Species at Risk Act
Management Plan Series

Management Plan for the Giant and Unarmoured Threespine Sticklebacks (*Gasterosteus aculeatus*) in Canada

Giant Threespine Stickleback

Unarmoured Threespine Stickleback

2022

Canada

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Cover illustration: Illustration of Giant Threespine Stickleback (top) and Unarmoured Threespine Stickleback (bottom) courtesy of Dr. Thomas Reimchen (University of Victoria).

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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 the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of a management plan for species listed as special concern and are required to report on progress 5 years after the publication of the final document on the Species at Risk Public Registry and every subsequent 5 years, until its objectives have been achieved.

The Minister of Fisheries, Oceans and the Canadian Coast Guard is the competent minister under SARA for the Giant and Unarmoured Threespine Sticklebacks (*Gasterosteus aculeatus*) and has prepared this management plan, as per section 65 of SARA. In preparing this management 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 wildlife 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, this management plan has been prepared in cooperation with the Province of British Columbia, Indigenous groups, and academia as per subsection 66(1) of SARA.

As stated in the preamble to SARA, success in the conservation of the species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions and measures for the conservation of the species set out in this 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 plan for the benefit of the Giant and Unarmoured Threespine Sticklebacks and Canadian society as a whole.

A SARA management plan includes measures for the conservation of a species of special concern to prevent it from becoming threatened or endangered. The competent minister must prepare a management plan that includes measures for the conservation of the species that the minister considers appropriate. These measures for the conservation of the species set out to achieve the management objectives identified in the management plan. Implementation of this management 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 of those who supported the development of the management plan for the Giant and Unarmoured Threespine Sticklebacks. Dr. Thomas Reimchen (University of Victoria) contributed expertise towards the development of the management plan. This management plan was prepared by Andrew Baylis (DFO), with input from Claire Salvador (DFO), Dr. Paul Grant (DFO) and Martin Nantel (DFO).

Executive summary

The Giant Threespine Stickleback (*Gasterosteus aculeatus*) and the Unarmoured Threespine Stickleback (*Gasterosteus aculeatus*)[1] were listed as special concern under the *Species at Risk Act* (SARA) in 2019. This management plan is part of a series of documents regarding the Giant and Unarmoured Threespine Sticklebacks and should be taken into consideration together with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (2013).

Giant Threespine Stickleback

The Giant Threespine Stickleback is a small lake-dwelling fish endemic to Haida Gwaii in British Columbia. The Giant Threespine Stickleback has 2 independently-derived populations in 2 lakes: Mayer Lake and Drizzle Lake, both of which are located in the northeast area of Graham Island, the furthest north island in the Haida Gwaii archipelago. The Giant Threespine Stickleback's large adult body size, as compared to typical freshwater Threespine Stickleback, is associated with the presence of larger predatory fishes, and may be an anti-predation adaptation. Characteristics and needs of the Giant Threespine Stickleback are described in section 4.

The main threats facing the Giant Threespine Stickleback are described in section 5 and include: predation by aquatic invasive species, alteration of predator regime, and sedimentation and pollution.

The management objective (section 6) for the Giant Threespine Stickleback is:

- to maintain self-sustaining populations of Giant Threespine Stickleback in Mayer Lake and Drizzle Lake, comprising approximately 75,000 and 100,000 individuals, respectively, taking into account natural variation (Moodie 1984; Reimchen 1990; Reimchen 2004)

A description of the broad strategies and measures for the conservation of the Giant Threespine Stickleback that provide the best chance of achieving the management objective are included in section 7.

Unarmoured Threespine Stickleback

The Unarmoured Threespine Stickleback is a small lake-dwelling fish endemic to Haida Gwaii in British Columbia. The Unarmoured Threespine Stickleback has 3 independently-derived populations in 3 lakes: Boulton Lake, Serendipity Lake, and Rouge Lake, all of which are located in the northeast area of Graham Island, the furthest north island in the Haida Gwaii archipelago. The Unarmoured Threespine Stickleback is characterized by a lack of 1 or more spines, as well as reduced or absent lateral plates. This unarmoured morphology is likely to be an adaptation to a lack of predatory fishes in its habitat. Characteristics and needs of the Unarmoured Threespine Stickleback are described in section 4.

[1] Referred to in the BC Conservation Data Centre as the Charlotte Giant and Unarmoured Stickleback

The main threats facing the Unarmoured Threespine Stickleback are described in section 5 and include: predation by aquatic invasive species, and sedimentation and pollution.

The management objective (section 6) for the Unarmoured Threespine Stickleback is:

- to maintain self-sustaining populations of Unarmoured Threespine Stickleback in Boulton Lake, Rouge Lake, and Serendipity Lake, comprising approximately 350,000, 17,500, and 22,000 individuals, respectively, taking into account natural variation (Reimchen 1984)

A description of the broad strategies and measures for the conservation of the Unarmoured Threespine Stickleback that provide the best chance of achieving the management objective are included in section 7.

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Background

1 Introduction

The Giant Threespine Stickleback (*Gasterosteus aculeatus*) and the Unarmoured Threespine Stickleback (*Gasterosteus aculeatus*) were listed as special concern under the *Species at Risk Act* (SARA) in 2019.

This management plan is part of a series of documents regarding the Giant and Unarmoured Threespine Sticklebacks and should be taken into consideration together with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (COSEWIC 2013). A management plan includes measures for the conservation of the species to ensure that a species of special concern does not become threatened or endangered. It sets objectives and identifies measures for the conservation of the species to support achieving the management objectives.

2 COSEWIC species assessment information

Date of assessment: November 2013

Species' common name: Giant Threespine Stickleback

Scientific name: *Gasterosteus aculeatus*

Status: Special concern

Reason(s) for designation: This freshwater stickleback is of unusually large size and is currently known to exist in 2 small lakes that are in relatively remote areas. The populations could, however, quickly become endangered if invasive species were to be introduced as has been observed in other stickleback forms.

Canadian occurrence: British Columbia

Status history: Designated special concern in April 1980. Status re-examined and confirmed in November 2013.

Date of assessment: November 2013

Species' common name: Unarmoured Threespine Stickleback

Scientific name: *Gasterosteus aculeatus*

Status: Special concern

Reason(s) for designation: This morphologically distinctive small-bodied freshwater fish is currently known to exist in only 3 very small lakes that are in a relatively remote area. The populations could, however, quickly become endangered if invasive species were to be introduced as has been observed in other stickleback forms.

Canadian occurrence: British Columbia

Status history: Designated special concern in April 1983. Status re-examined and confirmed in November 2013.

3 Species status information

Table 1. Summary of existing protection or other status designations assigned to Giant Threespine Stickleback.

Jurisdiction	Authority/organization	Year(s) assessed and/or listed	Status/description	Designation level
Canada	*Species at Risk Act* (SARA)	2019	Schedule 1: special concern	Species
British Columbia	Conservation Data Centre	2018	Red List[2]; S1[3]	Species
International	NatureServe	1995	G1[4]	Species

Table 2. Summary of existing protection or other status designations assigned to Unarmoured Threespine Stickleback.

Jurisdiction	Authority/organization	Year(s) assessed and/or listed	Status/description	Designation level
Canada	*Species at Risk Act* (SARA)	2019	Schedule 1: special concern	Species
British Columbia	Conservation Data Centre	2018	Red List; S1S2[5]	Population
International	NatureServe	2019	G5T2[6]	Population

4 Species information

4.1 Species description

The Threespine Stickleback has a recent and unique evolutionary history and displays elaborate social and breeding behaviours. Although genetic investigations support marine origins for both the Giant and the Unarmoured Sticklebacks (*Gasterosteus aculeatus*) in the northern hemisphere, they appear to have independent significant, and parallel evolutionary derivations from the marine Threespine Stickleback. For these reasons, as well as its widespread occurrence and ease of being held in captivity, the Threespine Stickleback has become the subject of numerous studies over the last 2 decades, including those that focus on evolutionary processes.

[2] Red List includes any native species or subspecies that have, or are candidates for, Extirpated, Endangered, or Threatened status in British Columbia
[3] Conservation Status in BC is critically imperiled (S1)
[4] Global conservation status is critically imperiled (G1)
[5] Conservation Status in BC is critically imperiled/imperiled (S1S2)
[6] Global conservation status is globally secure/subspecies imperilled (G5T2)

As is suggested by its name, the defining morphological characteristic of the Giant Threespine Stickleback is its large body size as an adult as compared to typical freshwater Threespine Sticklebacks. Gambling and Reimchen (2012) propose that to be considered “giant”, an adult freshwater Threespine Stickleback form must have a mean standard length of at least 75 mm. Some individuals on record have exceeded 100 mm in adult standard length. The increased body size of the Giant Threespine Stickleback is associated with the presence of Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*) and Prickly Sculpin (*Cottus asper*) and may be an anti-predation adaptation (Moodie and Reimchen 1976; Reimchen 1988, 1991). The Giant Threespine Stickleback also differs morphologically from other Threespine Stickleback freshwater forms in that it typically is more streamlined, has more gill rakers and lateral plates, has longer pelvic spines, and is black in colour overall with silver shading and less pronounced breeding colours (Moodie 1972; Reimchen et al*.* 1985).

Though most Threespine Sticklebacks are equipped with armour for predator defence consisting of spines and lateral plates, some of them are characterized by partial or complete absence of these morphological features. The majority of Unarmoured Threespine Sticklebacks exhibit a lack of 1 or more spines, as well as reduced or absent lateral plates (Reimchen 1984). Contrasting to the Giant Threespine Stickleback’s increased size associated with predatory fish presence, the Unarmoured Threespine Stickleback’s lack of spines and plates is likely to be an adaptation to a lack of predatory fishes in its habitat (Moodie and Reimchen 1976; Reimchen 1980, 1984, 1994).

An Unarmoured Threespine Stickleback individual’s composition of spines and plates may vary in response to different predator pressures. Birds such as Common Loon (*Gavia immer*) and macroinvertebrates such as trichopteran (caddisfly) larvae, odonate (dragonfly and damselfly) nymphs, leeches, and diving beetles are the primary predators of the Unarmoured Threespine Stickleback in the absence of predatory fishes. Anti-predator armour adaptations may vary within a population (Reimchen 1980). Avian predators are gape-limited (what they eat is determined by how wide they can open their mouths) and are inhibited by dorsal and pelvic spines on their Stickleback prey. Where avian predators are common, Unarmoured Threespine Stickleback may retain some of their spines as a defence mechanism. In contrast, these spines may be disadvantageous when grappling macroinvertebrates are the main predators. These macroinvertebrates grasp spines to feed on the fish. Armour can also vary spatially and temporally depending on the life history and seasonal habitat use of predatory birds and macroinvertebrates.

4.2 Population abundance and distribution

The Giant Threespine Stickleback has a highly restricted range and is endemic to Haida Gwaii on the west coast of British Columbia (figure 1). This fish is only found in 2 lakes: Mayer Lake in the Mayer River drainage and Drizzle Lake in the Sangan River drainage (Moodie 1972, 1984; Moodie and Reimchen 1973, 1976; Reimchen 1984; Reimchen et al*.* 1985). These 2 separate populations evolved independently from one another by parallel evolution. Both of these lakes are located in the northeast area of Graham Island, the furthest north island of Haida Gwaii. Mayer Lake and Drizzle Lake are found in the Pacific Islands National Freshwater Biogeographic Zone. Though the distribution of Giant Threespine Stickleback has not changed since it was discovered in the late 1960s, it is possible that other populations of Giant Threespine Stickleback exist elsewhere.

In 1985, using mark-recapture techniques and nest density recordings, it was estimated that the abundance of the Drizzle Lake population ranged from 30,000 to 120,000, with a mean value of 75,000 adults (Reimchen 1990). A 2013 update to this estimate based on observations and recruitment suggests that the Drizzle Lake population is comprised by approximately 96,000 adults (Gambling and Reimchen 2012). The abundance of the Mayer Lake population has not been empirically estimated, but expert opinion suggests that the population exceeds 100,000 adults (Reimchen 2004).

The Unarmoured Threespine Stickleback is part of a circumboreal complex of Threespine Stickleback which show a lack of 1 or more spines in the majority of their individuals. The Unarmoured Threespine Stickleback is only found on Haida Gwaii on the west coast of British Columbia (figure 1). Like the Giant Threespine Stickleback, the Unarmoured Threespine Stickleback is found only in a small number of lakes on northeast Graham Island, in the Pacific Islands National Freshwater Biogeographic Zone (Moodie and Reimchen 1976, Reimchen 1980, 1984). These lakes are located in separate drainages, and include: Boulton, Rouge, and Serendipity Lakes. The populations found in each of these 3 lakes are likely to have evolved independently from one another by parallel evolution.

Population estimates based on catch per unit effort in the 1970s and 1980s produced the following abundances: 350,000 for Boulton Lake, 17,500 for Rouge Lake, and 22,000 for Serendipity Lake (Reimchen 1984). In the summer of 2015, a drying event at Rouge Lake resulted in the reduction of that population from 17,500 to an estimated 30 to 100 individuals (Reimchen pers. comm. 2017). Trapping in 2016 and 2017 yielded small numbers; however, in 2018, trapping results showed numbers similar to those observed in the 1970s, indicating a rebound in the Rouge Lake population (Reimchen pers. comm. 2019). No change has been detected in the Unarmoured Threespine Stickleback’s distribution since its discovery, but it may be possible that other populations exist.

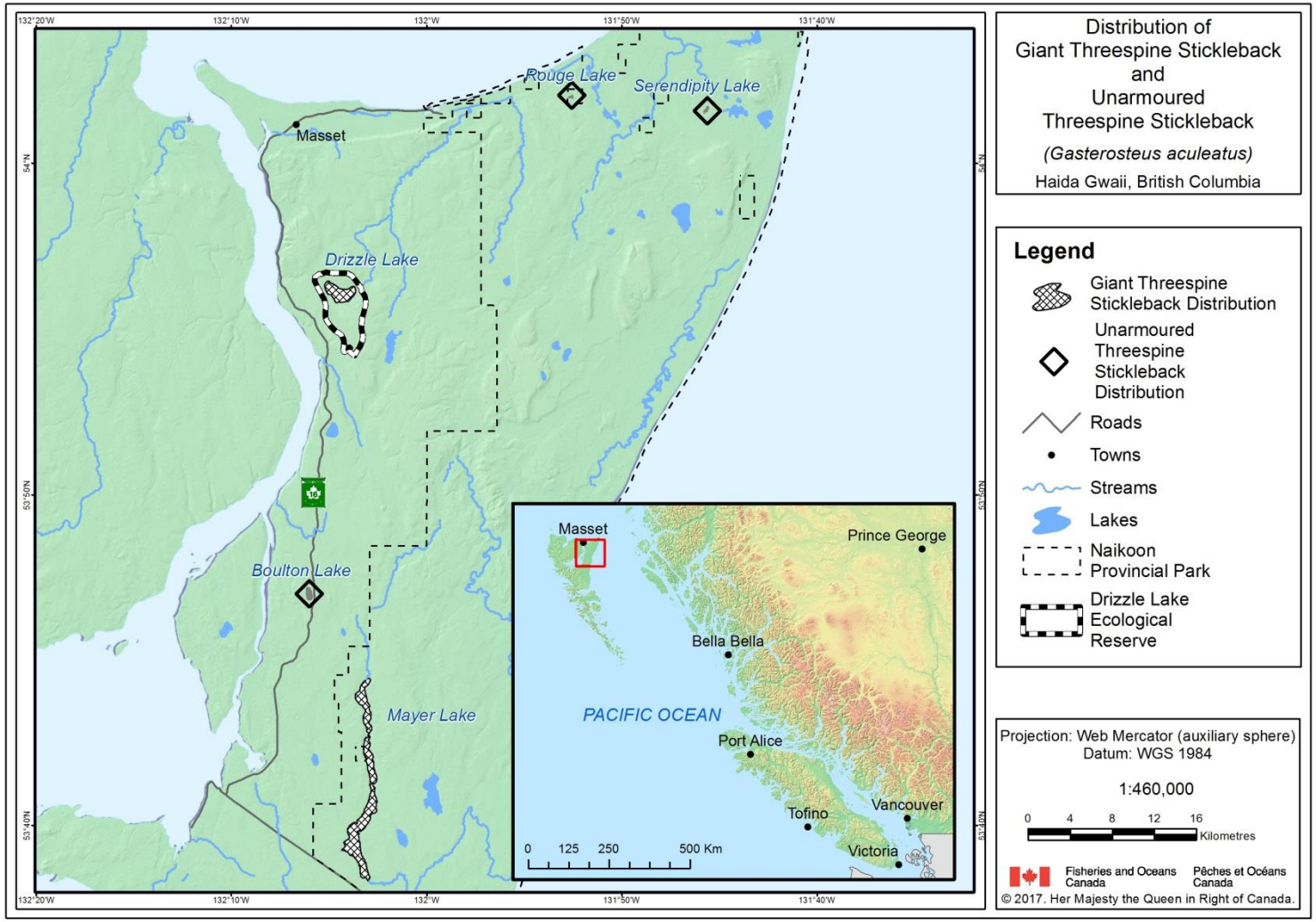

Figure 1. Distribution of Giant Threespine Stickleback and Unarmoured Threespine Stickleback in Canada.

4.3 Needs of the species

4.3.1 Habitat and biological needs

The Giant Threespine Stickleback is found in Mayer Lake and Drizzle Lake, located in the Queen Charlotte Lowland Ecoregion. This ecoregion is characterized by poorly drained lowlands with a significant presence of *Sphagnum* bogs and coniferous forests (Reimchen 1984). Mayer Lake is 495 ha in area and 10 m deep, and drains to the east into Hecate Strait through Mayer River (B.C. Ministry of Environment 1984). Drizzle Lake is 148 ha in area and 16 m deep, and drains into Dixon Entrance to the north through Drizzle Creek and the Skonun and Sangan Rivers (B.C. Parks 1973). Both lakes are open with at least 1 tributary and outflow, and share similar water quality characterized by low calcium levels, low pH, and significant tannin staining (Reimchen 1989).

The Giant Threespine Stickleback tends to live in pelagic (open water) areas, while preferring to nest in the shallower littoral (shoreline) zone amongst aquatic vegetation along gentle slopes of sandy substrate. Both males and females overwinter in deeper waters, spending spring and summer in shallower areas to spawn (Moodie 1972, 1984). Unlike other forms of Threespine Stickleback (including the Unarmoured Threespine Stickleback) that have a typical maximum lifespan of 2 to 3 years, the Giant Threespine Stickleback has a maximum lifespan of at least 4 to 8 years (4 years old for Mayer Lake and 8 years old for Drizzle Lake; Reimchen 1992b; Gambling and Reimchen 2012).

The Unarmoured Threespine Stickleback is found in Boulton Lake, Rouge Lake, and Serendipity Lake, which are also located in the Queen Charlotte Lowlands Ecoregion and are surrounded by *Sphagnum* bog and coniferous forests (Reimchen 1984). These lakes are all small (Boulton Lake: 18 ha; Rouge Lake: 2 ha; Serendipity Lake: 2 ha), shallow, and acidic; Boulton Lake is the largest and least acidic of the 3. The substrate of these lakes generally consists of a thick layer of organic sediments, though some of Boulton Lake is characterized by sand and gravel. Adult female Unarmoured Threespine Sticklebacks tend to be primarily limnetic (spending their time in open surface waters) in the spring and summer, while adult males remain closer to shore to nest (Reimchen 1980). As a result of the small size and acidic quality of these lakes, large fishes and birds are minimally present and predation by these species is reduced or eliminated; this may be related to the lack of spines and lateral armour plates associated with the Unarmoured Threespine Stickleback (Reimchen 1984).

The Giant and Unarmoured Threespine Sticklebacks are likely to have specific nesting and rearing habitat needs similar to other Threespine Sticklebacks found in lakes. These needs include sustained littoral and pelagic productivity, absence of invasive species, and maintenance of gently sloping sand/gravel beaches and natural littoral macrophytes (aquatic plants) for nesting and juvenile rearing (COSEWIC 2013). In addition, the Giant and Unarmoured Threespine Sticklebacks both show preference for an aquatic environment with very specific features, limiting the range of suitable habitat. For example, Giant Threespine Stickleback thrives in areas with predation pressure restricted to gape-limited predators (including large predatory fishes such as Coastal Cutthroat Trout [*Oncorhynchus clarkii clarkii*] and diving birds such as Common Loon [*Gavia immer*]); it also requires gently sloped beaches made up of sand or gravel with aquatic vegetation present for nesting and rearing. Conversely, the Unarmoured Threespine Stickleback lives only in small, shallow, acidic bog lakes where no large predatory fishes and few bird predators are present.

4.3.2 Limiting factors

Limiting factors are non-anthropogenic factors that may restrict the abundance and distribution of a wildlife species or population. Both the Giant and Unarmoured Threespine Sticklebacks have inherent limiting factors within their range.

North American Beaver (*Castor canadensis*) activity has the potential to flood shorelines and reduce access to spawning sites for both the Giant and Unarmoured Threespine Sticklebacks. Though no impact has been observed since the introduction of *Castor canadensis* in the mid-1900s, beaver activity could become a limiting factor in the future.

Severe winter conditions resulting in winter kill could be considered a limiting factor for Unarmoured Threespine Stickleback particularly because of the small size of the lakes that it inhabits. Populations in Boulton, Rouge, and Serendipity Lakes have maintained themselves despite these seasonal occurrences.

In the summer of 2015, a drying event was observed at Rouge Lake; the lake almost entirely dried up, and no Unarmoured Threespine Sticklebacks were observed (Reimchen pers. comm. 2016). In mid-July 2016, approximately 50% of the original area of the lake remained dry, and the wetted area was significantly shallower than in previous years. Analysis of catch per unit effort over several years in Rouge Lake revealed a reduction in population from ~17,500 (Reimchen 1984) to 30 to 100 individuals (Reimchen pers. comm. 2017)[7]. It is possible the destruction of a beaver lodge that had been maintaining higher water level at Rouge Lake since 1975 contributed to the drying event in 2015. Though the Rouge Lake population has since rebounded (Reimchen pers. comm. 2019), drying events like this limit the abundance and distribution of these populations and may increase in frequency in the future as a result of climate change.

[7] In July 2016, 8 baited traps were set over the course of 3 days, and 6 adult Unarmoured Threespine Sticklebacks were caught including 1 gravid female. Another gravid female was caught in July 2017.

5 Threats

An assessment and prioritization of threats to the Giant and Unarmoured Threespine Sticklebacks was informed by COSEWIC (2013). For more details on the threat assessment process used in this management plan, refer to the Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk (DFO 2014). The specific assessment categories and associated rankings used for threat assessment (see tables 3 and 4) are provided in appendix C. Assessment category definitions are provided in footnotes to the tables.

5.1 Threat assessment

Table 3. Giant Threespine Stickleback threat assessment.

Threat	Level of concern[8]	Extent[9]	Occurrence[10]	Frequency[11]	Severity[12]	Causal certainty[13]
Alteration of predator regime	Medium	Extensive	Unknown/ anticipated	Unknown	Unknown	Medium
Predation by aquatic invasive species	Medium	Extensive	Unknown/ anticipated	Unknown	Unknown	High
Sedimentation and pollution	Low	Broad (primarily Mayer Lake)	Unknown/ anticipated	Recurrent	Unknown	Low

Table 4. Unarmoured Threespine Stickleback threat assessment.

Threat	Level of concern	Extent	Occurrence	Frequency	Severity	Causal certainty
Predation by aquatic invasive species[14]	Medium	Extensive	Unknown/ anticipated	Unknown	Unknown	High
Sedimentation and pollution	Medium	Broad (primarily Boulton Lake)	Unknown/ anticipated	Recurrent	Unknown	Low

[8] Level of concern: signifies that managing the threat is of (high, medium or low) concern for the conservation of the Giant and Unarmoured Threespine Sticklebacks, consistent with the management objectives. This criterion considers the assessment of all the information in the table.
[9] Extent: proportion of the Giant and Unarmoured Threespine Sticklebacks affected by the threat (extensive, broad, narrow, or restricted).
[10] Occurrence: timing of occurrence of the threat and describes whether a threat is historical, current, anticipated, and/or unknown.
[11] Frequency: temporal extent of the threat (1-time, seasonal, recurrent, continuous or unknown).
[12] Severity: magnitude of impact caused by the threat and level to which it affects Giant and Unarmoured Threespine Sticklebacks conservation (extreme, high, medium, low, or unknown).
[13] Causal certainty: strength of evidence linking the threat to the conservation of the Giant and Unarmoured Threespine Sticklebacks (very high, high, medium, low, or very low).
[14] Including native species introduced beyond their native range in Haida Gwaii (for example, Coastal Cutthroat Trout [*Oncorhynchus clarkii clarkii*]).

5.2 Description of threats

Both the Giant and Unarmoured Threespine Sticklebacks are vulnerable to similar threats.

Giant Threespine Stickleback

Threat: alteration of predator regime

The distinct morphology of the Giant Threespine Stickleback is likely maintained by selective predation by gape-limited predators such as Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*) and Common Loon (*Gavia immer*) (Reimchen 1984). Reduction in this predation pressure may result in increased hybridization between the Giant Threespine Stickleback and the parapatric stream form of Threespine Stickleback (Moodie 1984). Overfishing of species such as Coastal Cutthroat Trout would reduce predation pressure on Giant Threespine Sticklebacks in Mayer and Drizzle Lakes. Increased recreational activities in Mayer and Drizzle Lakes may result in reduced predation pressure by birds such as Common Loon. Measures that reduce impacts on predator populations are likely to prevent negative adaptive changes such as hybridization.

Threat: predation by aquatic invasive species (AIS)

Recreational activities such as angling and boating may result in the increased probability of introduction of AIS, including bait fishes and non-native game fishes. AIS refers to all species that are not native to the Mayer, Drizzle, Boulton, Rouge and Serendipity Lake watersheds, and can have severe consequences on other endemic forms of Threespine Stickleback (Taylor and Piercey 2017). This devastating impact of invasive species has been demonstrated in 2 stickleback species pairs in recent decades: the collapse of Enos Lake Stickleback species pair into a morphologically and genetically indistinct hybrid swarm followed the appearance of American Signal Crayfish and the extinction of Hadley Lake Stickleback species pair followed the introduction of Brown Bullhead (Hatfield 2001; Taylor et al. 2006). Risk assessments have suggested that some lakes on Haida Gwaii may provide suitable habitat for Smallmouth Bass (*Micropterus dolomieu*) and Northern Pike (*Esox lucius*) (Bradford et al. 2008, Tovey et al. 2008). The magnitude of the effects of the potential introduction of these species is unknown, but may be significant. Mayer Lake and Drizzle Lake are accessible to the public, but they are located in Naikoon Provincial Park and Drizzle Lake Ecological Reserve, respectively, which may allow for effective options for threat management.

Threat: sedimentation and pollution

Sedimentation and pollution from rural and industrial activities within the watershed, such as real estate development, agriculture, and forestry, could impact the nearshore spawning areas for Giant Threespine Stickleback and pose a threat to its conservation.

Unarmoured Threespine Stickleback

Threat: predation by AIS

Unarmoured Threespine Stickleback are especially vulnerable to the development of a predator regime involving predatory fish species such as Coastal Cutthroat Trout. Coastal Cutthroat Trout is native to the Haida Gwaii archipelago but not found within the range of Unarmoured

Threespine Stickleback, and could be introduced to Serendipity, Rouge, or Boulton Lake by anglers. Small lakes elsewhere in British Columbia that are similar to Serendipity, Rouge, and Boulton Lakes have been known to support communities of large fish (Ormond et al. 2011). The occurrence of AIS is linked to recreational activities such as angling and boating (Moodie 1984; Reimchen 1984). Boulton Lake is close to the Haida Gwaii Highway, which enables ease of access and in turn may result in introduction of AIS. Risk assessments have suggested that Haida Gwaii is home to some areas of habitat that may be conducive to AIS, the introduction of which could be disastrous for the Unarmoured Threespine Stickleback based on previous effects on other endemic Threespine Sticklebacks (Taylor and Piercey 2017). Northern Red-legged Frog (*Rana aurora*) was introduced to Graham Island possibly as early as 1964, and was confirmed present in 2002 (Golumbia et al. 2008). This species has since been observed in Boulton Lake and in recent years Northern Red-legged Frog tadpoles have outnumbered sticklebacks in survey traps and coincides with a similar increase in native leech populations (Reimchen pers. comm. 2019). The potential trophic interactions between Northern Red-legged Frog and the Unarmoured Threespine Sticklebacks in Boulton Lake have not been investigated, but may be a concern for the population in the future.

Threat: sedimentation and pollution

Spawning areas of Unarmoured Threespine Stickleback are vulnerable to sedimentation and pollution from rural and industrial activities, such as real estate development, agriculture, and forestry, within the watershed. As a result, sedimentation and pollution pose a low level threat to the Unarmoured Threespine Stickleback.

Management

6 Management objectives

Management objectives establish, to the extent possible, the number of individuals and/or populations, and their geographic distribution,necessary to prevent the Giant and Unarmoured Threespine Sticklebacks from becoming threatened or endangered.

The management objective for the Giant Threespine Stickleback is:

- To maintain self-sustaining populations of Giant Threespine Stickleback in Mayer Lake and Drizzle Lake, comprising approximately 75,000 and 100,000 individuals, respectively, taking into account natural variation (Moodie 1984, Reimchen 1990, Reimchen 2004)

The management objective for the Unarmoured Threespine Stickleback is:

- To maintain self-sustaining populations of Unarmoured Threespine Stickleback in Boulton Lake, Rouge Lake, and Serendipity Lake, comprisingapproximately 350,000, 17,500, and 22,000 individuals, respectively, taking into account natural variation (Reimchen 1984)

7 Broad strategies and measures for the conservation of the species to meet objectives

This management plan includes 4 broad strategies and related measures for the conservation of the species to prevent the Giant and Unarmoured Threespine Sticklebacks from becoming threatened or endangered.

Section 7.1 provides an overview of the actions related to conserving the Giant and Unarmoured Threespine Sticklebacks already completed and underway. Section 7.2 identifies the broad strategies for the conservation of Giant and Unarmoured Threespine Stickleback. The measures for the conservation of the Giant and Unarmoured Threespine Sticklebacks to be implemented are summarized in an implementation schedule (tables 5, 6, and 7) in section 7.3. To the extent possible, the scheduleprioritizes actions and identifies leads, partners and timelines.

7.1 Actions already completed or currently underway

Dr. Tom Reimchen (University of Victoria) has been studying Haida Gwaii Threespine Sticklebacks since the late 1960s, including long-term studies at Drizzle Lake (Giant Threespine Stickleback) and Boulton Lake (Unarmoured Threespine Stickleback). His research efforts have examined functional morphology of bony plates, spines, and nuptial colour; predator diversity and causes of mortality; evolutionary and ecological aspects of defense morphology; parasitology; and dinoflagellate life history on Unarmoured Threespine Stickleback.

7.2 Broad strategies

The following broad strategies support the management objectives outlined in section 6. Broad strategies and conservation measures are summarized and prioritized in tables 5 to 7.

1. Inventory and monitoring
2. Research
3. Management and coordination
4. Stewardship and outreach

7.3 Measures for the conservation of the species

The measures set out in this management plan provide the best chance of achieving the management objectives for Giant and Unarmoured Threespine Stickleback. They guide not only activities to be undertaken by Fisheries and Oceans Canada (DFO) but those for which other jurisdictions, organizations and individuals may have a role to play. As new information becomes available, these measures and the priority of these measures may change.

Table 5 identifies the measures to be undertaken by DFO.

DFO strongly encourages all Canadians to participate in the conservation of the Giant and Unarmoured Threespine Stickleback by undertaking the measures for the conservation of the species outlined in this management plan. Table 6 identifies the measures to be undertaken collaboratively between DFO and its partners, other agencies, organizations or individuals.

Note that due to the extremely limited ranges of the Giant and Unarmoured Sticklebacks, a precautionary approach should be employed with regards to the frequency of census surveys to minimize the risks and impacts of surveys to these populations.

Table 7 identifies the remaining measures that represent responsibilities and/or opportunities for other jurisdictions, organizations or individuals to lead for the conservation of the Giant and Unarmoured Threespine Sticklebacks. If your organization is interested in participating in one of these measures, please contact the Species at Risk Pacific Region office.

Federal programs that may support some of the outlined activities include the Habitat Stewardship Program for Species at Risk, the Aboriginal Fund for Species at Risk Program, and the Canada Nature Fund for Aquatic Species at Risk.

The measures for the conservation of the Giant and Unarmoured Threespine Sticklebacks included in this management plan and that are to be implemented by DFO are subject to the availability of funding and other required resources. As indicated in the following tables, partnerships with specific organizations will provide expertise and capacity to carry out some of the listed measures. The identification of partners is intended to be advice to other jurisdictions and organizations and carrying out these actions will be subject to each group's priorities and budgetary constraints.

The tables also identify the status and timelines for measures for the conservation of the Giant and Unarmoured Threespine Sticklebacks. Status indicates whether the measure is already underway or initiated, or whether it is a new measure to be undertaken. The timeline identifies the amount of time that is anticipated to be required to complete the measure.

Table 5. Measures for the conservation of the Giant and Unarmoured Threespine Sticklebacks to be undertaken by Fisheries and Oceans Canada (DFO).

#	Conservation measure	Broad strategy	Priority[15]	Threat or concern addressed	Timeline
1	Develop a long-term population and distribution monitoring plan for the Giant and Unarmoured Threespine Sticklebacks.	Inventory and monitoring	Medium	All	2022 to 2026

Table 6. Measures for the conservation of the Giant and Unarmoured Threespine Sticklebacks to be undertaken collaboratively between Fisheries and Oceans Canada (DFO) and its partners.

#	Conservation measure	Broad strategy	Priority	Threat or concern addressed	Timeline	Partners
2	Implement long-term population and distribution monitoring plan for Giant and Unarmoured Threespine Sticklebacks.	Inventory and monitoring	Medium	All	Beyond 2027 to 2031	Academia, provincial government, Indigenous groups
3	Conduct scientific research that contributes to conservation and/or addresses knowledge gaps affecting management of Giant and Unarmoured Threespine Sticklebacks. Research may include: • increasing knowledge related to interactions between Giant and Unarmoured Threespine	Research	Low	All	2027 to 2031	Academia, provincial government, Indigenous groups

[15] "Priority" reflects the degree to which the measure contributes directly to the conservation of the Giant and Unarmoured Threespine Sticklebacks or is an essential precursor to a measure that contributes to the conservation of the Giant and Unarmoured Threespine Sticklebacks:

- "high" priority measures are considered likely to have an immediate and/or direct influence on the conservation of the Giant and Unarmoured Threespine Sticklebacks
- "medium" priority measures are important but considered to have an indirect or less immediate influence on the conservation of the Giant and Unarmoured Threespine Sticklebacks
- "low" priority measures are considered important contributions to the knowledge base about the Giant and Unarmoured Threespine Sticklebacks and mitigation of threats

#	Conservation measure	Broad strategy	Priority	Threat or concern addressed	Timeline	Partners
	Sticklebacks and other species, including predators and aquatic invasive species • analyzing water quality parameters (for example, temperature, nutrients, contaminants), especially in areas where impacts from rural and industrial activities are a concern, in relation to Giant and Unarmoured Threespine Stickleback distribution and abundance.					
4	Develop and implement initiatives to prevent aquatic invasive species from entering and becoming established within the range of Giant and Unarmoured Threespine Sticklebacks. Such initiatives may include: • risk analysis of intentional and unintentional pathways of introduction for aquatic invasive species • assess likelihood of introduction, establishment, and impact for a variety of aquatic invasive species • implement a system of monitoring and communication for early detection and rapid response in the event that high-risk invasive species are detected within the range of the Giant and Unarmoured Threespine Sticklebacks	Management and coordination	High	Predation by aquatic invasive species	2027 to 2031	Academia, provincial government, Indigenous groups

Table 7. Measures for the conservation of the Giant and Unarmoured Threespine Sticklebacks that represent responsibilities and/or opportunities for other jurisdictions, organizations or individuals to lead.

#	Conservation measure	Broad strategy	Priority	Threat or concern addressed	Timeline	Potential / confirmed jurisdiction or organization
5	Share information about Giant and Unarmoured Threespine Sticklebacks and encourage land owners and relevant levels of government to consider them in the development, implementation, and updating of land use plans and management guidelines.	Management and coordination	Low	All	2022 to 2026	Indigenous groups, stewardship groups, industry, local and provincial governments
6	Develop outreach and stewardship projects in support of conservation measures and foster awareness of Giant and Unarmoured Threespine Sticklebacks and their threats. Target audiences may include local community members, landowners, industry, recreational groups, and local schools.	Stewardship and outreach	Low	All	2022 to 2026	Indigenous groups, stewardship groups, industry, local and provincial governments

8 Measuring progress

The performance indicators presented below provide a way to define and measure progress toward achieving the management objectives. A successful management program will achieve the overall aim of maintaining self-sustaining populations of Giant and Unarmoured Threespine Sticklebacks in their current distribution. Progress towards meeting these objectives will be reported on in the report on the progress of the management plan implementation. The performance indicators are:

- observe a stable or positive trend in Giant and Unarmoured Threespine Stickleback population abundances by 2031, taking into account natural variation

- observe a preservation of Giant and Unarmoured Threespine Stickleback distribution by 2031, taking into account natural variation

9 References

Bergstrom, C. A., & Reimchen, T. E. (2000). Functional implications of fluctuating asymmetry among endemic populations of *Gasterosteus aculeatus*. *Behaviour*, 137(7), 1097-1112.

Bergstrom, C. A., & Reimchen, T. E. (2002). Geographical variation in asymmetry in *Gasterosteus aculeatus*. *Biological Journal of the Linnean Society*, 77(1), 9-22.

Bergstrom, C. A., & Reimchen, T. E. (2003). Asymmetry in structural defenses: insights into selective predation in the wild. *Evolution*, 57(9), 2128-2138.

Bergstrom, C. A., & Reimchen, T. E. (2005). Habitat dependent associations between parasitism and fluctuating asymmetry among endemic stickleback populations. *Journal of evolutionary biology*, 18(4), 939-948.

Bradford, M.J., C.P. Tovey, and M-L. Heborg. (2008). Biological Risk Assessment for Northern Pike (Esox lucius), Pumpkinseed (Lepomis gibbosus), and Walleye (Sander vitreus) in British Columbia. Canadian science Advisory Secretariat. CSAS Research Document 2008/74.

B.C. Conservation Data Centre. 2020. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. (accessed February 26, 2020).

B.C. Ministry of Environment. (1984). Fisheries Inventory Data Queries (FIDQ). B.C. Minist. of Environ. Victoria, B.C. (accessed February 26, 2020).

B.C. Parks. (1973). Drizzle Lake Ecological Reserve Detailed Description. B.C. Parks Smithers, B.C.

Chan, Y. F., Marks, M. E., Jones, F. C., Villarreal, G., Shapiro, M. D., Brady, S. D., ... & Myers, R. M. (2010). Adaptive evolution of pelvic reduction in sticklebacks by recurrent deletion of a Pitx1 enhancer. science, 327(5963), 302-305.

COSEWIC. (2013). COSEWIC assessment and status report on the Giant Threespine Stickleback *Gasterosteus aculeatus* and the Unarmoured Threespine Stickleback *Gasterosteus aculeatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiv + 62 pp.

Fisheries and Oceans Canada (DFO). (2014). Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/013.

Fisheries and Oceans Canada (DFO). (2018). Recovery Strategy for the Misty Lake Sticklebacks (*Gasterosteus aculeatus*) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. iv + 41pp.

Gambling, S. J., & Reimchen, T. E. (2012). Prolonged life span among endemic Gasterosteus populations. *Canadian Journal of Zoology*, 90(2), 284-290.

Golumbia, T., Bland, L., Moore, K., & Bartier, P. (2008). History and current status of introduced vertebrates on Haida Gwaii. Lessons from the islands: introduced species and what they

tell us about how ecosystems work, 8-31.

Jones, F. C., Chan, Y. F., Schmutz, J., Grimwood, J., Brady, S. D., Southwick, A. M., ... & Schluter, D. (2012). A genome-wide SNP genotyping array reveals patterns of global and repeated species-pair divergence in sticklebacks. *Current biology*, 22(1), 83-90.

Moodie, G. E. E. (1972). Morphology, life history, and ecology of an unusual stickleback (*Gasterosteus aculeatus*) in the Queen Charlotte Islands, Canada. *Canadian Journal of Zoology*, 50(6), 721-732.

Moodie, G. E. E. (1984). Status of the Giant (Mayer Lake) Stickleback, Gasterosteus sp., on the Queen Charlotte Islands, British Columbia. *Canadian field-naturalist*.

Moodie, G. E. E., & Reimchen, T. E. (1973). Endemism and conservation of sticklebacks in the Queen Charlotte Islands.

Moodie, G. E. E., & Reimchen, T. E. (1976). Phenetic variation and habitat differences in Gasterosteus populations of the Queen Charlotte Islands. *Systematic Zoology*, 25(1), 49-61.

Natureserve. 2020. NatureServe Web Service. Arlington, VA. U.S.A. (accessed February 26, 2020).

Ormond, C. I., Rosenfeld, J. S., & Taylor, E. B. (2011). Environmental determinants of threespine stickleback species pair evolution and persistence. *Canadian Journal of Fisheries and Aquatic Sciences*, 68(11), 1983-1997.

Reimchen, T. E. (1980). Spine deficiency and polymorphism in a population of *Gasterosteus aculeatus*: an adaptation to predators?. *Canadian Journal of Zoology*, 58(7), 1232-1244.

Reimchen, T. E. (1984). Status of unarmoured and spine-deficient populations(Charlotte unarmoured stickleback) of threespine stickleback, Gasterosteus sp., on the Queen Charlotte Islands, British Columbia. *Canadian field-naturalist*. Ottawa ON, 98(1), 120-126.

Reimchen, T. E. (1988). Inefficient predators and prey injuries in a population of giant stickleback. *Canadian Journal of Zoology*, 66(9), 2036-2044.

Reimchen, T. E. (1989). Loss of nuptial color in threespine sticklebacks (*Gasterosteus aculeatus*). *Evolution*, 43(2), 450-460.

Reimchen, T. E. (1990). Size-Structured Mortality in a Threespine Stickleback (*Gasterosteus aculeatus*)–Cutthroat Trout (Oncorhynchus clarki) Community. *Canadian Journal of Fisheries and Aquatic Sciences*, 47(6), 1194-1205.

Reimchen, T. E. (1991). Trout foraging failures and the evolution of body size in stickleback. *Copeia*, *1991*(4), 1098-1104.

Reimchen, T. E. (1994). Predators and morphological evolution in threespine stickleback. *The evolutionary biology of the threespine stickleback*, 240-276.

Reimchen, T. E. (1997). Parasitism of asymmetrical pelvic phenotypes in stickleback. *Canadian Journal of Zoology*, *75*(12), 2084-2094.

Reimchen, T.E. (2004). Update status report on giant (Mayer Lake) stickleback, *Gasterosteus aculeatus* [Unpublished Interim Draft Report]. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-17 pp.

Reimchen, T. E., & Bergstrom, C. A. (2009). The ecology of asymmetry in stickleback defense structures. *Evolution*, *63*(1), 115-126.

Reimchen, T. E., & Nosil, P. (2001a). Dietary differences between phenotypes with symmetrical and asymmetrical pelvis in the stickleback *Gasterosteus aculeatus*. *Canadian Journal of Zoology*, *79*(3), 533-539.

Reimchen, T. E., & Nosil, P. (2001b). Ecological causes of sex-biased parasitism in threespine stickleback. *Biological Journal of the Linnean Society*, *73*(1), 51-63.

Reimchen, T. E., & Nosil, P. (2001c). Lateral plate asymmetry, diet and parasitism in threespine stickleback. *Journal of Evolutionary Biology*, *14*(4), 632-645.

Reimchen, T. E., & Nosil, P. (2004). Variable predation regimes predict the evolution of sexual dimorphism in a population of threespine stickleback. *Evolution*, *58*(6), 1274-1281.

Reimchen, T. E., Stinson, E. M., & Nelson, J. S. (1985). Multivariate differentiation of parapatric and allopatric populations of threespine stickleback in the Sangan River watershed, Queen Charlotte Islands. *Canadian Journal of Zoology*, *63*(12), 2944-2951.

Spoljaric, M. A., & Reimchen, T. E. (2007). 10 000 years later: Evolution of body shape in Haida Gwaii three-spined stickleback. *Journal of Fish Biology*, *70*(5), 1484-1503.

Spoljaric, M. A., & Reimchen, T. E. (2008). Habitat-dependent reduction of sexual dimorphism in geometric body shape of Haida Gwaii threespine stickleback. *Biological Journal of the Linnean Society*, *95*(3), 505-516.

Spoljaric, M. A., & Reimchen, T. E. (2011). Habitat-specific trends in ontogeny of body shape in stickleback from coastal archipelago: Potential for rapid shifts in colonizing populations. *Journal of Morphology*, *272*(5), 590-597.

Taylor, E. B., Boughman, J. W., Groenenboom, M., Sniatynski, M., Schluter, D., & Gow, J. L. (2006). Speciation in reverse: morphological and genetic evidence of the collapse of a three-spined stickleback (*Gasterosteus aculeatus*) species pair. *Molecular Ecology*, *15*(2), 343-355.

Taylor, E. B., & Piercey, R. S. (2017). 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*, 1-12.

Tovey, C.P., M.J. Bradford, and M-L. Herborg. (2008). Biological Risk Assessment for Smallmouth bass (Micropterus dolomieu) and Largemouth bass (Micropterus salmoides) in British Columbia. Canadian Science Advisory Secretariate Research Document 2008/075.

Walker, I.J, Barrie, J.V., Dolan, A.H., Gedalof, Z., Manson, G., Smith, D., and Wolfe, S. (2007). Coastal vulnerability to climate change and sea-level rise, Northeast Graham Island, Haida Gwaii (Queen Islands), British Columbia. Ottawa, Ontario: Prepared for the Climate Change Impacts and Adaptation Directorate, Natural Resources Canada.

Appendix A: effects on the environment and other species

In accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals (2010), *Species at Risk Act* (SARA) recovery planning documents incorporate strategic environmental assessment (SEA) considerations throughout the document. The purpose of a 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.

Management planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that plans may also 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 plan itself, but are also summarized below in this statement.

This management plan will benefit the environment by promoting the conservation of Giant and Unarmoured Threespine Sticklebacks, thereby contributing to FSDS goal 4 (conserving and restoring ecosystems, wildlife and habitat, and protecting Canadians). Specifically, it will help to attain the associated target 4.1 which is to have populations of federally listed species at risk exhibit trends that are consistent with 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 potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. For information on how the management plan and Giant and Unarmoured Threespine Sticklebacks potentially link to, or interact with, other species and the ecosystem, refer to the following sections of the document: Species description, Needs of the species, and Measures for the conservation of the species.

Appendix B: record of cooperation and consultation

Management plans are to be prepared in cooperation and consultation with other jurisdictions, organizations, affected parties and others as outlined in the *Species at Risk Act* (SARA) section 66. Fisheries and Oceans Canada received contributions of expertise from Dr. Thomas Reimchen (The University of Victoria) during the development of this management plan.

In addition, consultation on the draft management plan occurred through a 30-day targeted external review with drafts circulated to the Council of Haida Nation, other levels of governments including the province of BC and the Villages of Port Clements and Masset, species experts, special interest groups on Haida Gwaii, and other federal departments. Comments resulted in minor revisions and clarifications.

Additional stakeholder, Indigenous, and public input was sought through the publication of the proposed document on the Species at Risk Public Registry for a 60-day public comment period. No feedback was received.

Appendix C: threat assessment categories

Likelihood of occurrence	Definition	Symbol
Known or very likely to occur	This threat has been recorded to occur 91 to 100%	**K**
Likely to occur	There is 51 to 90% chance that this threat is or will be occurring.	**L**
Unlikely	There is 11 to 50% chance that this threat is or will be occurring	**UL**
Remote	There is 1 to 10% or less chance that this threat is or will be occurring.	**R**
Unknown	There are no data or prior knowledge of this threat occurring now or in the future.	**U**

Level of impact	Definition	Symbol
Extreme	Severe population decline (for example, 71 to 100%) with the potential for extirpation.	**E**
High	Substantial loss of population (31 to 70%) or Threat would jeopardize the survival or recovery of the population.	**H**
Medium	Moderate loss of population (11 to 30%) or Threat is likely to jeopardize the survival or recovery of the population.	**M**
Low	Little change in population (1 to 10%) or Threat is unlikely to jeopardize the survival or recovery of the population.	**L**
Unknown	No prior knowledge, literature or data to guide the assessment of threat severity on population.	**U**

Causal certainty	Definition	Rank
Very high	Very strong evidence that threat is occurring and the magnitude of the impact to the population can be quantified.	**1**
High	Substantial evidence of a causal link between threat and population decline or jeopardy to survival or recovery	**2**
Medium	There is some evidence linking the threat to population decline or jeopardy to survival or recovery	**3**
Low	There is a theoretical link with limited evidence that threat is leading to a population decline or jeopardy to survival or recovery	**4**
Very low	There is a plausible link with no evidence that the threat is leading to a population decline or jeopardy to survival or recovery	**5**

Threat occurrence	Definition	Symbol
Historical	A threat that is known to have occurred in the past and negatively impacted the population.	**H**
Current	A threat that is ongoing, and is currently negatively impacting the population.	**C**
Anticipatory	A threat that is anticipated to occur in the future, and will negatively impact the population.	**A**

Threat frequency	Definition	Symbol
Single	The threat occurs once.	**S**
Recurrent	The threat occurs periodically, or repeatedly.	**R**
Continuous	The threat occurs without interruption.	**C**

Threat extent	Definition	Symbol
Extensive	71 to 100% of the population is affected by the threat.	**E**
Broad	31 to 70% of the population is affected by the threat.	**B**
Narrow	11 to 30% of the population is affected by the threat.	**NA**
Restricted	1 to 10% of the population is affected by the threat.	**R**