

Report on the Progress of Recovery Strategy Implementation for the Paxton Lake and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada for the Period 2016 to 2021

Paxton Lake and Vananda Creek Stickleback Species Pairs



2022

Recommended citation:

Fisheries and Oceans Canada. 2022. Report on the Progress of Recovery Strategy Implementation for the Paxton Lake and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada for the Period 2016 to 2021. *Species at Risk Act Recovery Strategy Report Series*. Fisheries and Oceans Canada, Ottawa. iv+ 16 pp.

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Également disponible en français sous le titre
« Rapport sur les progrès de la mise en œuvre du programme de rétablissement des paires d'espèces d'épinoches du lac Paxton et du ruisseau Vananda (*Gasterosteus aculeatus*) au Canada pour la période 2016 à 2021. »

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ISBN 978-0-660-43114-7
Catalogue no. En3-4/23-1-2022E-PDF

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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 the protection of species at risk throughout Canada. Under section 46 of the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the competent minister is responsible for reporting on the implementation of the recovery strategy for a species at risk, and on the progress towards meeting its objectives within 5 years of the date when the final recovery strategy was placed on the Species at Risk Public Registry, and in every subsequent 5-year period until its objectives have been achieved or the species' recovery is no longer feasible.

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

The Minister of Fisheries and Oceans is the competent minister under SARA for the Paxton Lake Benthic Threespine Stickleback, Paxton Lake Limnetic Threespine Stickleback, Vananda Creek Benthic Threespine Stickleback, and Vananda Creek Limnetic Threespine Stickleback and has prepared this progress report.

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

Acknowledgments

This progress report was prepared by Maggie Boothroyd, Ahdia Hassan and Erin Gertzen (Fisheries and Oceans Canada [DFO]). To the extent possible, this progress report has been prepared with inputs from DFO Science, British Columbia Ministry of Environment and Climate Change Strategy, British Columbia Ministry of Forests, Lands, Natural Resources Operations and Rural Development, and University of British Columbia. DFO would also like to express its appreciation to all individuals and organizations who have contributed toward the recovery of the Paxton Lake and Vananda Creek Stickleback species pairs.

Executive summary

The Paxton Lake Benthic Threespine Stickleback, Paxton Lake Limnetic Threespine Stickleback, Vananda Creek Benthic Threespine Stickleback, and Vananda Creek Limnetic Threespine Stickleback (herein referred to as the Paxton Lake and Vananda Creek Stickleback species pairs) (*Gasterosteus aculeatus*) were included on Schedule 1 of the *Species at Risk Act* (SARA) as endangered when SARA came into force. The "[Recovery Strategy for Paxton Lake, Enos Lake¹, and Vananda Creek Stickleback Species Pairs \(*Gasterosteus* spp.\) in Canada](#)" (DFO 2007) was finalized and published on the Species at Risk Public Registry in 2007. Progress made towards recovery was reported on in the previous "[Report on the Progress of Recovery Strategy Implementation for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs \(*Gasterosteus* spp.\) in Canada for the Period 2007 to 2015](#)" (DFO 2016). The recovery strategy was amended in 2019 to include updates to the biology, recovery feasibility assessment, threats, population and distribution objectives, and areas identified as critical habitat ([DFO 2019](#)).

The main threats identified in the 2019 recovery strategy for the Paxton Lake and Vananda Creek Stickleback species pairs include: aquatic invasive species; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); scientific collections / *in situ* research; recreation; and disease.

The population objectives for the Paxton Lake and Vananda Creek Stickleback species pairs are to maintain, or where possible increase, abundance relative to the 2016 observed population sizes² of each species pair. The distribution objectives are to maintain the current spatial distribution of each species pair.

The "Report on the Progress of Recovery Strategy Implementation for the Paxton Lake and Vananda Creek Stickleback Species Pairs in Canada for the Period 2016 to 2021" reports on the progress made by Fisheries and Oceans Canada (DFO) and its partners towards implementing the recovery strategy and achieving its objectives. During this time period, progress has been made towards implementing the recovery strategy, including:

- population abundance was estimated in 2016 for the Paxton Lake Stickleback species pair and within Priest Lake for the Vananda Creek Stickleback species pair
- critical habitat was identified for Paxton Lake and Vananda Creek Stickleback species pairs in the 2019 recovery strategy (DFO 2019) and subsequently protected through SARA critical habitat orders in 2020
- a preliminary aquatic invasive species (AIS) prevention and monitoring plan was developed for the Paxton Lake and Vananda Creek Stickleback species pairs
- protection of Paxton Lake and Vananda Creek Stickleback species pairs and their critical habitats were highlighted as objectives in the Texada Island Official Community Plan
- research has been conducted to understand the mechanism(s) of speciation and maintenance of genetic divergence for these species pairs

¹ Enos Lake Benthic Threespine Stickleback and Enos Lake Limnetic Threespine Stickleback (*Gasterosteus aculeatus*) collapsed into a single genetic and morphological hybrid form following the appearance of the American Signal Crayfish (*Pacifastacus leniusculus*; Taylor and Piercey 2018). Recovery of the Enos Lake Stickleback species pair has been determined to not be biologically or technically feasible and the species pair is therefore not included within this progress report; refer to 2019 recovery strategy (DFO 2019) for more information.

² The 2016 abundances are thought to be near historical levels and self-sustaining (DFO 2019).

Systematic monitoring has not occurred for Paxton Lake and Vananda Creek Stickleback species pairs since 2016, but the overall condition of the species' is believed to have remained stable over the reporting period (Schluter pers. comm. 2021). While there has been measurable progress towards addressing the broad strategies and research and management approaches outlined in the recovery strategy, further work is required to support the survival and recovery of the Paxton Lake and Vananda Creek Stickleback species pairs. Priority next steps may include development and implementation of the following: an AIS monitoring and prevention plan, long-term programs to monitor population abundance and distribution, and a water monitoring program.

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1 Introduction

The “Report on the Progress of Recovery Strategy Implementation for the Paxton Lake and Vananda Creek Stickleback Species Pairs in Canada for the Period 2016 to 2021” (progress report) outlines the progress made towards meeting the objectives listed in the “Recovery Strategy for Paxton Lake, Enos³ Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada” (DFO 2007; DFO 2019) during the indicated time period⁴. The progress report is one in a series of documents for these species that are linked and should be taken into consideration together, including: the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports (COSEWIC 2010a, b), the “Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus* spp.) in Canada” (DFO 2007), the “Report on the Progress of Recovery Strategy Implementation for the Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada for the Period 2007 to 2015” (), the amended “Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus* spp.) in Canada” (herein referred to as the 2019 recovery strategy; DFO 2019), and the “Action Plan for the Paxton Lake and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada” (DFO 2020).

Section 2 of this progress report reproduces or summarizes relevant information from the 2019 recovery strategy on the threats to the species, population and distribution objectives for achieving recovery, broad strategies and approaches to meeting the objectives, and performance indicators to measure the progress of recovery. For more details, readers should refer back to the 2019 recovery strategy (DFO 2019). Progress in carrying out these broad strategies and approaches is reported in section 3.1. Section 3.2 reports on the progress of meeting the performance indicators and other commitments identified in the recovery strategy. Section 4 summarizes the progress toward achieving the population and distribution objectives.

2 Background

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

The Paxton Lake Benthic Threespine Stickleback, Paxton Lake Limnetic Threespine Stickleback, Vananda Creek Benthic Threespine Stickleback, and Vananda Creek Limnetic Threespine Stickleback (herein referred to as the Paxton Lake and Vananda Creek Stickleback species pairs) (*Gasterosteus aculeatus*) were included on Schedule 1 of the *Species at Risk Act* (SARA) as endangered when SARA came into force. Listing under SARA led to the development and publication of the “Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada in 2007” (DFO 2007), and the amended 2019 recovery strategy (DFO 2019). The 2019 recovery strategy is

³ Enos Lake Benthic Threespine Stickleback and Enos Lake Limnetic Threespine Stickleback collapsed into a single genetic and morphological hybrid form following the appearance of the American Signal Crayfish (*Pacifastacus leniusculus*; Taylor and Piercey 2018). Recovery of the Enos Lake Stickleback Species Pair has been determined to not be biologically or technically feasible and the species pair is therefore not included within this progress report; refer to 2019 recovery strategy (DFO 2019) for more information.

⁴ While two recovery strategies (DFO 2007 and DFO 2019) were in place during the timeframe that this document reports on (2016 to 2021), this document refers specifically to the broad strategies, approaches, and performance indicators from the 2019 recovery strategy (DFO 2019).

consistent with the information provided in the COSEWIC status reports (COSEWIC 2010a, b) and the COSEWIC summary information is included in section 2 of the 2019 recovery strategy (DFO 2019).

Section 5 of the 2019 recovery strategy provides information on the threats to the species' survival and recovery (DFO 2019). These threats include: aquatic invasive species; water management (including water pollution and/or sedimentation); land use (including habitat loss or degradation); scientific collections / *in situ* research; recreation; and disease.

Critical habitat for the Paxton Lake and Vananda Creek Stickleback species pairs has been identified, to the extent possible, in section 8 of the 2019 recovery strategy (DFO 2019). Protection of Paxton Lake and Vananda Creek Stickleback species pairs' critical habitat was accomplished in 2020 through SARA critical habitat orders made under subsections 58(4) and (5), which invoked the prohibition in subsection 58(1) against the destruction of any part of the identified critical habitat. Table 9 of the 2019 recovery strategy also provides examples of activities that are likely to result in destruction of critical habitat (that is, threats to critical habitat); the list of activities provided is neither exhaustive nor exclusive, and their inclusion has been guided by the relevant threats to habitat described in the recovery strategy.

2.2 Recovery

This section summarizes the information, found in the 2019 recovery strategy (DFO 2019), on the population and distribution objectives, that are necessary for the recovery of the Paxton Lake and Vananda Creek Stickleback species pairs and on performance indicators that provide a way to define and measure progress toward achieving the population and distribution objectives.

Section 6 of the 2019 recovery strategy identified the following population and distribution objectives necessary for the recovery of the Paxton Lake and Vananda Creek Stickleback species pairs:

- maintain, or where possible increase, abundance relative to the 2016 observed population sizes⁵ of each species pair
- maintain the current spatial distribution of each species pair

Section 9 of the 2019 recovery strategy includes the following performance indicators to define and measure progress toward achieving the population and distribution objectives:

- observe a stable or positive trend in Paxton Lake and Vananda Creek Stickleback species pairs population abundances by 2022, taking into account natural variation
- confirm stable spatial distribution of Paxton Lake and Vananda Creek Stickleback species pairs by 2022, taking into account natural variation

3 Progress towards recovery

The 2019 recovery strategy divides the recovery effort into 8 broad strategies:

- 1) develop and implement monitoring programs

⁵ The 2016 abundances are thought to be near historical levels and self-sustaining (DFO 2019).

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

3.1 Activities supporting recovery

Table 1 provides information on the implementation of broad strategies and their associated research and management approaches identified in the recovery planning table of the 2019 recovery strategy. A number of recovery activities were implemented prior to 2016 and have been documented in the “Report on the Progress of Recovery Strategy Implementation for the Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada for the Period 2007 to 2015” ([DFO 2016](#)).

Table 1. Details of research and management approaches supporting the recovery of the Paxton Lake and Vananda Creek Stickleback species pairs from 2016 to 2021. When more than one participant is associated with a recovery activity, they are listed in alphabetical order.

#	Broad strategy	Research and management approach	Descriptions and results	Participants
1	Develop and implement monitoring programs	Develop and implement an ongoing long-term program to monitor population and distribution of Paxton and Vananda Stickleback species pairs.	<p>A long-term program to monitor population and distribution of Paxton and Vananda Stickleback species pairs has not yet been developed.</p> <p>Population abundance was last estimated in 2016 for Paxton Lake Stickleback species pair and a portion of the range of the Vananda Creek Stickleback species pair (Schluter et al. 2017):</p> <ul style="list-style-type: none"> total population estimates for the Paxton Lake Stickleback species pair were 22,191 (95% confidence intervals: 17,544, 28,991) for the benthic species and 368,885 (95% confidence intervals: 236,137, 842,518) for the limnetic species total population estimates of the Vananda Creek Stickleback species pair within Priest Lake were 118,058 (95% confidence intervals: 101,351, 141,358) for the benthic species and 110,612 (95% confidence intervals: 78,068, 189,684) for the limnetic species there have been no direct population estimates from other parts of the Vananda Creek Stickleback species pair range (that is, Emily Lake, Spectacle Lake and the Vananda Creek which connects the lakes) 	British Columbia Ministry of the Environment and Climate Change Strategy (BC ENV), Fisheries and Oceans Canada (DFO), University of British Columbia (UBC)

#	Broad strategy	Research and management approach	Descriptions and results	Participants
2	Conduct research on the Paxton Lake and Vananda Creek Stickleback species pairs	Conduct scientific research that contributes to recovery and/or addresses knowledge gaps affecting management of the Paxton Lake and Vananda Creek Stickleback species pairs. These include studies exploring basic biology and threat clarification.	Research to understand ecological processes leading to speciation and the maintenance of genetic divergence has been conducted on stickleback species pairs (including Paxton Lake and Vananda Creek Stickleback species pairs). This includes experimental studies to understand the role of mate choice (Bay et al. 2017) and to test the effects of predator presence on behaviour (Miller et al. 2016), diet (Rudman et al. 2016), and trait selection (Miller et al. 2016; Miller et al. 2017; Gygas et al. 2018; Samuk et al. 2018; Rennison et al. 2019). Results may support improved management of Paxton Lake and Vananda Creek Stickleback species pairs and their habitat.	Academia, UBC, University of California (UC)
3	Conduct research on the Paxton Lake and Vananda Creek Stickleback species pairs	Investigate potential water quality implications and effects on the species pairs from the use of explosives for mining activities within the species pairs' watersheds.	No actions completed during this reporting period.	N/A

#	Broad strategy	Research and management approach	Descriptions and results	Participants
4	Develop an Aquatic Invasive Species management plan	Develop and implement an Aquatic Invasive Species (AIS) management plan to prevent aquatic invasive species from entering and becoming established in lakes containing these species pairs.	<p>A preliminary AIS prevention and monitoring plan was developed for the Paxton Lake and Vananda Creek Stickleback species pairs; the report provides direction on actions needed to monitor and prevent AIS establishment in lakes that contain Paxton Lake and Vananda Creek Stickleback species pairs (Matthews and Wilson 2021). Specific areas addressed in the report include:</p> <ul style="list-style-type: none"> • identifying high priority AIS • identifying potential partners to conduct AIS monitoring • identifying potential pathways of AIS introduction (for example, fishing and recreational boating) • assessing the risk of AIS establishment based on lake and watershed accessibility, use, and other factors <p>General public awareness of AIS has increased over the reporting period owing to increased provincial- and national-scale AIS prevention campaigns such as: Don't Let it Loose and Clean, Drain, Dry.</p>	<p>BC ENV, Invasive Species Council of British Columbia, DFO, municipalities</p>
5	Develop an Aquatic Invasive Species management plan	Research potential impacts of recreational lake usage on Paxton Lake and Vananda Creek Stickleback species pairs and develop mitigation measures to address impacts.	<p>Accessibility of Paxton Lake by recreational users was assessed as low (Matthews and Wilson 2021).</p> <p>Accessibility of the lakes in the range of the Vananda Creek Stickleback species pair by recreational users varies between lakes. Accessibility was assessed as low-moderate for Emily Lake, moderate for Spectacle Lake, and high for Priest Lake (Matthews and Wilson 2021).</p> <p>Mitigation measures proposed to address AIS introduction pathways associated with recreational lake use include early detection monitoring and increased education and outreach (Matthews and Wilson 2021). Implementation of these measures has not yet begun.</p>	<p>BC ENV</p>

#	Broad strategy	Research and management approach	Descriptions and results	Participants
6	Establish baseline water quality parameters for the Paxton Lake and Vananda Creek Stickleback species pairs	Establish baseline parameters for turbidity, temperature, pH, and dissolved oxygen for all lakes and streams containing the Paxton Lake and Vananda Creek Stickleback species pairs to better understand the species' biological needs and the parameters that affect habitat quality.	No actions completed during this reporting period.	N/A
7	Develop a comprehensive water management plan for each basin	Identify and evaluate water management options to satisfy both conservation and stakeholder needs. This may include developing and implementing projects to promote water conservation and the adoption of best practices for water use in the Paxton Lake and Vananda Creek Stickleback species pairs' watersheds.	<p>The Texada Island Official Community Plan (Rodan et al. 2020) outlines the overall community goals which include balancing economic growth with environmental stewardship, including the protection of Paxton Lake and Vananda Creek Stickleback species pairs and their critical habitat. Specific policies to protect water resources include: promoting water conservation and stewardship, maintaining native vegetation buffers, recommending riparian assessments by qualified environmental professionals for projects taking place near water, and liaising with provincial agencies to ensure compliance with legislation.</p> <p>This community plan (Rodan et al. 2020) provides recommendations and strategies to agricultural landowners to maintain water quality, which is an important critical habitat attribute for Paxton Lake and Vananda Creek Stickleback species pairs. These strategies include community education and the promotion of setbacks for agricultural buildings and livestock grazing areas.</p>	qathet Regional District, Industry, municipalities

#	Broad strategy	Research and management approach	Descriptions and results	Participants
8	Develop land management strategies	Develop land management strategies, including assessing current strategies (for example, Wildlife Habitat Areas), identifying and evaluating land use planning and management options, and developing best management practices and mitigation measures for land use in the species pairs' watersheds.	<p>The Texada Island Official Community Plan (Rodan et al. 2020) states the overall objective for resource management is to reduce risk to domestic water sources (refer to table 1: row 7), sensitive ecosystems, and rare and endangered species (including the Paxton Lake and Vananda Creek Stickleback species pairs) from unnecessary environmental changes.</p> <p>This community plan (Rodan et al. 2020) outlines policies to protect sensitive and endangered ecosystems and species at risk, including Paxton Lake and Vananda Creek Stickleback species pairs. These policies include liaising with provincial agencies and private property owners to advocate for the protection of the Stickleback species pairs and their critical habitat and supporting efforts to educate the public on the impacts of invasive plants.</p> <p>In compliance with Wildlife Habitat Area #2-250⁶, Prime Length Timber Ltd. completed a stewardship plan that includes buffers around waterbodies to prevent site-specific and cumulative forestry from degrading habitat in lakes occupied by the Vananda Creek Stickleback species pair (Chartwell 2020).</p>	qathet Regional District, BC ENV, industry, municipalities
9	Develop protocols for scientific investigations of the Paxton Lake and Vananda Creek Stickleback species pairs	Update the protocols for scientific investigations that include the collection and use of <i>in situ</i> studies to increase scientific understanding of Paxton Lake and Vananda Creek Stickleback species pairs (Rosenfeld et al. 2008).	<p>An update to the existing protocol "Guidelines for the Collection and <i>In Situ</i> Scientific Study of Stickleback species pairs (<i>Gasterosteus</i> spp.) in British Columbia" (Rosenfeld et al. 2008) is underway (Woodruff et al. 2021). The update will incorporate new information such as the 2016 population estimates (refer to table 1: row 1).</p> <p>Since 2017, DFO has applied population size percentage-based maximum removal numbers that have been calculated using the 2016 population estimates (Schluter et al. 2017; refer to table 1 row 1) when considering whether to permit scientific research in support of conservation under Section 73 of the <i>Species at Risk Act</i>.</p>	BC ENV, UBC

⁶ Wildlife Habitat Area #2-250 is 881ha of provincial Crown land established in 2013 to protect Vananda Creek Stickleback species pairs (B.C. Reg. 582/2004).

#	Broad strategy	Research and management approach	Descriptions and results	Participants
10	Develop and implement outreach and stewardship projects for the Paxton Lake and Vananda Creek Stickleback species pairs	Develop outreach and stewardship projects in support of recovery measures and foster awareness of the Paxton Lake and Vananda Creek Stickleback species pairs. Target audiences should include local community members, landowners, industry, recreational groups, and local schools.	In 2021, DFO Conservation and Protection developed public outreach signage for Paxton Lake and Vananda Creek Stickleback species pairs describing species' biology as well as SARA status and protections. The signs were installed at the Paxton Lake trailhead and public access points at Priest Lake and Spectacle Lake.	DFO
11	Develop and implement outreach and stewardship projects for the Paxton Lake and Vananda Creek Stickleback species pairs	Establish and support a group that undertakes stewardship initiatives that increase understanding and awareness of the Paxton Lake and Vananda Creek Stickleback species pairs.	A previously established stewardship group, the Texada Island Stickleback Group , has not been active during this reporting period, but the website remains online to provide educational resources on Paxton Lake and Vananda Creek Stickleback species pairs.	Texada Island Stickleback Group, BC ENV

3.2 Summary of progress towards recovery

3.2.1 Status of performance indicators

Table 2 provides a summary of the progress made toward meeting the performance indicators identified in the 2019 recovery strategy. Each indicator has been assigned 1 of 4 statuses:

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

Table 2. Details of the progress made toward meeting the performance indicators outlined in the 2019 recovery strategy for Paxton Lake and Vananda Creek Stickleback species pairs.

Performance indicator	Status	Details
Observe a stable or positive trend in Paxton Lake and Vananda Creek Stickleback species pairs population abundances by 2022, taking into account natural variation	partially met	<p>Population abundance was last estimated in 2016 for Paxton Lake Stickleback species pair and a portion of the range of the Vananda Creek Stickleback species pair (Schluter et al. 2017; see table 1 row 1); these estimates informed the population and distribution objectives in the 2019 recovery strategy (DFO 2019).</p> <p>There has been no systematic monitoring of abundance for Paxton Lake or Vananda Creek Stickleback species pairs, so population trends are unknown; however trapping success suggests that numbers are high (Schluter et al. 2017) and researchers continue to successfully trap these species in Paxton and Priest lakes (Schluter pers. comm. 2021). No sampling occurred in other parts of the Vananda Creek Stickleback species pair range (that is, Emily Lake, Spectacle Lake, and Vananda Creek) during the reporting period.</p> <p>Population estimates for the Paxton Lake and Vananda Creek Stickleback species pairs in 2005 and 2016 indicated some variability in total population sizes (Nomura 2005; Schluter et al. 2017), however the large confidence intervals associated with the estimates, and few data points mean trends cannot be inferred at this time.</p>

Performance indicator	Status	Details
		Developing and implementing long-term monitoring plans were identified as high priority measures in the action plan (DFO 2020) and will provide a method to measure this performance indicator.
Confirm stable spatial distribution of Paxton Lake and Vananda Creek Stickleback species pairs by 2022, taking into account natural variation	not met	<p>There has been no systematic monitoring of the distribution of Paxton Lake and Vananda Creek Stickleback species pairs, so distribution trends are unknown. The species' distributions are thought to approximate historical distribution (DFO 2019).</p> <p>Developing and implementing long-term monitoring plans were identified as high priority measures in the action plan (DFO 2020) and will provide a method to measure this performance indicator.</p>

3.2.2 Completion of action plan

The Action Plan for the Paxton Lake and Vananda Creek Stickleback species pairs (*Gasterosteus aculeatus*) in Canada was published in 2020 ([DFO 2020](#)). It is a comprehensive document that 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.

3.2.3 Critical habitat identification and protection

For the Paxton Lake and Vananda Creek Stickleback species pairs, critical habitat was identified to the extent possible, using the best available information, in section 8 of the 2019 recovery strategy ([DFO 2019](#)). Protection of Paxton Lake and Vananda Creek Stickleback species pairs' critical habitat was accomplished in 2020 through 4 SARA critical habitat orders (1 for each of the 4 species) made under subsections 58(4) and (5), which invoke the prohibition in subsection 58(1) against the destruction of any part of the identified critical habitat ([SOR/2020-25](#); [SOR/2020-26](#); [SOR/2020-27](#); [SOR/2020-28](#)).

3.2.4 Recovery feasibility

As stated in the 2019 recovery strategy (DFO 2019), Paxton Lake and Vananda Creek Stickleback species pairs are historically precarious species because they were never widespread or abundant within Canada. For historically precarious species, recovery is considered feasible if the extent of irreversible biological or ecological change is such that it is technically and biologically feasible to improve the condition⁷ of the species to approach its historic condition. Based on this, recovery for the Paxton Lake and Vananda Creek Stickleback species pairs was determined to be biologically and technically feasible.

4 Concluding statement

Within this reporting period (2016 to 2021), through the implementation of the “Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback species pairs (*Gasterosteus aculeatus*) in Canada” ([DFO 2007](#), DFO 2019), progress has been made in supporting recovery of the Paxton Lake and Vananda Creek Stickleback species pairs, including:

- population abundance was estimated in 2016 for the Paxton Lake Stickleback species pair and within Priest Lake for the Vananda Creek Stickleback species pair
- critical habitat for the Paxton Lake and Vananda Creek Stickleback species pairs was identified in the 2019 recovery strategy (DFO 2019) and subsequently protected through 4 SARA critical habitat orders in 2020
- a preliminary AIS prevention and monitoring plan was developed for the Paxton Lake and Vananda Creek Stickleback species pairs which provides direction on actions needed for early detection AIS monitoring and prevention of AIS establishment
- protection of Paxton Lake and Vananda Creek Stickleback species pairs and their critical habitats were highlighted as objectives in the Texada Island Official Community Plan

⁷ Condition of the species: combination of the level of redundancy, resilience, representation, population and distribution, trend, threats, ecological role and any other factors that together determine the risk of extinction or extirpation of the species in Canada.

- research has been conducted to understand the mechanism(s) of speciation and maintaining genetic divergence, which may improve management of Paxton Lake and Vananda Creek Stickleback species pairs and their habitat
- an update to the “Guidelines for the Collection and *In Situ* Scientific Study of Stickleback species pairs (*Gasterosteus* spp.) in British Columbia” is underway

Monitoring has not occurred for Paxton Lake and Vananda Creek Stickleback species pairs since the 2016 abundance estimates were used to set the population and distribution objectives in the 2019 recovery strategy (DFO 2019), but the overall condition of the species’ is believed to have remained stable over the reporting period as researchers continue to successfully trap these species. While there has been measurable progress towards addressing the research and management approaches outlined in the recovery strategy, further work is required to support the survival and recovery of the Paxton Lake and Vananda Creek Stickleback species pairs. Priority next steps may include:

- developing and implementing a long-term population monitoring program to enable measurement of performance indicators and population and distribution objectives
- implementing an AIS monitoring and prevention plan
- implementing a water quality monitoring program
- establishing baseline water quality parameters for all lakes and streams that contain the species pairs
- assessing the potential water quality implications of mining
- establishing or reconvening a stewardship group to support public outreach and education within the species’ range

DFO remains committed to recovering the Paxton Lake and Vananda Creek Stickleback species pairs. Efforts to date have built a strong foundation for continued research and management of these species over the next reporting period. Progress made to date would not have been achieved without the contributions of our partners including the British Columbia Ministry of Environment and Climate Change Strategy and the University of British Columbia. DFO is looking forward to continuing these successful collaborations and welcomes the participation of additional partners.

5 References

- Bay, R.A., M.E. Arnegard, G.L. Conte, J. Best, N.L. Bedford, S.R. McCann, M.E. Dubin, Y.F. Chan, F.C. Jones, D.M. Kingsley, D. Schluter, and K. Peichel. 2017. Genetic coupling of female mate choice with polygenic ecological divergence facilitates stickleback speciation. *Current Biology* 27:3344-3349.
- Chartwell. 2020. Prime Length Timber Ltd. Forest Stewardship Plan. 21 pp.
- COSEWIC. 2010a. COSEWIC assessment and status report on the Paxton Lake Benthic and Limnetic Threespine Stickleback Species Pair *Gasterosteus aculeatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa xiv + 22 pp.
- COSEWIC. 2010b. COSEWIC assessment and status report on the Vananda Creek Benthic and Limnetic Threespine Stickleback Species Pair *Gasterosteus aculeatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa xiv + 25 pp.
- DFO (Fisheries and Oceans Canada). 2007. Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus spp.*) in Canada. Species at Risk Act Recovery Strategy Series, Fisheries and Oceans Canada, Ottawa. v + 31 pp.
- DFO (Fisheries and Oceans Canada). 2016. Report on the Progress of Recovery Strategy Implementation for the Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada for the Period 2007 – 2015. Species at Risk Act Recovery Strategy Report Series. Fisheries and Oceans Canada, Ottawa. iii + 23 pp.
- DFO (Fisheries and Oceans Canada). 2019. Recovery Strategy for Paxton Lake, Enos Lake, and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. ix + 45 pp.
- DFO (Fisheries and Oceans Canada). 2020. Action Plan for the Paxton Lake and Vananda Creek Stickleback Species Pairs (*Gasterosteus aculeatus*) in Canada. Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa. v + 24 pp.
- Gygax, M., A.K. Rentsch, S.M. Rudman, and D.J. Rennison. 2018. Differential predation alters pigmentation in threespine stickleback (*Gasterosteus aculeatus*). *Journal of Evolutionary Biology* 31:1589-598.
- Matthews, E., and G. Wilson. 2021. Draft Exotic Species Prevention and Monitoring Plan for Threespine Stickleback Species Pair (*Gasterosteus spp.*) Lakes of Texada Island. Unpublished Fisheries Project Report No. RD xxx, Ecosystems Branch, Province of British Columbia Ministry of Environment and Climate Change Strategy. Report prepared for British Columbia Ministry of Environment and Climate Change Strategy, and Fisheries and Oceans Canada. 65 pp.
- Miller, S.E., M. Barrueto, and D. Schluter. 2017. A comparative analysis of experimental selection on the stickleback pelvis. *Journal of Evolutionary Biology* 30:1165–1176.

- Miller, S.E., K.M. Samuk, and D.J. Rennison. 2016. An experimental test of the effect of predation upon behaviour and trait correlations in the threespine stickleback. *Biological Journal of the Linnean Society* 119:117-125.
- Nomura, M. 2005. Population study of Paxton Lake stickleback species pair – 2005. unpublished data report. 5 pp.
- Rennison, D.J., S.M. Rudman, and D. Schluter. 2019. Genetics of adaptation: Experimental test of a biotic mechanism driving divergence in traits and genes. *Evolution Letters* 3:513-520.
- Roddan, L., J. Dykstra, S. McCormick, A. Atkins, S. Clark, A. Maclsaac, R. Rasmussen, T. Schumacher, T. Smith, D. Vaughn, C. Childress, T. Hollo, J. Mason, C. Richards, J. Scott, C. Timms, and B. Walker. 2020. Draft Texada Island Official Community Plan. vi + 76 pp.
- Rosenfeld, J., D. Sneep, T. Hatfield, D. McPhail, J. Richardson, D. Schluter, E. Taylor, and P. Wood. 2008. Guidelines for the Collection and In Situ Scientific Study of Stickleback Species Pairs (*Gasterosteus* spp.). The Recovery Team for Non-Game Freshwater Fish Species in British Columbia. Report prepared for Fisheries and Oceans Canada, Vancouver, British Columbia. 6 pp.
- Rudman, S.M., J. Heavyside, D.J. Rennison, and D. Schluter. 2016. Piscivore addition causes a trophic cascade within and across ecosystem boundaries. *Oikos* 125:1782–1789.
- Samuk, K.M., J. Xue, and D.J. Rennison. 2018. Exposure to predators does not lead to the evolution of larger brains in experimental populations of threespine stickleback. *Evolution*. 72:916-929.
- Schluter, D., M. Roesti, and T. Veen. 2017. [Mark-recapture estimates of stickleback population sizes in Paxton and Priest Lakes in 2016](#). Biodiversity Research Centre and Zoology Department, University of British Columbia. Report Prepared for the British Columbia Ministry of Environment and Climate Change Strategy and Fisheries and Oceans Canada. 9 pp.
- Schluter, D., pers. comm. 2021. Email correspondence with M. Boothroyd. October 2021. Professor, University of British Columbia, Vancouver, BC.
- SOR/2020-25. Species at Risk Act: [Critical Habitat of the Paxton Lake Benthic Threespine Stickleback \(*Gasterosteus aculeatus*\) Order](#). Canada Gazette Part II, 154(5). Retrieved from the Canada Gazette website on Oct 22, 2021.
- SOR/2020-26. Species at Risk Act: [Critical Habitat of the Paxton Lake Limnetic Threespine Stickleback \(*Gasterosteus aculeatus*\) Order](#). Canada Gazette Part II, 154(5). Retrieved from the Canada Gazette website on Oct 22, 2021.
- SOR/2020-27. Species at Risk Act: [Critical Habitat of the Vananda Creek Benthic Threespine Stickleback \(*Gasterosteus aculeatus*\) Order](#). Canada Gazette Part II, 154(5). Retrieved from the Canada Gazette website on Oct 22, 2021.

- SOR/2020-28. Species at Risk Act: [Critical Habitat of the Vananda Creek Limnetic Threespine Stickleback \(*Gasterosteus aculeatus*\) Order](#). Canada Gazette Part II, 154(5). Retrieved from the Canada Gazette website on Oct 22, 2021.
- Taylor, E.B., and R.S. Piercey. 2018. Going, going, gone: evidence for loss of an endemic species pair of threespine sticklebacks (*Gasterosteus aculeatus*) with implications for protection under species-at-risk legislation. *Conservation Genetics* 19:297-308.
- Thompson, A.C., T.D. Capellini, C.A. Guenther, Y.F. Chan, C.R. Infante, D.B. Menke, and D.M. Kingsley. 2018. [A novel enhancer near the Pitx1 gene influences development and evolution of pelvic appendages in vertebrates](#). *eLife* <https://doi.org/10.7554/eLife.38555>.
- Woodruff, P., M. Nantel, and G. Wilson. 2021. Draft Guidelines for the Collection and In Situ Scientific Study of Stickleback Species Pairs (*Gasterosteus* spp.) in British Columbia. British Columbia Ministry of Environment and Climate Change Strategy. Unpublished Report Prepared for Fisheries and Oceans Canada. 13 pp.
- Xie, K.T., G. Wang, A.C. Thompson, J.I. Wucherpfennig, T.E. Reimchen, A.D.C. MacColl, D. Schluter, M.A. Bell, K.M. Vasquez, and D.M. Kingsley. 2019. DNA fragility in the parallel evolution of pelvic reduction in stickleback fish. *Science* 363:81-84.