitat features and attributes (Hatfield 2009).

[15] Other mechanisms influencing reproductive separation have been under investigation since publication of the Recovery Strategy.

Table 4. Summary of critical habitat biophysical functions, features and attributes for the Paxton Lake and Vananda Creek Benthic and Limnetic Sticklebacks.

Geographic location	Life Stage	Function	Features	Attributes
Paxton, Spectacle, Priest and Emily Lakes	Benthic eggs, fry, juveniles and adults Limnetic eggs, fry, juveniles and adults	Nursery, rearing, foraging (except for Limnetic adults) and resting	Lake littoral habitat	▪ Stable faunal community, free of aquatic invasive species ▪ Presence of macrophyte beds (within natural range of abundance) ▪ Physical habitat complexity, including fallen logs ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation) ▪ Stable lake water levels (within the natural range of variation) ▪ Adequate food supply, including benthic invertebrates
Paxton, Spectacle, Priest and Emily Lakes	Benthic and Limnetic adults	Mating, spawning and nest creation and defense	Lake littoral habitat	▪ Stable water clarity and transmission of light (i.e. little or no turbidity) ▪ Stable faunal community, free of aquatic invasive species ▪ Presence of macrophyte beds (within natural range of abundance) ▪ Physical habitat complexity, including fallen logs ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation) ▪ Stable lake water levels (within the natural range of variation) ▪ Adequate food supply, including benthic invertebrates
Paxton, Spectacle, Priest and Emily Lakes	Limnetic juveniles and adults	Rearing, foraging and resting	Lake pelagic habitat	▪ Stable faunal community, free of aquatic invasive species ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation) ▪ Adequate food supply, including zooplankton

Geographic location	Life Stage	Function	Features	Attributes
Paxton, Spectacle, Priest and Emily Lakes	Benthic and Limnetic Juveniles and adults	Overwintering and winter foraging	Lake pelagic habitat	▪ Stable faunal community, free of aquatic invasive species ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation) ▪ Adequate food supply
Paxton, Spectacle, Priest and Emily Lakes	Benthic eggs, fry, juveniles and adults Limnetic eggs, fry, juveniles and adults	Mating, spawning, nest creation and defence, nursery, rearing, foraging resting	Riparian area surrounding wetted perimeters of the lakes	▪ Physically stable foreshore environment (e.g. stable riparian banks) ▪ Sufficient riparian vegetation to provide food and nutrients ▪ Adequate supply of cover (large woody debris, overhanging vegetation) ▪ Adequate filtering and absorption of surface water run-off
Shallow marsh between Spectacle and Priest Lakes Stream and marsh between Emily and Priest Lakes	Vananda Creek Benthic and Limnetic adults and juveniles	Movement and migration	Stream and marsh habitat	▪ Free of barriers to movement by fish ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation)
			Riparian area surrounding wetted perimeters of the streams and marshes	▪ Physically stable foreshore environment (e.g. stable riparian banks) ▪ Sufficient riparian vegetation to provide food and nutrients ▪ Adequate supply of cover (large woody debris, overhanging vegetation) ▪ Adequate filtering and absorption of surface water run-off

Brief discussions on the habitat features and attributes are provided below, adopted from the work by Hatfield (2009) and the Recovery Strategy (NRTSSP 2007).

Critical Habitat Feature – Lake littoral habitat

Lake littoral habitat serves important spawning and rearing functions for the Paxton Lake and Vananda Creek Stickleback Species Pairs. During spawning season, Benthic adults build their nests under cover of macrophytes or other structures, while Limnetic adults tend to spawn in open habitats (McPhail 1994; Hatfield and Schluter 1996; Hatfield 2009). Both Limnetic and Benthic Stickleback fry are reared in the littoral zone (Hatfield 2009). Littoral macrophyte beds constitute both a source of food (benthic invertebrates associated with the lake bottom and macrophyte surfaces) and refuge from predation (NRTSPP 2007). As juveniles, Limnetics are common along steep, rocky, unvegetated littoral shorelines, compared to Benthics which shelter around macrophytes in littoral areas (Gow pers. comm., as cited in Hatfield 2009). As adults, Limnetics feed on zooplankton in the pelagic zone of the lake, whereas adult Benthics remain in the littoral zone feeding on benthic invertebrates (Schluter 1995).

<u>Critical Habitat Attribute</u> – *Stable faunal community, free of aquatic invasive species*

Maintaining a stable faunal community, including the macrophyte community, fish, zooplankton and macroinvertebrates which all contribute to the lake ecosystem as a whole, is necessary if the Paxton Lake and Vananda Creek Species Pairs are to be conserved (Hatfield 2009). The Stickleback Species Pairs have evolved in coastal freshwater systems where only one other fish species exist - Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) (Vamosi 2003). A stable ecological community for the lakes containing these Stickleback Species Pairs is crucial, as any invasive species in the lake habitat can easily upset the balance of the lake ecosystem. This is exemplified by the rapid extinction of the Hadley Lake Stickleback Species Pair following the invasion of Brown Bullhead (*Ameiurus nebulosus*), and the collapse of the Stickleback Species Pair at Enos Lake on Vancouver Island following the invasion of Signal Crayfish (*Pacifastacus leniusculus*) (Taylor et al. 2006; Behm et al. 2010; Rosenfeld et al. 2008). A stable ecological community structure free of invasive species is critical to the survival of the Paxton Lake and Vananda Creek Stickleback Species Pairs.

<u>Critical Habitat Attributes</u> – *Presence of macrophyte beds (within natural range of abundance); physical habitat complexity, including fallen logs*

Macrophyte beds represent an important attribute of critical habitat for the Paxton Lake and Vananda Creek Stickleback Species Pairs. Macrophyte beds in the littoral zone constitute the primary nesting and spawning locations for Benthic Sticklebacks as well as key rearing habitats for juveniles of both species. Due to different nest selection with respect to macrophyte coverage and its associated habitat complexity, macrophyte beds indirectly help to maintain mate recognition and reproductive isolation between the Benthic and Limnetic Stickleback species (McPhail 1994; Hatfield and Schluter 1996). Macrophytes stabilize littoral zone substrates and significantly contribute to the production of benthic macroinvertebrates that support the Benthic Stickleback species. They help maintain lake turbidity, which is an important factor for accurate mate recognition. As a result they also indirectly contribute to light transmission level (Hatfield 2009), another critical habitat attribute. The complex physical habitat structure that macrophyte beds provide is identified as a critical habitat attribute, since the observed hybridization and collapse of the Enos Lake Stickleback Species Pair coincides with the introduction of crayfish and the loss of macrophytes (Taylor et al. 2006; Behm et al. 2010).

The natural temporal range in distribution and abundance of macrophyte beds is unknown. The specific extent of macrophyte loss that can be sustained before hybridization rates reach a level causing the species to collapse into a hybrid swarm is also unknown. It is recommended, therefore, that macrophyte abundance and distribution be maintained within the natural range currently found in each lake (Hatfield 2009).

Other elements of physical habitat structure, such as fallen logs, are also an important source of cover for Sticklebacks.

<u>Critical Habitat Attribute</u> – *Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation)*

Stable water quality parameters in both pelagic and littoral habitats are important for healthy Stickleback populations. These include chemical and physical parameters such as pH, dissolved oxygen, turbidity, suspended solids, nutrients, dissolved organic carbon and low pollutant levels.

Solitary Stickleback populations exist across a broad range of lake productivities in British Columbia (Lavin and McPhail 1985, 1986 and 1987). In contrast, Stickleback Species Pairs are found only in lakes with relatively high productivity, typically with calcareous bedrock present in the watershed (McPhail 1994). The evolution of Stickleback Species Pairs is believed to have been possible only under specific levels of benthic and pelagic invertebrate production that facilitated exclusive adaptations to either a pelagic (zooplankton) or littoral (benthic invertebrate) food resource. Changes to water quality parameters, including nutrient levels that alter the relative productivity of zooplankton and benthos, could alter the selective environment in which Stickleback Species Pairs exist (Schluter 1995; Vamosi et al. 2000). Altered nutrient status may lead to demographic collapse or hybridization between the two species by altering the fitness of Limnetics, Benthics or hybrids.

As a group, Sticklebacks are tolerant of a fairly large range of water quality conditions. The precise needs of the Paxton Lake and Vananda Creek Species Pairs are unknown but are believed to be similar to other Stickleback species (Hatfield 2009). The Recovery Strategy indicates that the British Columbia *Water Quality Guidelines* are considered appropriate for basic water quality parameters for the Paxton Lake and Vananda Creek Stickleback Species Pairs (NRTSSP 2007).

<u>Critical Habitat Attribute</u> – *Stable lake water levels (within the natural range of variation)*

Lake water levels can be subject to human influence through the construction of dams and the extraction of water. Water licenses currently allow substantial volumes to be extracted from several lakes that are home to Paxton Lake and Vananda Creek Stickleback Species Pairs, and, in some cases the annual extraction volume exceeds the volume of the lake (NRTSSP 2007; Larson 1976).

Since lake water levels can affect littoral habitat and macrophyte abundance, water level stability is important to the persistence of the Paxton Lake and Vananda Creek Stickleback Species Pairs. The relative extent of littoral habitat may affect reproductive isolation during nesting, growth and survival of juveniles of both species, adult abundance and individual size, as well as hybrid fitness (NRTSSP 2007). Variation in the extent of littoral habitat outside of the natural range will significantly increase the probability of species hybridization and collapse. Based on genetic evidence, historic hybridization has been considerably higher in the Paxton Lake species pair than in other species pairs (Taylor and McPhail 1999, as cited in COSEWIC 2010b). This higher rate of hybridization is thought to be consistent with the higher rate of historical perturbations, including drawdowns from water extraction, in Paxton Lake (COSEWIC 2010b).

<u>Critical Habitat Attributes</u> – *Stable water clarity and transmission of light (i.e. little or no turbidity)*

Light transmission levels and water clarity are an important attribute of the littoral habitat feature during spawning season. Changes in these attributes can be a significant issue for the reproductive success of the Paxton Lake and Vananda Creek Stickleback Species Pairs. Differences in breeding coloration between Benthics and Limnetics are key cues used in mate discrimination and reproductive isolation (Boughman 2001). Changes in concentration of suspended solids, dissolved organic carbon (e.g. tannins), or other aspects of lake water quality that affect light transmission may disrupt mate recognition using visual cues, and could compromise the reproductive isolation between the benthic and limnetic forms of the Stickleback Species Pairs (Engström-Öst and Candolin 2007; Hatfield 2009). The possible collapse of Enos Lake Stickleback Species Pair into a hybrid swarm may also be attributed to the altered turbidity or water colour caused by invasive species (Taylor et al. 2006). No published data is available to quantify this attribute; however, it is reasonable to infer that a stable level of light transmission in the littoral habitat is critical in the spawning season.

<u>Critical Habitat Attribute</u> – *Adequate food supply, including benthic invertebrates*

The availability of an adequate supply of food is an important attribute of littoral and pelagic critical habitat features for Benthic and Limnetic Sticklebacks. Both Benthic and Limnetic fry feed in inshore areas once they leave the nest (Schluter 1995). Limnetic adults feed on zooplankton in the pelagic zone of the lake, whereas Benthic adults remain in the littoral zone and feed on benthic invertebrates (Schluter 1995).

<u>Critical Habitat Feature – Lake pelagic habitat</u>

Pelagic habitat is critical to the Paxton Lake and Vananda Creek Stickleback Species Pairs as it provides adult and juvenile rearing and overwintering functions. Adult Limnetic Stickleback, with the exception of nesting males, feed on zooplankton in the pelagic zone of the lake (Schluter 1995). By late summer individuals begin moving to deeper water habitats where they overwinter (Hatfield 2009). It is reasonable to infer that, similar to littoral habitat, overwintering populations will require pristine pelagic lake environments. As such, critical pelagic lake habitat attributes will include a stable ecological lake community structure, free of invasive species, as well as favorable water quality parameters (e.g. temperature, pH, dissolved oxygen, turbidity, suspended solids and nutrients).

<u>Critical Habitat Feature – Riparian area surrounding wetted perimeters of lakes, streams and marshes</u>

On riparian areas and their function as critical habitat for the Paxton Lake and Vananda Creek Stickleback Species Pairs, Hatfield (2009) states:

> "Riparian zones form a physical transition zone between aquatic and terrestrial ecosystems, and there are often strong physical and biological interactions between the two. For fish, riparian zones offer three important functions: streambank and lakeshore stability (e.g., roots bind soils and prevent erosion or sloughing), instream cover (e.g., large and small woody debris, overhanging vegetation), and food (e.g., insect fall and contribution to invertebrate food sources). There are abundant data demonstrating the importance of riparian areas to physical processes, general ecology, and fish populations in lakes and streams […], though admittedly there is considerably more information available for streams than for lakes."

Based on the discussion offered by Hatfield (2009), the riparian area critical habitat feature has the following attributes:

Critical Habitat Attribute – *Physically stable foreshore environment (e.g. stable riparian banks) and adequate filtering and absorption of surface water run-off*

Of special significance to the Paxton Lake and Vananda Creek Stickleback Species Pairs is the role of vegetated riparian areas in preventing additional sediment from entering the lakes. Increased sedimentation could lead to increases in lake turbidity that may potentially trigger increased hybridization between the species pairs, particularly if the increased turbidity occurs during the breeding season. Vegetated riparian areas increase bank stability as plant roots bind soils, thereby reducing sedimentation. They also filter and absorb surface water run-off that could otherwise carry high sediment loads into the lakes.

Critical Habitat Attribute – *Adequate supply of cover (large woody debris, overhanging vegetation)*

As described by Hatfield (2009), the provision of in-stream cover by a supply of large woody debris and overhanging vegetation is an important function of the riparian zone.

Critical Habitat Attributes – *Sufficient riparian vegetation to provide food and nutrients*

Lake riparian areas contribute to the energy base of aquatic ecosystems through inputs of leaves, dissolved nutrients and insect fall; such external inputs can amount to up to half of the carbon base of lake ecosystems (Pace et al. 2004), particularly in small lakes with large perimeter to area ratios. Typically the contribution is less than half, but has been measurable in many studies (e.g. France and Peters 1995; France et al. 1996; France and Steedman 1996).

Riparian areas provide inputs of terrestrial invertebrates that are directly consumed by fish; large woody debris inputs from the riparian zone also provide substrate for invertebrates and structural heterogeneity that influences fish abundance and the ecology of the littoral zone (Schindler et al. 2000; Christensen et al. 1996). Again it is difficult to quantify this critical habitat attribute. However it is reasonable to infer that integrity of riparian areas plays an important role in maintaining a stable food supply to aquatic environment.

Critical habitat feature – Stream and marsh habitat

The three lakes containing a Stickleback Species Pair in the Vananda Creek watershed are connected by stream and marsh habitat. Benthic and Limnetic Sticklebacks move through the shallow marsh between Spectacle and Priest Lakes in both directions (COSEWIC 2010a). The stream and marsh between Emily and Priest Lakes are also potentially navigable to Sticklebacks (Taylor and McPhail 2000). As well as providing for the movement of Sticklebacks between lakes and creating opportunities for gene flow between the lake populations, riparian areas beside these habitats provide sources of terrestrial invertebrates and large woody debris as described earlier.

2.2.2 Geographic Location

The following locations of the critical habitat functions, features and attributes for the Paxton Lake and Vananda Creek Stickleback Species Pairs have been identified using the bounding box approach. This means that critical habitat is not comprised of the entire area within the identified boundaries, but only those areas within the identified geographic boundaries where the described biophysical feature and the function it supports occur. These are the areas that the Minister of Fisheries and Oceans considers necessary to support the recovery objectives for these Stickleback Species Pairs.

Figures 3 and 4 show the boundaries and coordinates of the bounding boxes that contain critical habitat features, functions and attributes for the Vananda Creek and Paxton Lake Stickleback Species Pairs. These critical habitat maps are produced based on best available information and are only meant to provide geographical information related to critical habitat.

The geospatial extent of critical habitat for the Paxton Lake and Vananda Creek Stickleback Species Pairs includes the entirety of Paxton, Spectacle, Priest and Emily Lakes and an associated riparian area. Hatfield (2009) recommended that critical habitat for the Paxton Lake and Vananda Creek Stickleback Species Pairs include "a riparian buffer of 15 to 30 m width surrounding the wetted perimeter of [the lakes]". A 15 metre riparian buffer is important for bank stability, woody debris supply, and for food and nutrient inputs from litter fall and insect drop into the lake and streams. The larger 30 metre riparian buffer is suggested for areas where shade provides a specific function to the habitat. Shade is not as important for the lakes due to their larger surface area which results in most of the lake receiving sunlight regardless if the riparian buffer is 15 meters or 30 meters. Also, woody debris supply and insect drops are likely more important than shade for Stickleback Species Pairs (Hatfield 2009). Therefore, the width of the riparian area surrounding the lakes included in the critical habitat bounding box area for the Paxton Lake and Vananda Creek Stickleback Species Pairs is 15 metres measured from the wetted perimeter of each lake.

In 2009, Hatfield recommended that a "riparian buffer of 15 to 30 m width surrounding […] all ephemeral and perennial streams flowing into the [species pair] lakes" be included in critical habitat, due to concerns over sediment inputs from upstream activities. Individual Sticklebacks are not present in these streams. Subsequent DFO guidance on critical habitat identification using the bounding box approach clarified that critical habitat includes the biophysical features and attributes within an area frequented by the species that provide the functional capacity for the species to carry out its life cycle processes (DFO 2012). Therefore, streams that the Paxton Lake and Vananda Creek Stickleback Species Pairs do not frequent have not been included in critical habitat. The need of the Paxton Lake and Vananda Creek Stickleback Species Pairs for lake habitat that has attributes such as stable light transmission levels (i.e. little or no turbidity) in order to successfully spawn and not hybridize has been addressed by identifying these critical habitat attributes as being necessary for the survival and recovery of these Stickleback Species Pairs in Section 2.2.1 above.

Streams that may support movement of Benthic and Limnetic Sticklebacks between lakes in the Vananda Creek watershed are also included in the area containing critical habitat for the Paxton Lake and Vananda Creek Stickleback Species Pairs, along with an associated riparian area of 30 metres. This includes the shallow marsh between Spectacle and Priest Lakes, which Sticklebacks move through in both directions, and the stream and marsh between Emily and Priest Lakes, which are also potentially navigable to Sticklebacks (COSEWIC 2010a; Taylor and McPhail 2000).

Overall, the geographic extent of critical habitat for the Paxton Lake Stickleback Species Pair includes:

1. The entire Paxton Lake and a riparian area of 15 metre width surrounding the wetted perimeter of the lake. The wetted perimeter is to be interpreted on the ground as the high water mark for ungauged lakes as defined in the *Riparian Areas Regulation*'s Schedule of Assessment Methods (B.C. Reg. 376/2004).[16]

The geographic extent of critical habitat for the Vananda Creek Stickleback Species Pair includes:

1. The entire lakes (Spectacle, Priest and Emily Lakes) and a riparian area of 15 metre width surrounding the wetted perimeter of the lakes. The wetted perimeter is to be interpreted on the ground as the high water mark for ungauged lakes as defined in the *Riparian Areas Regulation*'s Schedule of Assessment Methods (B.C. Reg. 376/2004).[17]
2. The shallow marsh between Spectacle and Priest Lakes and a riparian area of 30 metre width surrounding the wetted perimeter of the marsh. The wetted perimeter of the marsh is to be interpreted on the ground as the high water mark for streams and wetlands, respectively, as defined in the *Riparian Areas Regulation*'s Schedule of Assessment Methods (B.C. Reg. 376/2004).[18]
3. The stream and marsh between Emily and Priest Lakes and a riparian area of 30 metre width surrounding the wetted perimeter of both sides of the stream and surrounding the wetted perimeter of the marsh. The wetted perimeter of the stream and marsh is to be interpreted on the ground as the high water mark for streams and wetlands, respectively, as defined in the *Riparian Areas Regulation*'s Schedule of Assessment Methods (B.C. Reg. 376/2004).[19]

[16] The *Riparian Areas Regulation*'s Schedule of Assessment Methods defines the high water mark for ungauged lakes as "*where the presence and action of annual flood waters area is so common and usual and so long continued in all ordinary years, as to mark on the soil of the bed of the body of water a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself and includes areas that are seasonally inundated by floodwaters."*

[17] Ibid.

[18] The *Riparian Areas Regulation*'s Schedule of Assessment Methods defines the high water mark for streams as "*the visible high water mark of a stream where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the stream a character distinct from that of its banks, in vegetation, as well as the nature of the soil itself, and includes the active floodplain"*. The *Riparian Areas Regulation*'s Schedule of Assessment Methods defines the outer edge of wetlands as "*from an ecological perspective, either an abundance of hydrophytes or hydric soil conditions is generally sufficient to indicate a wetland ecosystem. The boundary or high water mark of the wetland is identified by changes in vegetation structure, loss of obligate hydrophytes, and absence of wetland soil characteristics*."

[19] Ibid.

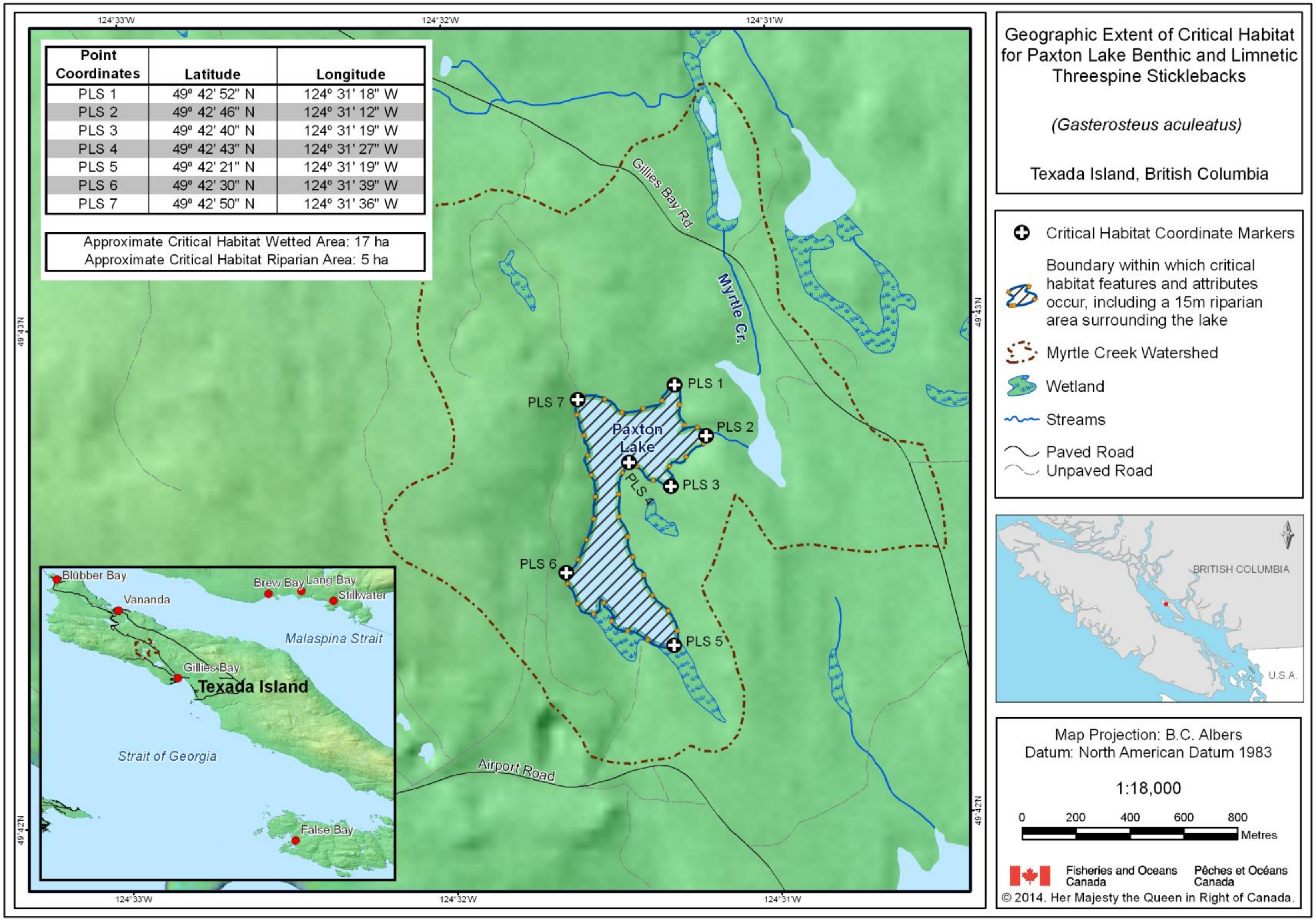
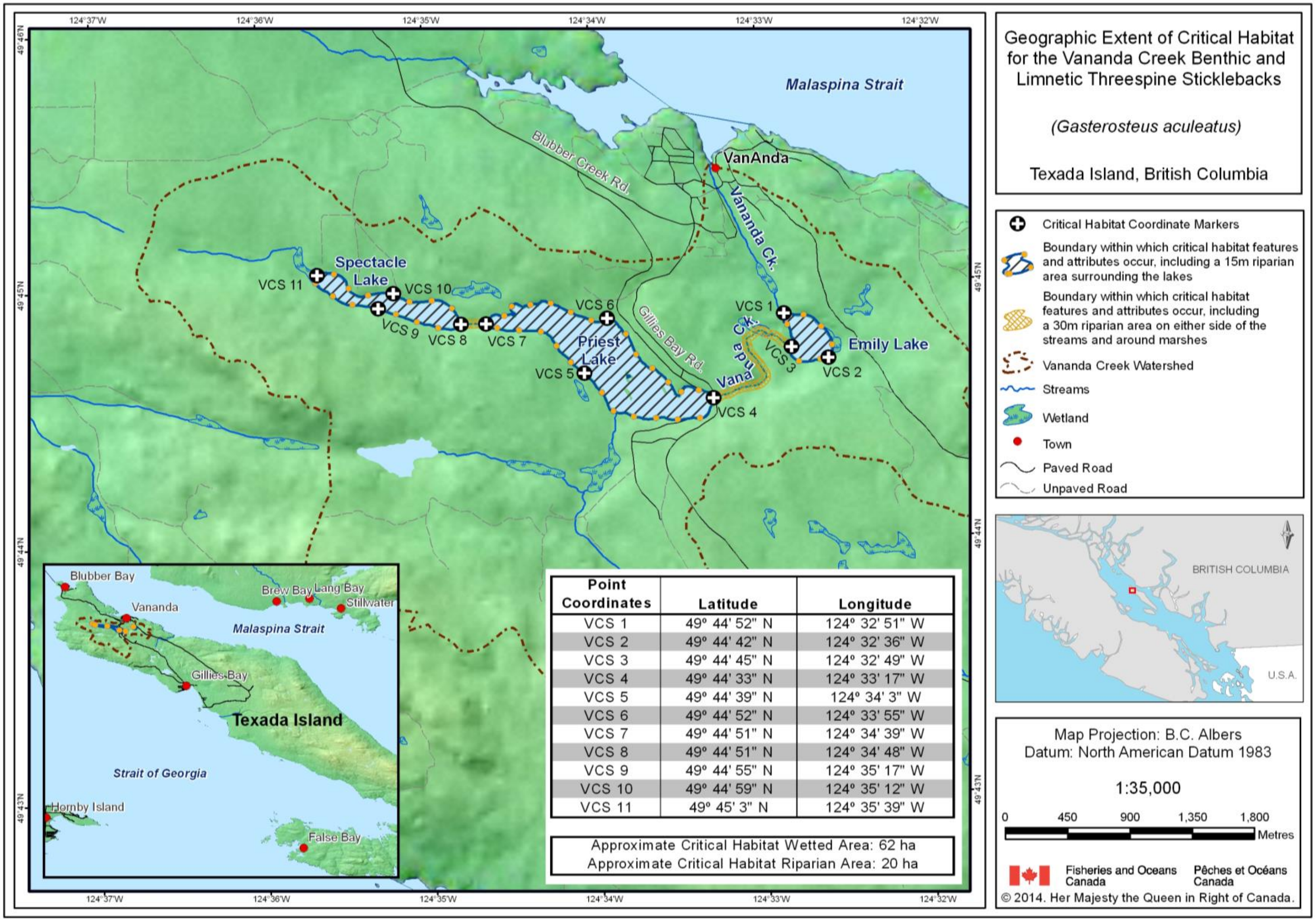


Figure 3. Geographic Extent of Critical Habitat for Paxton Lake Benthic and Limnetic Threespine Sticklebacks.



Point Coordinates	Latitude	Longitude
VCS 1	49° 44' 52" N	124° 32' 51" W
VCS 2	49° 44' 42" N	124° 32' 36" W
VCS 3	49° 44' 45" N	124° 32' 49" W
VCS 4	49° 44' 33" N	124° 33' 17" W
VCS 5	49° 44' 39" N	124° 34' 3" W
VCS 6	49° 44' 52" N	124° 33' 55" W
VCS 7	49° 44' 51" N	124° 34' 39" W
VCS 8	49° 44' 51" N	124° 34' 48" W
VCS 9	49° 44' 55" N	124° 35' 17" W
VCS 10	49° 44' 59" N	124° 35' 12" W
VCS 11	49° 45' 3" N	124° 35' 39" W

Figure 4. Geographic Extent of Critical Habitat for the Vananda Creek Benthic and Limnetic Threespine Sticklebacks.

2.2.3 Examples of activities likely to result in destruction of critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For the Paxton Lake and Vananda Creek Stickleback Species Pairs' critical habitat, it is anticipated that this will be accomplished through a SARA Critical Habitat Protection 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.

Because the identified critical habitat is for both the limnetic and the benthic forms of the Paxton Lake and Vananda Creek Stickleback Species Pairs, which together make up the species complex for each pair, the destruction of critical habitat for one species could have significant consequences for the other species of the pair, in terms of effects on the health of individuals, their residences and their identified critical habitat. The legal protections provided by SARA apply equally to both the Limnetic and Benthic species of the Paxton Lake and Vananda Creek Stickleback Species Pairs.

The activities likely to destroy critical habitat described in this section are neither exhaustive nor exclusive and have been guided by the threats in Section 3 of the Recovery Strategy (NRTSSP 2007). The absence of a specific human activity in Table 5 does not preclude or restrict the Department's ability to regulate it pursuant to SARA. Furthermore, the inclusion of an activity in Table 5 does not result in its automatic prohibition since it is the destruction of critical habitat that is prohibited. Activities that impact critical habitat but do not result in its destruction are not prohibited. Since habitat use is often temporal in nature, every activity is assessed on a case-by-case basis and site-specific mitigation is applied where it is reliable and available. In every case, where information is available, thresholds and limits are associated with attributes to better inform management and regulatory decision-making. However, in many cases the knowledge of a species and its critical habitat may be lacking, including specific information associated with the species or habitat thresholds of tolerance to disturbance from human activities, and should be acquired.

Table 5 contains examples of activities that are likely to destroy critical habitat for the Paxton Lake and Vananda Creek Stickleback Species Pairs. Detailed explanations follow the table.

Table 5. Examples of activities likely to result in the destruction of critical habitat.

Activity	Effect Pathway	Functions Affected	Features Affected	Attributes Affected
Exotic, Invasive, or Introduced Species: Introduction through deliberate or inadvertent human actions potentially leading to subsequent establishment of non-native aquatic species into lakes	Alteration of water quality which could impact water clarity required for mate recognition. Change in vegetation community composition or structure which may affect reproductive isolation and nesting sites. Change in the faunal community that results in impacts to Stickleback populations, either directly through increased predation or displacement from nesting habitat leading to recruitment failure, or indirectly through competition for food and resources or reduced availability of prey.	Rearing, foraging and resting Mating, spawning and nest creation and defense Overwintering and foraging	Lake pelagic habitat Lake littoral habitat	▪ Stable faunal community, free of aquatic invasive species ▪ Presence of macrophyte beds (within natural range of abundance) ▪ Physical habitat complexity, including fallen logs ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation) ▪ Adequate food supply including zooplankton and benthic invertebrates

Activity	Effect Pathway	Functions Affected	Features Affected	Attributes Affected
Habitat loss and degradation: Substantial riparian vegetation removal within the defined riparian areas	Reduction in bank stability leading to an increase in sediment inputs to water, which could: - impact water clarity required for mate recognition while spawning; and/or - change aquatic vegetation cover or the food and nutrient regime in the lakes. Reduction in vegetative cover from predators and terrestrially-derived food. Increases in amount of sunlight reaching the lake(s), stream or marsh enhancing algal production and leading to temporary loss of habitat. Alteration of water quality (e.g. nutrients, sediment, turbidity, etc.). See pathway for Exotic, Invasive or Introduced Species and Water Pollution.	Rearing, foraging and resting Mating, spawning and nest creation and defense Overwintering and foraging	Lake pelagic habitat Lake littoral habitat Riparian area surrounding wetted perimeters of lakes, streams and marshes	▪ Physically stable foreshore environment (e.g. stable riparian banks) ▪ Sufficient riparian vegetation to provide food and nutrients ▪ Adequate supply of cover (large woody debris, overhanging vegetation) ▪ Adequate filtering and absorption of surface water run-off ▪ Physical habitat complexity, including fallen logs ▪ Stable water clarity and transmission of light (i.e. little or no turbidity) ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation)
Water pollution: Non-point source pollution and changes in water quality resulting from land use practices, e.g. from road construction, and poorly maintained roads, stream crossings, and transmission routes	Increase in sediment inputs to water could impact water clarity required for mate recognition while spawning.	Mating, spawning and nest creation and defense	Lake littoral habitat	▪ Stable water clarity and transmission of light (i.e. little or no turbidity) ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation)

Activity	Effect Pathway	Functions Affected	Features Affected	Attributes Affected
Water Extraction / Impoundment: Excessive water extraction and/or impoundment resulting in changes to lake levels.	Impoundment and/or excessive water extraction could alter lake littoral and pelagic area ratios. This could result in changes to macrophyte beds and physical habitat structure, which would affect Stickleback nesting, foraging and spawning. Changes to lake levels could result in reduced availability of habitat for spawning and foraging.	Rearing, foraging and resting Mating, spawning and nest creation and defense	Lake pelagic habitat Lake littoral habitat	▪ Physical habitat complexity, including fallen logs ▪ Stable water quality parameters, including temperature, pH, dissolved oxygen, turbidity, suspended solids, dissolved organic carbon and nutrients (within the natural range of variation) ▪ Presence of macrophyte beds (within natural range of abundance) ▪ Stable lake water levels (within the natural range of variation)

Exotic, Invasive, or Introduced Species

The fish communities in the lakes that are home to the Stickleback Species Pair only contain Sticklebacks and Coastal Cutthroat Trout (Larson 1976). This simple fish community is considered to be a major determinant of the existence of Stickleback Species Pairs (Vamosi 2003; Ormond 2010). One of the greatest threats to the Paxton Lake and Vananda Creek Stickleback Species Pairs is from the introduction of aquatic invasive species through deliberate or inadvertent human activities (Hatfield 2009). Introduction pathways may include the use of live bait, unauthorized aquatic species transfer or stocking, pet and aquarium releases, unintentional species transfer from outdoor ponds or recreational boating, introduction and cultivation of live food fish (e.g. crayfish), deliberate or malicious introduction, and range expansion of invasive species. Aquatic invasive species may threaten Stickleback populations directly (e.g. predation or displacement from nesting habitat leading to recruitment failure) or indirectly (e.g. competition for food resources, or alteration of the selective regime of their habitat).

The introduction of invasive species has been implicated in the loss of two of five of the known Benthic-Limnetic Stickleback Species Pairs. The Hadley Lake Benthic-Limnetic Stickleback Species Pair on Lasqueti Island, British Columbia became extinct within five years following the introduction of Brown Bullhead (Hatfield 2001). The Stickleback Species Pair in Enos Lake on Vancouver Island may have collapsed due to hybridization that coincided with the arrival of Signal Crayfish (Taylor et al. 2006; Behm et al. 2010).

Habitat loss and degradation and water pollution

The lands in the Paxton Lake and Vananda Creek watersheds have had a long history of disturbances, including rock quarrying, forest harvesting and other development. Landscape alteration and riparian loss from these practices have potential to result in increased turbidity and sedimentation of the lakes from run-off over exposed lands or roads. The tolerance of the Paxton Lake and Vananda Creek Stickleback Species Pairs to changes in water quality is unknown. However, adverse changes in lake water quality can be expected to adversely affect water transparency (e.g. increased turbidity or dissolved organic carbon, with resultant reduction of light transmission levels), which in turn may disrupt reproductive isolation mechanisms of Stickleback Species Pairs by interfering with female mate discrimination, and subsequently elevate the hybridization rate (Engström-Öst and Candolin 2007). An increase in hybridization rate by as little as 3% is sufficient to cause the collapse of Benthics and Limnetics into a hybrid swarm (Wood et al. 2004).

Riparian loss or alteration may also cause increased lake temperatures and reduce food and nutrient inputs to foreshore environments. Such changes in lake ecology may lead to littoral habitat changes which could alter optimum rearing and spawning conditions and affect Stickleback population dynamics.

Water Extraction / Impoundment:

In the Paxton Lake and Vananda Creek watersheds, lake levels are affected by the diversion and storage of water. Existing licenses are large relative to the volume of some of the lakes and size of the catchments. For example, existing water licenses on Paxton Lake allow annual diversions of more than twice the volume of the lake, yet inflows are low due to a small catchment area and limited precipitation (NRTSSP 2007). Severe drawdowns have occurred in the past as a result of mining operations (Larson 1976). The community of Van Anda depends on water extraction from the Vananda Creek watershed for its drinking water supply and for firefighting. Licensed annual diversion rates total around 15% of Priest Lake volume and about 82% of Emily Lake volume (Harvey and Brown 2013). Depending on the timing and duration of extractions, lake level drawdown may cause loss of the effective littoral zone available for foraging and nesting as critical habitat functions. Large drawdowns and subsequent lake impoundment can shrink lake volume and depth to such an extent that pelagic habitat essentially disappears and littoral habitat is all that remains, or can adversely impact littoral habitat growth and quality which affects habitat availability and productivity. Such modifications can also adversely affect water temperatures. Effects from water extraction and impoundment can result in direct effects on the Paxton Lake and Vananda Creek Stickleback Species Pairs by reducing available spawning and foraging habitat.

2.3 Proposed Measures to Protect Critical Habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For the Paxton Lake and Vananda Creek Stickleback Species Pairs' critical habitat, it is anticipated that this will be accomplished through a SARA Critical Habitat Protection 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.

In addition to this prohibition, various other mechanisms are expected to aid in the protection of critical habitat. For example, the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) established an 881 ha Wildlife Habitat Area (WHA) #2-250[20] on provincial Crown land for Vananda Creek Benthic and Limnetic Sticklebacks under the *Government Actions Regulation* (B.C. Reg. 582/2004) of the *Forest and Range Practices Act* (FRPA) in 2013. *Forest Act* and *Range Act* agreement-holders who prepare and submit plans and who conduct forest or range practices must comply with the WHA and General Wildlife Measures (GWMs) that apply to it.[21] MFLNRO also established a WHA (#2-250) in 2015 under the *Environmental Protection and Management Regulation* (EPMR; B.C. Reg. 200/2014) of the *Oil and Gas Activities Act* (OGAA) encompassing the same geographic area as FRPA's WHA #2-250. WHAs established under the OGAA do not include GWMs, as authority for regulating oil and gas activities in the WHA is transferred from MFLNRO to the Oil and Gas Commission (OGC) upon its establishment. WHA designations under the EPMR are considered by the OGC in adjudicating oil and gas activity permits.[22]

[20] WHA #2-250 under FRPA. WHA is composed of a 242 ha Core Area and a 639 ha Management Zone.
[21] Specifically, the WHA establishes (among others) GWMs that describe what forest or range practices may or may not be permitted within its boundaries, such as: timber harvest and salvage; development of roads, trails, landings, recreation sites, facilities and structures; use of pesticides; and, surface erosion, sediment delivery, and turbidity.
[22] This OGAA WHA would bring into effect the EPMR's "government's environmental objectives" for that area of wildlife habitat. Specifically, the OGC must be satisfied that: there is no "material adverse effect on the ability of the wildlife habitat within the wildlife habitat area to provide for the survival, within the wildlife habitat area, of the wildlife species for which the wildlife habitat area was established" and "that oil and gas activities on an operating area outside of a wildlife habitat area be carried out at a time and in a manner that does not result in physical disturbance to high priority wildlife or their habitat, including disturbance during sensitive seasons and critical life-cycle stages" (B.C. Reg. 200/2014). Depending on the OGC's ability to answer these two questions, an oil and gas operating area in a WHA may or may not be approved .

The Powell River Regional District has also enacted the Texada Island Watershed Protection Bylaw No. 237, 1993. This bylaw has (among other actions) delineated zones surrounding Priest and Spectacle Lakes “to protect the Priest Lake Watershed from deleterious activity and uses which would tend to result in erosion, siltation and pollution of essential water resources” and “to permit only those uses and activities on the Lakes which are compatible with the maintenance of the water in the Lakes in a natural state.”[23]

Both the WHA #2-250 and the Texada Island Watershed Protection Bylaw No. 237, 1993 are considered beneficial to critical habitat protection given the current understanding of the nature and extent of the identified threats to the species.

2.4 Residence

SARA defines a residence as:

> *“a dwelling place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating;”* [s. 2(1)].

Stickleback Species Pairs, including Paxton Lake and Vananda Creek Species Pairs, spawn in the shallow littoral areas of lakes (McPhail 1994). Limnetics spawn from early April to early June in open nesting sites on gravel or rock substrates, or on submerged logs, and at depths of no more than one metre. Benthics spawn from mid-March to mid-May and choose sites under the cover of aquatic vegetation or other structures in slightly deeper water, up to two metres (McPhail 1994; Hatfield and Schluter 1996, as cited in Hatfield 2009). The males of the species build nests in which a female lays her eggs. Males may mate with several females over a one to four day period. The males guard and defend the nests throughout nest construction, mating and a ‘parental care’ phase until fry are about one week old (Wood et al. 2004). Defended territories are related to the size of the individual male (Wood et al. 2004).

The nests created, modified, used and defended by Paxton Lake and Vananda Creek Stickleback Species Pairs for spawning and early stages of rearing represent discrete dwelling places requiring significant investment in their creation and maintenance by the male Sticklebacks. The nests have the functional capacity to support successful spawning and hatching and are occupied during the life stages of adult, egg and juvenile hatch. As such, nests are considered a residence for the Paxton Lake and Vananda Creek Stickleback Species Pairs during the time they are occupied by the male through the spawning period, while incubating the eggs and protecting the juveniles after they have hatched and left the nest, and until the male has finished all its nesting cycles.

Paxton Lake and Vananda Creek Benthic and Limnetic Sticklebacks build nests within the littoral zone of the lakes in which they are found. These nests are considered residences as defined by SARA.

[23] Texada Island Watershed Protection Bylaw No. 237, 1993

3. Evaluation of Socio-Economic Costs and of Benefits

SARA 49(1)(e) requires that an action plan include an evaluation of its socio-economic costs, and the benefits to be derived from its implementation. 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. The Act'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.*" 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, under the federal *Fisheries Act*, DFO developed aquatic invasive species (AIS) regulations which will benefit 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 (i.e. bequest, existence and option values[24]). Activities that positively affect the recovery of these species may result in positive benefits to Canadians. The recent and unique evolutionary history of these 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. Some costs for the actions described could not be included in this evaluation. 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

[24] 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.[25]

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 associated Recovery Strategy (NRTSSP 2007) provide a way to define and measure progress toward achieving the population and distribution objective.

Reporting on implementation of the Action Plan (as required by s. 55 of SARA) will be done by assessing progress towards implementing the broad strategies outlined in the Recovery Strategy.

Reporting on the ecological and socio-economic impacts of the Action Plan (as required by s. 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.

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

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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 invasive alien species 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 exotic species (including invasive and/or introduced species), 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, 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. Introduced species, 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 is thought to have been caused by the introduction of the American Signal Crayfish which 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 the *Species at Risk Act* (SARA) in June 2003 when the Act came into force, and 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 as per section 48(1) of SARA. Processes for coordination and consultation between the federal and British Columbian 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.

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, which included the identification of critical habitat and its anticipated protection mechanism, 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 First Nations 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.

Regional consultation comments 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. All feedback received during the consultation period was considered in creating the final Action Plan.