PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Misty Lake Sticklebacks (*Gasterosteus aculeatus*) in Canada

Misty Lake Lentic Stickleback

Misty Lake Lotic Stickleback

2016

Canada

Recommended citation:

Fisheries and Oceans Canada. 2016. Recovery Strategy for the Misty Lake Sticklebacks (*Gasterosteus aculeatus*) in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. iv + 41pp.

For copies of the recovery strategy, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry (www.sararegistry.gc.ca[1]).

Cover illustration: Photographs of Misty Lake Lentic Stickleback and Misty Lake Lotic Stickleback (*Gasterosteus aculeatus*) from the lentic (lake) (top photo) and from the (lotic) (inlet) stream (bottom photo). Photos by Renaud Kaueffer, with the help of Maryse Boisjoly and Shahin Muttalib.

Également disponible en français sous le titre
« Programme de rétablissement des épinoches (*Gasterosteus aculeatus*) du lac Misty au Canada [Proposition]»

ISBN ISBN to come
Catalogue no. Catalogue no. to come

[1] www.registrelep.gc.ca/default_e.cfm

PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years.

The Minister of Fisheries and Oceans is the competent minister under SARA for the Misty Lake Sticklebacks and has prepared this strategy, as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Government of British Columbia as per section 39(1) of SARA.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Misty Lake Sticklebacks and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Fisheries and Oceans Canada and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[2] www.ec.gc.ca/media_archive/press/2001/010919_b_e.htm

ACKNOWLEDGMENTS

Fisheries and Oceans Canada (DFO) extends its appreciation to the many individuals and organizations that supported the development of this recovery strategy. DFO acknowledges the efforts of the members of the former Non-Game Freshwater Fish Recovery Team (listed below) for preparing an early draft of this recovery strategy. DFO also acknowledges Dr. Michael Jackson of Acroloxus Wetlands Consultancy Ltd. and his employees who provided species expertise and assisted in updating the draft strategy. The valuable information, expertise and perspectives shared by stakeholders at a recovery planning technical workshop for the Misty Lake Sticklebacks, which included scientific and technical experts from the University of British Columbia, both provincial Ministry of Environment and Parks staff, the Kwakiutl First Nation, the Texada Stickleback Group, and Acroloxus Wetlands Conservancy are also acknowledged and greatly appreciated. Chelsey Cameron (DFO) and Heather Stalberg (DFO) authored the recovery strategy, with contributions from Martin Nantel, Alyssa Gerick, Tom Brown, and Sean MacConnachie from DFO.

Members of the Non-Game Freshwater Fish Recovery Team assembled to provide science-based recommendations to the government with respect to the recovery of the Misty Lake Sticklebacks at the time of drafting the 2008 draft recovery strategy were:

Jordan Rosenfeld, British Columbia Ministry of Environment, (co-chair)
Dan Sneep, DFO, (co-chair)
Todd Hatfield, Solander Ecological Research, (coordinator)
Don McPhail, formerly of University of British Columbia
John Richardson, University of British Columbia
Dolph Schluter, University of British Columbia
Eric Taylor, University of British Columbia
Paul Wood, University of British Columbia

This recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, or the official positions of the organizations with which the individuals are associated.

EXECUTIVE SUMMARY

Descended from the marine Threespine Stickleback (*Gasterosteus aculeatus*), parapatric (meaning species living adjacentto each other) lake-stream stickleback species are of considerable scientific interest and value due to their recent and unique evolutionary history. Although they live in contiguous geographic ranges, they interbreed relatively little in the overlapping habitat, and are genetically, ecologically and morphologically distinct. Parapatric lake-stream sticklebacks are relatively rare and, while other lake-stream pairs have been documented, each are independently derived.

The Misty Lake Lentic Stickleback (*Gasterosteus aculeatus*) and the Misty Lake Lotic Stickleback (*Gasterosteus aculeatus*) occur only within the Misty Lake watershed, a sub-basin of the Keogh River drainage on northern Vancouver Island, British Columbia. The Misty Lake Stickleback complex includes an inlet form (lotic), a lake-dwelling form (lentic), and a population in the outlet stream that is considered part of the lentic species. The Misty Lake Lentic and Lotic Sticklebacks are listed as Endangered in Schedule 1 of SARA.

Threats to Misty Lake Sticklebacks include: the introduction or invasion and subsequent establishment of aquatic exotic and invasive species that predate upon, or compete with, the Misty Lake Sticklebacks or degrade habitat quality; point and non-point source water pollution from contaminants such as hydrocarbons or pesticides, and increased sediment loads and degradation of water quality from land use activities in the watershed respectively; non-conforming use of the ecological reserve; riparian vegetation removal; water extraction; climate change; and excessive removal of individuals for scientific research.

This recovery strategy for Misty Lake Sticklebacks includes the following population and distribution objectives: (1) To maintain self-sustaining populations and the current distribution of the lake and stream (inlet and outlet) forms of the Misty Lake Sticklebacks through maintaining current habitat area and habitat quality; and (2) to maintain the two distinct forms by preventing an increase in hybridization that could lead to the collapse of the species pair into a hybrid swarm. As well, broad strategies and approaches necessary to address threats to the recovery of Misty Lake Sticklebacks are identified. Activities may be added, adapted and revised as new information is gathered.

A description of the residence for the Misty Lake Sticklebacks is included in this document.

Critical habitat for the Misty Lake Sticklebacks is identified in this recovery strategy to the extent possible using the best available information, and includes specific habitat features and attributes required to support abundance, distribution and reproductive isolation of the species pair. The critical habitat has been identified using the bounding box approach wherein the following features are considered critical habitat; the entirety of Misty Lake, the length of the inlet and outlet streams to the extent currently known to be occupied by Misty Lake Sticklebacks, the swampy transition zones between the lake and the inlet and outlet streams, a riparian area of 15 meters surrounding the lake perimeter, and a 30 meter riparian area surrounding the swampy transition zones and the inlet and outlet streams adjacent to the currently known occupied extent. The attributes associated with the critical habitat features are

described to the extent possible. It is anticipated that the critical habitat will be protected from destruction by a SARA Critical Habitat Order.

A detailed action plan will be completed within five years of posting the final recovery strategy on the Species at Risk Public Registry.

RECOVERY FEASIBILITY SUMMARY

In accordance with SARA, the competent minister must determine the feasibility of recovery for each species at risk. The draft *Species at Risk Act* Policies, Overarching Policy Framework (2009) sets out four criteria that help standardize the process by which the competent minister determines if recovery is technically and biologically feasible. These criteria are posed as questions and answered below:

1. Are individuals of the wildlife species capable of reproduction available now or in the foreseeable future to sustain the population or improve its abundance?

Yes. Misty Lake Sticklebacks are believed to be self-supporting at present, although the precise status of each population is unknown.

2. Is sufficient suitable habitat available to support the species or could it be made available through habitat management or restoration?

Yes. Sufficient suitable habitat currently exists within the natural range of this species.

3. Can the primary threats to the species or its habitat (including threats outside Canada) be avoided or mitigated?

Yes. Controlling threats to Misty Lake Sticklebacks and their habitat is feasible, but rests more on social rather than technical considerations. For example, the primary threats are introduction of non-native species and general land use which could be managed to a great extent with existing regulations, but may require additional outreach and support from stakeholders.

4. Do recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe?

Yes. Special recovery techniques are not required for recovery of Misty Lake Sticklebacks. Recovery efforts are best concentrated on the effective management of current and future threats. This is believed to be entirely feasible. There are no significant technical challenges. It should be stressed, however, that Misty Lake Sticklebacks will likely always be highly restricted in their distribution.

In summary, Misty Lake Sticklebacks are found only in a highly restricted range within Canada. It is this endemism along with the evolutionary significance of the two forms existing as a parapatric pair that supports their current status. Since there is no plan to purposely transplant them elsewhere, they will continue to be confined to a small area. It is likely that they will remain at some risk due to this highly restricted distribution. However, DFO is of the opinion that with the support of local governments, stakeholders and the public, recovery of the Misty Lake Sticklebacks is feasible.

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1. COSEWIC SPECIES ASSESSMENT INFORMATION

Date of Assessment: November 2006

Common Name (population): Misty Lake Lentic Stickleback

Scientific Name: *Gasterosteus* sp.

COSEWIC Status: Endangered

Reason for Designation: This lake-dwelling fish is part of an endemic, highly divergent species pair restricted to a single stream-lake complex on Vancouver Island with an extremely small area of occurrence. This species pair could quickly become extinct due to introduction of non-native aquatic species or perturbations to the habitat. Proximity of this complex to a major highway and public access make an introduction likely. Logging activities in the watershed, as well as highway use and related maintenance, could impact habitat quality to some degree.

Canadian Occurrence: British Columbia

COSEWIC Status History: Designated Endangered November 2006. Assessment based on new status report.

Date of Assessment: November 2006

Common Name (population): Misty Lake Lotic Stickleback

Scientific Name: *Gasterosteus* sp.

COSEWIC Status: Endangered

Reason for Designation: This stream-dwelling fish is part of an endemic, highly divergent species pair restricted to a single stream-lake complex on Vancouver Island with an extremely small area of occurrence. This species pair could quickly become extinct due to introduction of non-native aquatic species or perturbations to the habitat. Proximity of this complex to a major highway and public access make an introduction likely. Logging activities in the watershed, as well as highway use and related maintenance, could impact habitat quality to some degree.

Canadian Occurrence: British Columbia

COSEWIC Status History: Designated Endangered November 2006. Assessment based on new status report.

2. SPECIES STATUS INFORMATION

The Misty Lake Lentic Stickleback (*Gasterosteus aculeatus*) and Misty Lake Lotic Stickleback (*Gasterosteus aculeatus*) (Misty Lake Sticklebacks) occur only within the Misty Lake watershed on northern Vancouver Island, such that its entire range lies within Canada and British Columbia (B.C.), specifically. There are other lakes with similarly well documented lake-stream pairs of sticklebacks in B.C. (Mayer Lake [Moodie 1972] and Drizzle Lake [Reimchen et al. 1985], and a number on Vancouver Island [Hendry and Taylor 2004] and other B.C. locations), yet they have all evolved separately and are considered to be distinct species pairs. The Misty Lake Sticklebacks have a provincial rank of S1 (critically imperiled and Red-listed) and a global rank of G1 (critically imperiled); British Columbia Conservation Data Centre (2011). The Misty Lake Lentic and Lotic Sticklebacks are both listed as Endangered in Schedule 1 of SARA.

3. SPECIES INFORMATION

3.1 Species Description

The Misty Lake Sticklebacks are a form of Threespine Stickleback (*Gasterosteus aculeatus*), which is a small (usually 35-55 mm) fish common to coastal marine and freshwater habitats throughout the northern hemisphere. It is composed of two distinct forms: a lake-dwelling (lentic) form and a stream-dwelling (lotic) form that resides in the inlet stream (Figure 1). The two forms are parapatric, meaning their ranges do not significantly overlap but are immediately adjacent to each other; they only occur together in a narrow contact zone. The two forms occur in three populations (lake, inlet stream and outlet stream). COSEWIC (2006) defines the inlet stream population as a designatable unit, or species, the lake population as another species, and, due to the similarities between the outlet stream population and lake population, suggests the outlet population be considered part of the lake species.

The inlet and lake populations are highly divergent morphologically, ecologically and genetically. The lake and outlet populations are less so, with the outlet fish being genetically and morphologically quite similar (Hendry 2002). The lake fish have shallower (i.e. streamlined) bodies, larger caudal fins and smaller pelvic girdles that are advantageous for sustained swimming in the pelagic habitat of the lake, compared with the inlet fish whose morphology confers increased maneuverability in structurally complex stream environments (Figure 1; Hendry et al. 2011). These morphological differences, along with the reduced number of gill rakers in inlet fish compared with lake fish (Hendry et al. 2002, Kaeuffer et al. 2012) indicate adaptive divergence to their alternate foraging regimes. Stomach content analysis suggests that adults of the lake form feed predominantly on zooplankton and insect larvae in the surface waters of the lake, while the inlet stream population forages mainly for benthic macro-invertebrates in the stream (Kaeuffer et al. 2012) (COSEWIC 2006) as does the outlet stream population, even though they have not fully adapted morphologically to the stream environment (Berner et al. 2008).

The inlet and lake populations also differ in other aspects of morphology (Lavin and McPhail 1993; Hendry et al. 2002; Sharpe et al. 2008) and colour (Lavin and McPhail 1993), as well as behaviour, such as aggression, mating display (Delcourt et al. 2008, Raeymaekers et al. 2010), and nest characteristics (Raeymaekers et al. 2009). The low frequency of hybrids between lake and inlet fish (Lavin and McPhail 1993, McPhail 1994) is testament to the restricted gene flow that occurs between these populations (Hendry et al. 2002, Hendry and Taylor 2004, Moore and Hendry 2005, Moore et al. 2007). That is, there appears to be limited interbreeding between them, and they remain genetically distinct.

Unlike the inlet population, the outlet population is morphologically more similar to the lake population (Hendry et al. 2002, Moore and Hendry 2005, Delcourt et al. 2008, Sharpe et al. 2008), despite the contrasting prey resources between the lake and outlet (Berner et al. 2008). This pattern is the result of considerable gene flow from the lake that constrains the adaptation of the outlet population to its stream environment (Hendry et al. 2002, Moore and Hendry 2005, Moore et al. 2007, Berner et al. 2008). The inlet and outlet stream dwelling populations are separate and do not interact directly (Hatfield 2009).

The life history of the lake and stream forms is assumed to be similar. The life span of each of these forms has been estimated only from size-frequency plots. Fish from the inlet appear to live up to two years, whereas fish from the lake and outlet can reach three years of age. Within the entire system, breeding fish appear to be one to three years old, with the standard length of mature fish ranging from about 40 mm to more than 65 mm (John Baker 2006, Clark University, pers. comm. from COSEWIC 2008).

Figure 1. Photographs of Misty Lake Sticklebacks (*Gasterosteus aculeatus*) from the lake (top) and from the inlet stream (bottom).
Photos by Andrew Hendry.

The morphological and genetic divergence of the lake and stream forms in Misty Lake from a common stickleback ancestor most likely arose through adaptive divergence; that is, the adaptation of each form to different environmental conditions. As a result there are multiple potential reproductive barriers that may contribute to maintaining their distinctness that could be impacted by changes to habitat or environmental factors, such as changes to water quality or loss of aquatic vegetation (McKinnon and Rundle, 2002). Indeed, the collapse of the Enos Lake Benthic and Limnetic Stickleback (*Gasterosteus spp.*), another species pair on Vancouver Island, B.C., is thought to have resulted from environmental changes within the lake that altered the sticklebacks' selective regime (Taylor et al. 2006). Nevertheless, the usual tests for typical reproductive barriers in stickleback have not yet revealed any strong reproductive barriers in the Misty Lake system: selection against migrants is weak, breeding times overlap, females do not show a preference to breed with their own form in the laboratory (Räsänen et al. 2012), and hybrids show no mating disadvantage in the laboratory (reviewed in Raeymaekers et al. 2010). These results suggest that: (a) reproductive isolation between the lake and inlet populations may be achieved by a combination of many small reproductive barriers; or (b) that adaptive divergence may not, in fact, have driven the evolution of reproductive isolation; low gene flow between lake and inlet populations (and resulting genetic distinctness) may instead simply reflect partial spatial separation (Raeymaekers et al. 2010), or in simpler terms, habitat selection and geographic separation are likely the main mechanisms keeping the species apart (Hendry pers. comm. 2012).

There is no direct commercial value to the lake or stream forms. The Misty Lake Sticklebacks are part of Canada's native fauna, however, with its own intrinsic value, including its ecological role and contribution to biodiversity, education and science. Its scientific value is especially significant; along with other Threespine Stickleback species pairs that are endemic to B.C., this unique species pair contributes valuably to understanding evolution. In particular, it has proved to be an important system in shedding light on the balance between natural selection and gene flow in adaptive divergence (Hendry et al. 2002, Hendry and Taylor 2004, Moore et al. 2007, Berner et al. 2008, Hendry et al. 2009, Moore and Hendry 2009, Raeymaekers et al. 2010, Hendry et al. 2011).

3.2 **Population and Distribution**

The Misty Lake Stickleback populations occur only within the Misty Lake watershed, which is a sub-basin of the Keogh River drainage on northern Vancouver Island (Figure 2). Misty Lake is a small coastal lake (35.6 ha, see Appendix 3 for pictures of the lake and streams) that lies approximately 12 kilometers upstream of the ocean. Lavin and McPhail (1993) reported the lake form of the species pair to be primarily restricted to Misty Lake proper, although it is occasionally found in the inlet and outlet streams. Subsequent research has modified the understanding of the distribution of the species, where significant gene flow from the lake into the outlet stream has been found as discussed above in section 3.1, indicating movement of lake fish into the outlet stream. The inlet form is primarily restricted to the inlet stream and the swampy transition zone between the inlet stream and the lake (COSEWIC 2006). The population density of the outlet population (based on estimates from Catch per Unit Effort and a mark–recapture experiment) gradually decreases from the lake until 2.5 kilometers downstream of the lake, where none have been captured (Moore and Hendry 2009). This linear trend in population density is not apparent for the inlet population (Moore and Hendry 2009), however the number of inlet stickleback have been observed to decrease with increased distance upstream from the lake (Moore pers. comm. 2005, 2006 and Hendry pers. comm. 2005, 2006 cited in

COSEWIC 2006). Stickleback do not occupy the entire inlet stream length, which is approximately 20 kilometers long, however the upper extent of their distribution is unknown (COSEWIC 2006). Captures have been made 2.6 kilometers up the inlet from the lake (Moore and Hendry 2005). The two forms co-occur in the swampy transition zones between the lake and streams, especially during the breeding season (Lavin and McPhail 1993).

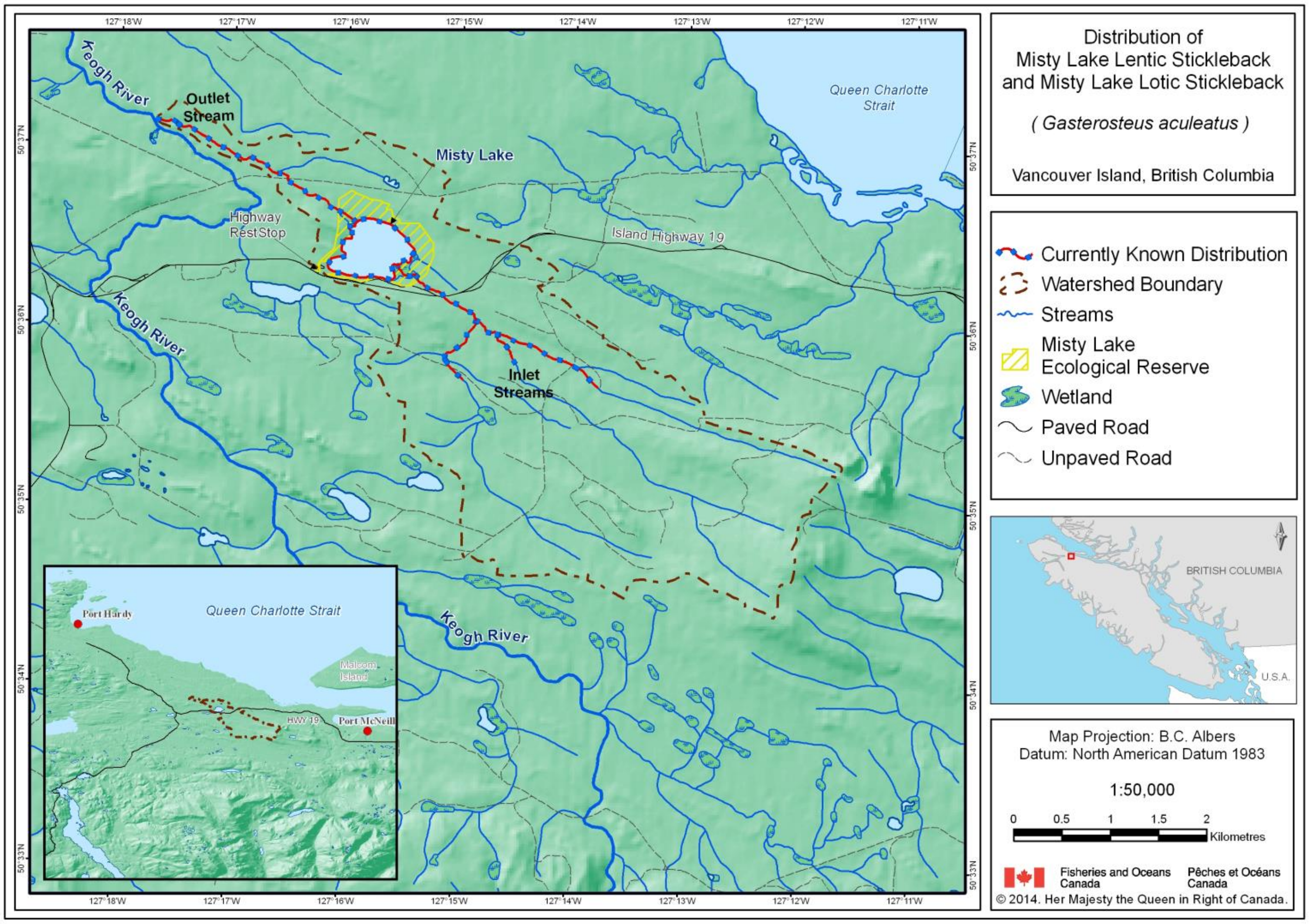

Figure 2. Currently known distribution of Misty Lake Sticklebacks.

There have been no empirical estimates of population census size (N) for the Misty Lake Sticklebacks although the lake population is believed to be considerably larger than either of the stream populations (Hendry and Taylor 2004). Moore suggested about 2,500 adults occupy the inlet and more than 4,000 occupy the outlet (pers. comm. cited in COSEWIC 2006). Catch rates have generally been high in both lake and stream environments: a thousand fish can be caught in a single day of trapping with 30 traps in the lake, sometimes with more than a hundred in a single trap, and several hundred fish can be caught in a single section of stream (A. Hendry, McGill University, pers. comm. from Hatfield 2009). Hendry believes population sizes exceed 5,000 for the inlet and more than 10,000 in the lake (pers. comm. from Hatfield 2009). This is supported by more recent mark-recapture work undertaken by Hendry in 2010 and 2011 on the streams, and 2009 and 2010 in the lake, where estimates were generated, depending upon the season and whether a correction factor was applied for mortality, of between 6,500-20,000 in the inlet stream, 9,000-50,000 in the outlet stream and greater than 50,000 in the lake (Hendry et al. 2012). All of these estimates are based on the extrapolation of capture data by experts rather than the application of quantitative population estimation methods.

An alternative to the direct assessment of N is to indirectly measure it using effective population size[3] (Ne) estimates from population genetic studies, and Ne:N ratios from the literature (summarized in Frankham 1995). Preliminary Ne estimates for the inlet and lake populations based on analysis of five microsatellite loci and two different methods suggest effective population size of breeding pairs in the low hundreds (Hatfield 2009). Using Frankham's (1995) average Ne:N ratio of 0.1 provides abundance estimates of mature fish in the order of a few thousand. While these estimates are consistent with those based on earlier expert opinion, they are not consistent with more recent data (Hendry et al. 2012) and expert opinion of Hendry (Hendry pers. comm. 2012).

Based on the extent and quality of existing habitat and the understanding that Misty Lake is a natural ecosystem which has been relatively stable over the longer term, there is no reason to expect that the historic abundance of Misty Lake Sticklebacks was significantly greater than it is at present, and population abundance appears to be stable (Hatfield 2009; COSEWIC 2006).

3.3 **Needs of the Misty Lake Sticklebacks**

The precise habitat requirements of the species pair are unknown. Therefore determination of the species' needs relies upon current knowledge of its diet and habitat use, as well as the habitat requirements needed to maintain reproductive isolation between the two forms. Furthermore, Misty Lake is considered to be a natural ecosystem that appears to be stable (COSEWIC 2006). Given that and other uncertainties about Misty Lake Sticklebacks (e.g., population size, trends and environmental limiting factors), their habitat needs will hereafter be based on the current lake and stream habitat conditions.

Misty Lake water is very dark, stained with tannins[4] (B.C. Ministry of Environment 2008) which makes it difficult to observe Misty Lake Stickleback nests during the breeding season. However, it is assumed that like other Threespine Stickleback species pairs, Misty Lake Sticklebacks use shallow littoral areas for spawning and that each form breeds predominantly in its preferred habitat (Lavin and McPhail 1993, McPhail 1994). While stream fish probably spawn and incubate in relatively quiescent areas within the streams, and lake fish do so in the littoral zone around the lake, at least some fish of both forms create a zone of overlap in nesting area among the swampy transition zones between the lake and the streams; gravid (carrying eggs) females of both forms have been caught in this zone (McPhail 1994). However, there may be micro-spatial segregation of nesting within this zone, as lake nests are more commonly built on sand rather than gravel compared to inlet nests (Raeymaekers et al. 2009). With the exception of spawning and incubation, the lake form likely spends the majority of time in the limnetic zone of the lake foraging on zooplankton, while the stream populations probably occupy low velocity areas in the

[3] Effective population size is the number of breeding pairs in an idealized population and is quite often smaller than the actual population size as not all individuals in a population are sexually mature.
[4] Tannins are a natural staining compound found in tree bark and other plants.

streams, feeding on benthos, drift and allochthonous[5] inputs. While sticklebacks in general are less likely to use fast riffle habitats, these areas are required for the benthic invertebrate production that nourishes them. Therefore, a complex of natural stream habitat is likely essential to maintain the stream populations (COSEWIC 2006).

Based on the current knowledge around habitat use for the Misty Lake Sticklebacks, the habitat requirements to support the necessary life functions (spawning, rearing, nursery and overwintering) can be broken down into three categories: water quality parameters, specifically water clarity; lake and stream productivity (oligotrophic (nutrient poor) versus eutrophic (nutrient rich)); and ecological community.

Water Quality Parameters

As a species in general, Threespine Sticklebacks are versatile, being able to live in a fairly large range of water quality conditions but may be at risk if water quality degrades beyond the normal range for oxygen, temperature, pH, pollutants or nutrients. The current provincial water quality standards for the protection of aquatic life are appropriate guidelines for basic parameters of water quality in lakes with Threespine Sticklebacks (Province of B.C. Water Quality Guidelines[6]).

However, some aspects of water quality may need to be maintained in a much narrower range than that required for short-term individual survival. For example, a significant issue for sympatric stickleback species pairs is how changes in specific water quality parameters that impact water clarity may affect barriers to reproductive isolation (Boughman 2001). In particular, there is concern that increases in turbidity that alter transmission of different wavelengths of light may interfere with behavioural mechanisms that influence mate recognition and choice (Seehausen et al. 1997). It is uncertain however if such changes would similarly affect the parapatric Misty Lake Stickleback. Hatfield (2009) noted changes in concentration of suspended solids, dissolved organic carbon (e.g., tannins), or other aspects of water chemistry that affect light transmission may disrupt mate recognition and that a breakdown of reproductive barriers could result in a higher frequency of hybridization, and possibly species collapse. Hendry (pers. comm. 2012) was less concerned about the potential breakdown of reproductive barriers given Räsänen et al.'s 2012 work which did not find reproductive barriers in Misty Lake Sticklebacks, and his own 2002 work (Hendry et al. 2002) which found the likely primary isolating barrier between the lake and inlet populations to be the tendency of lake fish to not enter the inlet stream and that few inlet stream fish enter the lake. Hendry considered habitat selection and geographic separation to be the most probable reasons for keeping the inlet stream and lake populations apart (Hendry pers. comm. 2012). As there remains some uncertainty regarding what reproductive barriers are important for Misty Lake Sticklebacks, it remains important to ensure that their selective regime is not altered to ensure persistence of this species pair.

Lake and Stream Productivity

[5] Allochthonous means organisms or organic sediments in a given ecosystem that originated from another system. In the case of Misty Lake, allochthonous inputs would come from the riparian areas (land based ecosystem) around the lake and streams.
[6] http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html

Misty Lake Sticklebacks live in an oligotrophic lake environment (COSEWIC 2006), with dark stained water (B.C. Ministry of Environment 2008, Lavin and McPhail 1993). Increases in nutrient levels (e.g., nitrogen and phosphorous) beyond the natural range may alter habitat quality by favouring production of unpalatable algae that cannot be consumed by zooplankton. Moreover, phytoplankton blooms may reduce macrophyte abundance through shading (Wetzel 2001). Macrophyte beds are known to be essential habitat elements for sympatric stickleback species pairs, providing nesting cover, key rearing and foraging habitat, and contributing significantly to the abundance of macroinvertebrates (Hatfield 2009). Stream characteristics such as the presence of shallow pools and existence of invertebrates are important for the stream form of the Misty Lake Sticklebacks (COSEWIC 2006). The presence and density of riparian habitat surrounding the stream controls the amount of sunlight reaching the stream and can alter the stream productivity, increasing algae growth which may make the habitat unsuitable for the species (COSEWIC 2006).

Ecological Community

Misty Lake Sticklebacks share their habitat with, and likely fall prey to, Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*), Rainbow Trout (*O. mykiss*), Coho Salmon (*O. kisutch*), Dolly Varden (*Salvelinus malma*) and Prickly Sculpin (*Cottus asper*) (COSEWIC 2006). A diverse range of avian birds (e.g., loon, heron, kingfisher), macroinvertebrate (e.g., dragonfly naiads, beetles) and mammalian piscivores (e.g., otters, mink) are also known to prey on stickleback (Reimchen 1994). However, the ways in which these predator-prey relationships impact the species have not been studied.

3.4 **Residence of the Misty Lake Sticklebacks**

SARA defines a residence as "*a dwelling place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*".

Misty Lake Sticklebacks begin reproductive activity in April and finish in July based on catches of gravid females between the months of May and June (COSEWIC 2006). Both forms of the male Misty Lake Stickleback build nests, and provide parental care by fanning the nest during incubation and until the juveniles are able to move to cover and feed (COSEWIC 2006). Based on similar sticklebacks studied in Mayer Lake (Moodie 1972) males probably complete about five nesting cycles during a single breeding season before dying, however another lake form of stickleback in Drizzle Lake can live well beyond its first breeding season (Reimchen 1992).

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

Due to the dark colour of the lake and streams, it is difficult to know exactly where the Misty Lake Sticklebacks build their nests. Breeding activity occurs in the lake and streams of the Misty Lake system; however gravid females of both the inlet and lake form were collected in the inlet swampy transition zone (McPhail 1994). Based on nesting behavior described for a similar stickleback in Mayer Lake (Moodie 1984) it is assumed that the male lake form of Misty Lake Sticklebacks build nests in shallow areas characterized by sand substrate, gentle gradient and underwater vegetation (COSEWIC 2006). No nests have been observed in the stream; however an experiment by Rayemakers et al. (2009) found that the nests built by the stream form were less bulky and more often built on gravel substrate rather than sand compared to the nests built by the lake form. Furthermore, comparing nesting behavior of stream stickleback on Little Campbell River (McPhail 1994), it can be assumed that the stream form of the Misty Lake Stickleback likely utilizes stream habitats with fine substrate, no current and heavy vegetation.

4. THREATS

4.1 Threat Assessment

Table 1. Threat Assessment Table

Threat	Level of Concern[1]	Extent	Occurrence	Frequency[2]	Severity[3]	Causal Certainty[4]
Threat Category: Aquatic Exotic, Invasive, or Introduced Species						
Specific Threat: Introduction/invasion and establishment of benthic fishes, crayfish, spiny-rayed fishes, bullfrogs or other aquatic invasive species	High	Widespread	Anticipated	Continuous	High	High
Threat Category: Water Pollution						
Specific Threat: Point source pollution from road run-off and rest stop	Medium	Localized / widespread	Current / anticipated	Recurrent	Low to High	Medium
Specific Threat: Non-point source pollution and changes in water quality resulting from land use practices	Medium / Low	Localized / widespread	Current / anticipated	Recurrent	Low to Medium	Medium
Threat Category: Habitat Loss or Degradation						
Specific Threat: Non-conforming recreational use of Misty Lake Ecological Reserve	Medium / Low	Localized to lake population	Unknown	Recurrent	Unknown	Low
Specific Threat: Riparian vegetation removal related to utility and transport corridors and land use	Low	Localized	Current / anticipated	One-time / continuous	Low	Low
Specific Threat:Water extraction	Low	Widespread	Unknown	Continuous	Unknown	Medium
Threat Category: Climate Change						
Specific Threat: Changes in precipitation, water flow, temperature, ice cover, timing, etc.	Low	Widespread	Anticipated	Continuous / Seasonal	Unknown	Low
Threat Category: Disturbance or Harm						
Specific Threat: Unpermitted or excessive removal of individuals for scientific research	Low	Widespread	Current	Recurrent	Low	Medium

[1] *Level of Concern: signifies that managing the threat is of High, Medium or Low concern for the recovery of the species, consistent with the population and distribution objectives. This criterion considers the assessment of all the information in the table.*

[2] *Frequency: reflects how often a threat, if it occurs, is predicted to impact the species (one-time, seasonal, recurrent, continuous or unknown).*

[3] *Severity: reflects the population-level effect (High: very large population-level effect; Moderate; Low; Unknown).*

[4] *Causal certainty: reflects the degree of evidence that is known for the threat (High: available evidence strongly links the threat to stresses on population viability; Medium: there is a correlation between the threat and population viability e.g. expert opinion; Low: the threat is assumed or plausible).*

4.2 Description of Threats

Given their highly endemic distribution, Misty Lake Sticklebacks can be considered vulnerable to a variety of localized threats. The following provides a general threat assessment based on their known biology, and the present and historical land and water use within the watershed. Most of the threats are not quantified, although this may become possible when more is known about the biology and specific habitat requirements of the species pair.

Aquatic Exotic, Invasive or Introduced Species

Introduction/invasion and establishment of benthic fishes, crayfish, spiny-rayed fishes, bullfrogs or other aquatic invasive species

One of the greatest threats to the Misty Lake Sticklebacks is from the introduction of or invasion by exotic or invasive species; the leading driver of biotic change in freshwater systems globally (Sala et al. 2000). Introduction pathways may include unauthorized transfer or stocking, pet and aquarium releases, plants spreading into new areas, fishing with live bait, cultivation of aquatic species for consumption (e.g., crayfish), deliberate malicious introduction, or range expansion of invasive species. Once established into the lake or stream system, invasive or exotic species may threaten stickleback populations directly (e.g., predation or displacement from nesting habitat leading to recruitment failure) or indirectly (e.g., competition for food resources, or alteration of the selective regime of their habitat). At present, the only known exotic species in Misty Lake is the common pet shop turtle, the Red-eared Slider, (*Trachemys scripta elegans)* (Philip 2007 pers. comm. from Harvey 2009). Nevertheless, the easy access to Misty Lake by the existing highway rest stop from Highway 19 at the southwest corner of the lake makes the likelihood of an exotic species invasion or introduction high.

While any invasive species introduction has the potential to detrimentally affect a natural ecosystem, the biggest threats to the Misty Lake Sticklebacks likely come from ecologically similar benthic fishes, crayfish, and spiny-rayed fishes. Such species are spreading in various parts of B.C. via illegal translocation and range expansion. The severity of such an invasion or introduction would be high, and due to the species limited range, any impact from an invasive species would be widespread. Misty Lake Sticklebacks are additionally susceptible to impacts from aquatic invasive species because an alteration of the selective regime of their habitat could imbalance the system that has allowed the two forms to evolve and be maintained. The extinction of the sympatric species pair Hadley Lake Benthic Stickleback (*Gasterosteus aculeatus*) and Hadley Lake Limnetic Stickleback (*Gasterosteus aculeatus*) on Lasqueti Island, B.C. is believed to have been caused by illegally introduced Brown Bullhead (*Ameiurus nebulosus*) (Hatfield 2001), which is known to occur in the southern third of Vancouver Island (Harvey 2009). Additionally, the invasion of Signal Crayfish (*Pacifastacus leniusculus*) into Enos Lake, Vancouver Island, B.C., is implicated in the collapse of the Enos Lake Benthic and Limnetic Stickleback sympatric species pair (Kraak et al. 2001, Taylor et al. 2006).

Water Pollution

Point source pollution from road run-off and rest stop

Point source pollution has the capacity to affect water quality and to degrade aquatic habitat. Highway 19, which approaches close to the southern shore of Misty Lake, and the highway rest stop at the southwest corner of the lake have both previously been identified as point sources of hydrocarbons and pesticides (B.C. Ministry of Environment 2003). The probability of runoff from these sources is high, as is the uncertainty of its consequences, which will depend on amount, composition and location of the release. The extent and severity to which existing levels of pollution negatively affect the Misty Lake Sticklebacks is unknown but ranges from low to high due to the chance event of a toxic spill or accident on the highway or at the rest stop. Pollutants of concern include hydrocarbons, sewage, pesticides, herbicides and fertilizers.

Non-point source pollution and changes in water quality resulting from land use practices

Land use activities that alter water quality parameters for oxygen, temperature, pH, clarity, nitrogen, or phosphorus may harm Misty Lake Sticklebacks. Currently, the main land use activity in the area is forest harvesting, including the associated construction, use, and maintenance of logging roads. Habitat, water quality, and hydrological changes from nearby logging are identified as threats by COSEWIC (2006). Cumulative logging impacts may be a concern, particularly to inlet habitat from erosion, sedimentation, altered flows and changes to the benthic community; however, there have been no apparent long-term impacts to date as a result of previous forest harvesting activity in the watershed (COSEWIC 2006).

The tolerance of the Misty Lake Sticklebacks to turbidity is unknown. Nevertheless, changes to water clarity and light transmission have been identified as a cause for concern for the management of sympatric Threespine Stickleback species pairs (Wood et al. 2004). Furthermore, a reduction in water clarity caused by increased suspended sediments once invasive crayfish destroyed the stabilizing macrophyte beds may be implicated in the demise of the sympatric Enos Lake Benthic and Limnetic Stickleback species pair (Taylor et al. 2006, Behm et al. 2010). The extent of the threat of non-point source pollution on the outlet stream would likely have localized impacts downstream, whereas any pollution entering into the inlet stream may have a widespread impact on the species if the pollution leads to downstream effects on the sensitive lake-stream swampy transition zone where both forms of Misty Lake Sticklebacks have overlapping breeding areas. As such, the threat from future non-point source pollution will depend on the extent, severity and proximity of pollution inputs to the lake and streams and the application of sedimentation and pollution prevention and mitigation measures.

Habitat Loss and Degradation

Non-conforming recreational use of Misty Lake Ecological Reserve

Misty Lake is located within a B.C. ecological reserve, specifically the Misty Lake Ecological Reserve[7] (en anglais seulement). It was established in 1996 to protect the lake form of stickleback and to provide opportunities for biological research (COSEWIC 2006). Ecological reserves can be used by the public for non-consumptive observational purposes. Non-conforming use of the Misty Lake Ecological Reserve could cause detrimental impacts and alterations of the aquatic community (COSEWIC 2006) degrading the habitat for use by the species. The activities prohibited are all consumptive uses and the use of motorized vehicles and canoes (B.C. Ministry of Parks 2003). Consumptive uses include hunting, fishing, camping and livestock grazing, and removal of materials, plants or animals (COSEWIC 2006). The use of motorized boats on the lake could introduce water pollution and disturb the fish, and fishing with live bait raises the risk

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[7] http://www.env.gov.bc.ca/bcparks/eco_reserve/misty_er.html

of introducing harmful aquatic invasive species. The frequency of use of the reserve is assumed to be recurrent but the severity of the threat is unknown and dependent on the scale of the non-conforming activity.

Riparian vegetation removal related to utility and transport corridors and land use

Some land-based activities have the capacity to alter aquatic habitat directly (e.g., impacts to riparian habitat, alteration of run-off rates or water storage capacity in headwaters) or indirectly (e.g., changes to water quality through introduction of pollutants as discussed above in the threat of water pollution). Development within the Misty Lake watershed is associated primarily with forestry and road building. Previous loss of riparian cover associated with forest harvest adjacent to the inlet stream was associated with an increase in algal growth (Moore, pers. comm. cited in COSEWIC 2006), which can potentially affect habitat use (COSEWIC 2006). On small coastal streams, such as Misty Lake inlet and outlet, replacement of lost riparian vegetation by green-up occurs quite quickly, and so the impact of any increased algae growth from forestry would likely be temporary (COSEWIC 2006). The frequency of this threat may be a one-time occurrence or continuous depending on the activity (forestry versus road or bridge construction). This threat is perhaps less prevalent than it has been historically, following the creation of the Misty Lake Ecological Reserve in 1996 (see section 6.1 below, and Figure 3 for more information). The species' persistence during more than 50 years of forestry and associated road building in the watershed further suggests that impacts from riparian vegetation removal is a low risk.

Water Extraction

The risk of declining water levels on Misty Lake as a result of water extraction or an alteration to the existing hydrology is significant due to its small, shallow nature. Any such decline could raise water temperatures, as well as eliminate littoral habitat that is believed to be important for the nesting of the lake form. Large drawdowns can shrink lake volume and depth to such an extent that deeper pelagic habitat, which is thought to be required as overwintering habitat for the lake form, essentially disappears and littoral habitat is all that remains. There are, however, no licensed water users on Misty Lake or its inlet and outlet streams, based on a water license query of the online provincial database, and it is assumed that there are no unlicensed water users. Future demand for water from Misty Lake is unknown, but it is unlikely to be problematic in the near future due to the presence of the Misty Lake Ecological Reserve and the abundance of alternative potential water sources. Therefore the level of concern for managing this threat is considered to be low.

Climate Change

Changes in precipitation, water flow, temperature, ice cover, timing, etc.

Scientific evidence clearly indicates that animal and plant distributions are responding to climate change (Parmesan and Yohe 2003, Rosenzweig et al. 2008). Since climate affects precipitation, water flow and water temperature in many ways, it has the potential to affect the abundance and distribution of Misty Lake Sticklebacks. For example, the onset and duration of breeding in sticklebacks are strongly influenced by temperature so the timing of reproduction and length of breeding season can be expected to change in response to altered water temperatures. Additionally, changes to water flow and water level may impact the spawning habitat of the stickleback in the littoral zone of the lake and quiescent areas within the streams. Climate change may also alter the average number of days with ice on the lake, the frequency of major forest fires as well as numerous other ecological cycles. Although the potential impact of future climate change on the recovery of the Misty Lake Stickleback populations is high, so is its uncertainty. This threat may be assessed and addressed at future stages of recovery planning for the Misty Lake Sticklebacks.

Disturbance or Harm

Unpermitted or excessive removal of individuals for scientific research

Due to their evolutionary significance, Misty Lake Sticklebacks are periodically removed by pole seine or minnow trap for the collection of tissue samples or laboratory experimentation. The removal of less than 5% of each lake and stream population is unlikely to impact long-term persistence (Harvey 2009). Such levels are, therefore, considered an allowable harm (Harvey 2009). Since the numbers of specimens that are periodically collected fall within this allowable limit (permit controlled), the probability of harm to the population is negligible, and is not considered a threat if it is managed correctly. If unpermitted or excessive removal of specimens occurs over 5% of the population size, the viability of the population may become at risk. There is however no evidence of such activities taking place. For more information on the allowable harm assessment see Harvey (2009).

5. POPULATION AND DISTRIBUTION OBJECTIVES

Recovery objectives are ideally stated as quantitative targets (e.g., for population abundance or habitat quantity and quality). Unfortunately, insufficient information is available about current population abundance, habitat requirements and habitat availability for the Misty Lake Sticklebacks to develop defensible quantitative targets. Considering this, population and distribution objectives for Misty Lake Sticklebacks are:

1. To maintain self-sustaining populations and the current distribution of the lake and stream forms of the Misty Lake Sticklebacks through maintaining current habitat area and habitat quality.

2. To maintain the two distinct forms by preventing an increase in hybridization that could lead to the collapse of the species pair into a hybrid swarm.

Since the Misty Lake Sticklebacks were assessed by COSEWIC as Endangered in part because of their limited geographic range and natural rarity (being limited to just one lake-stream complex), meeting these objectives may not result in COSEWIC reassessing the species to Threatened or Special Concern.

6. BROAD STRATEGIES AND GENERAL APPROACHES TO MEET OBJECTIVES

6.1 Actions Already Completed or Currently Underway

A number of recovery actions have already been initiated and/or completed. They include:

1. Misty Lake Ecological Reserve (en anglais seulement) was established in 1996 under the *Protected Areas of British Columbia Act*, with the primary intent of protecting sticklebacks in the lake. The reserve was increased from 55 ha to 68 ha in 2001, which represents the area of the lake itself and a strip of land around it. Misty Lake and short sections of the inlet and outlet streams are contained within the Misty Lake Ecological Reserve (COSEWIC 2006). The entire reserve affords protection from consumptive uses that include hunting, fishing, and camping. Since the creation of the Misty Lake Ecological Reserve, the sticklebacks have been protected from capture or retention within the reserve's boundaries, except when authorized by permit.

2. Taxonomic investigations, including some molecular genetics work, as well as population and distribution studies have been initiated and are ongoing. This research continues to increase scientific understanding of the Misty Lake Sticklebacks.

3. Signage at Misty Lake to inform the public about the general biology of the species pair, its biodiversity value, threats to its persistence (such as aquatic invasive species) and to provide information about the Ecological Reserve will be installed in 2016-2017.

4. Guidance on sampling protocols and monitoring recovery of freshwater species, including Misty Lake Sticklebacks, have been drafted by Harvey et al, (2013) which will inform how to undertake such works in the future.

6.2 Strategic Direction for Recovery

Table 2. Recovery Planning Table

Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches	Threat or Limitation
High	• Establish and support a Recovery Implementation Group (RIG) or alternative working group for the Misty Lake Sticklebacks.	• Invite stakeholders and interested parties to participate in a RIG. • Encourage local governments to have membership or representation on a RIG. • Establish the RIG leadership (chair, facilitator, etc.), develop terms of reference, and seek necessary funding to support RIG activities. Participate in the development of one or more action plans, which are to be guided by the recovery strategy, and to facilitate action planning communication and implementation.	• Lack of public awareness / involvement • Aquatic Exotic, Invasive or Introduced Species • Water Pollution • Habitat Loss or Degradation • Disturbance or Harm
High	• Determine the current distribution of key aquatic exotic, invasive or introduced species on Vancouver Island. • Develop and implement a Total Prevention Plan for aquatic invasive species.	• Aquatic invasive species assessment of distribution, proximity, likelihood of invasion/introduction. • Monitor for the presence of aquatic exotic / invasive / introduced species in Misty Lake. • Develop and implement a comprehensive Total Prevention Plan with direct links to stewardship group(s). • Develop a Rapid Response Plan to implement in case an aquatic exotic/invasive/introduced species is found in Misty Lake.	• Aquatic Exotic, Invasive or Introduced Species

High	• Address information gaps that inhibit conservation of the Misty Lake Sticklebacks and their critical habitat.
	• Increase scientific understanding of the Misty Lake Sticklebacks through additional investigation into their natural history and threats to their persistence.
		• Address key information gaps including:
		  ○ Population sizes
		  ○ Habitat use and requirements
		  ○ Life history information
		  ○ Causes of mortality (e.g., temperature, pollutants, predation, siltation of incubation habitat, etc.)
		  ○ Sedimentation and hybridization
		  ○ Environmental limiting factors to population growth
			• Information gaps concerning biology of the species and its needs
			• Water Pollution
			• Habitat Loss or Degradation
			• Climate Change
			• Disturbance or Harm

High	• Continue to develop sound protocols for scientific investigations (e.g., collection guidelines).	• Set boundaries for experimental work, enclosure experiment protocols and collection activities that can be incorporated into permitting processes.	• Disturbance or Harm

Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches	Threat or Limitation
Medium	• Habitat management and protection.	• Map land use and land ownership. • Undertake effects assessment of land use on pollutant sources. • Exercise caution (in favor of conservation) when planning/regulating/enforcing land development and water use. • Consider possibility of relocating the current highway rest stop away from Misty Lake. • Consider developing a watershed-scale Land Use Plan that includes key habitats and protection measures including consideration of cumulative impacts of development and resource use.	• Water Pollution • Habitat Loss or Degradation
Medium	• Increase understanding of population trends and make linkages to threats. • Continue to develop and implement a long term monitoring program to assess population response to management activities and/or threats.	• Examples of priority studies the monitoring program could include: ○ Trends in abundance of the Misty Lake Stickleback populations ○ Trends in hybridization rates ○ Trends in habitat quantity and quality • Examples of additional studies the monitoring program could include: ○ Trends in abundance of prey species ○ Water quality ranges ○ Land use impacts ○ Macrophyte coverage in lake ○ Riparian habitat removal impact on shade and sedimentation ○ Climate change impacts (flow in rivers, days of ice on lake, temperature, precipitation)	• Information gaps on threats and potential impacts to population trends • Aquatic Exotic, Invasive or Introduced Species • Habitat Loss or Degradation • Climate Change
Medium	• Develop and implement educational outreach materials to foster awareness of the species and encourage active local involvement in stewardship and habitat protection.	• Educational material (e.g., an educational brochure, web-based material) to explain the general biology of the species pair, its biodiversity value, threats to its persistence and information about the Ecological Reserve. • Consider developing material for Project WILD[8] (en anglais seulement). • Educational material for use in public schools, particularly schools nearest to the species' range. • Educational signage for placement at specific locations (e.g., road crossings, highway rest stop, etc.).	• Lack of public awareness / involvement • Aquatic Exotic, Invasive or Introduced Species • Water Pollution • Disturbance or Harm

6.3 Narrative to Support the Recovery Planning Table

A description of the recommended strategies and approaches was presented in Table 2. These will be further detailed in one or more action plans. Further plans and decisions may require involvement of stakeholders and participants, including government agencies, First Nations, private land owners, industry and local stewardship groups.

[8] http://wildbc.org/index.php/programs/project-wild/

The general approach recommended in this recovery strategy includes:

- establishing and supporting stewardship initiatives,
- undertaking specific research activities to fill knowledge gaps and clarify threats where necessary,
- minimizing impacts from land and water use, and
- designing and implementing sound monitoring programs.

7. CRITICAL HABITAT

7.1 Identification of the Species' Critical Habitat

Critical habitat is defined in SARA as:

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

Also, SARA defines habitat for aquatic species at risk as:

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

Critical habitat for Misty Lake Sticklebacks has been identified to the fullest extent possible using best available information, and provides the functions and features necessary to support the species' life-cycle processes. The critical habitat identified in this recovery strategy may be insufficient to achieve the species' population and distribution objectives if further research indicates that the current distribution does in fact extend beyond the currently known distribution. The critical habitat is described in terms of its geographic extent and supporting biophysical functions, features, and attributes. The schedule of studies outlines the research required to identify any additional critical habitat if necessary and to acquire more detail about the critical habitat identified to achieve the population and distribution objectives. A further refinement of the critical habitat biophysical features and attributes would further enable effective protection of the habitat and its functions that are essential for the species survival or recovery.

It should be noted that the critical habitat identified below is for both the lentic and lotic forms of the Misty Lake Sticklebacks which together form the species complex.

7.1.1 Information and Methods Used to Identify Critical Habitat

The critical habitat for Misty Lake Sticklebacks is informed by the publicly available research document *Identification of critical habitat for sympatric Stickleback species pairs and the Misty Lake parapatric stickleback species pair* (Hatfield 2009), which reflects the outcomes of the related peer review process undertaken through DFO's Canadian Science Advisory Secretariat; it is further refined to align with more recent policy on identifying critical habitat (DFO 2012).

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

1. **Identification of a population recovery target.**

A recovery target of an effective population size[9] exceeding 1,000 based on population genetic theory was considered to be a reasonable objective (Hatfield 2009).

2. **Determination of a quantitative relationship between habitat and population size.**

There was little information to compare habitat availability and abundance across the Misty Lake Stickleback populations so it was assumed that there was a linear relationship between habitat availability and population size (Hatfield 2009).

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

Sufficient habitat was determined by comparing current estimates of effective population size with the population recovery target (Hatfield 2009). Current effective population size abundance estimates for both the Misty Lake Stickleback lake and inlet populations were considered below the population recovery target, therefore, Hatfield (2009) recommended 100% of the stream and lake habitat should be defined as critical habitat. Furthermore, due to concerns regarding the threat of hybridization of the two forms of stickleback, this determination also considered other components of habitat quality such as ecological community and water quality, including the role of upstream habitat and riparian areas in maintaining the overall stability of the current Misty Lake Stickleback habitat.

Recent DFO guidance on critical habitat identification using the bounding box approach (described below), has clarified that critical habitat includes the biophysical features and attributes within an area frequented by the species that provide the functional capacity for the species to carry out its life-cycle processes (DFO 2012). The portion of Hatfield's recommended critical habitat (2009) that aimed to address threats beyond the known species distribution was thus revised to reflect this new departmental guidance.

7.1.2 Identification of Critical Habitat: Geographic extent

The features and attributes of the habitat that are necessary for the species' survival or recovery are more fully described in section 7.1.3 and then summarized in Table 3 below. Critical habitat has been spatially identified using the bounding box approach. Critical habitat is not comprised of the entire area within the identified boundary but only those areas within the identified geographic boundary where the described biophysical features occur. The bounding box area of the critical habitat and the general location of most of the features within it, plus a table of coordinates are shown in Figure 3.

[9] As per footnote 3, effective population size is the number of breeding pairs in an idealized population and is quite often smaller than the actual population size as not all individuals in a population are sexually mature.

The features of critical habitat are the entire lake, the length of the inlet stream extending up to that currently known to be occupied by the stream form of Misty Lake Stickleback, the outlet stream extending down to the extent currently known to be occupied by Misty Lake Stickleback, the swampy transition zones between the lake and streams and a riparian area associated with all of these features. Hatfield (2009) suggested including a riparian buffer of 15 to 30 meters surrounding the above mentioned areas (and other watercourses in the watershed). A 15 meter riparian buffer is important for bank stability, woody debris supply, and for food and nutrient input from litter fall and insect drop into the lake and streams. The larger 30 meter riparian buffer is suggested for areas where shade provides a specific function to the habitat which is true for the inlet and outlet stream populations. Shade is not as important for the lake due to its large surface area which results in most of the lake receiving sunlight regardless if the riparian buffer is 15 meters or 30 meters. Therefore, the features within the bounding box which make-up the geographic extent of critical habitat for both forms of the Misty Lake Sticklebacks are identified as:

- The entire lake including a riparian area of 15 meters width surrounding the wetted perimeter of the lake. The wetted perimeter is to be interpreted on the ground as the high water mark for ungauged lakes as defined in the Schedule of Riparian Areas Regulation Assessment Methods attached to the *Riparian Areas Regulation* (B.C. Reg. 376/2004).[10]

- The inlet stream up to the extent currently known to be occupied by the Misty Lake Stickleback (presently estimated at 2.6 km upstream from the lake), the swampy transition zone and a riparian area of 30 meter width surrounding the wetted perimeter of the inlet stream and swampy transition zone. The wetted perimeter of the stream and swampy transition zone is to be interpreted on the ground as the high water mark for streams and wetlands respectively, as defined in the Schedule of Riparian Areas Regulation Assessment Methods attached to the *Riparian Areas Regulation* (B.C. Reg. 376/2004)[11]. The inlet stream mean wetted width is two meters (COSEWIC 2006).

- The outlet stream extending to the lower extent of the currently known occupied habitat (presently estimated at 2.3 kilometers downstream of the lake), including the swampy transition zone, and a riparian area of 30 meters width surrounding the wetted perimeter

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

[11] The Schedule of Riparian Areas Regulation Assessment Methods defines the high water mark for streams as "*the visible high water mark of a stream where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the stream a character distinct from that of its banks, in vegetation, as well as the nature of the soil itself, and includes the active floodplain*".

The Schedule of Riparian Areas Regulation Assessment Methods defines the outer edge of wetlands as "*from an ecological perspective, either an abundance of hydrophytes or hydric soil conditions is generally sufficient to indicate a wetland ecosystem. The boundary or high water mark of the wetland is identified by changes in vegetation structure, loss of obligate hydrophytes, and absence of wetland soil characteristics*".

of the outlet stream and the swampy transition zone. The wetted perimeters of the outlet stream and swampy transition zone are to be interpreted as described above. The outlet stream mean wetted width is three meters (COSEWIC 2006).

The geographic extent of the critical habitat may be revised as new information becomes available. See Schedule of Studies (Table 4) for research objectives to obtain more information on the critical habitat geographic extent, features and associated attributes.

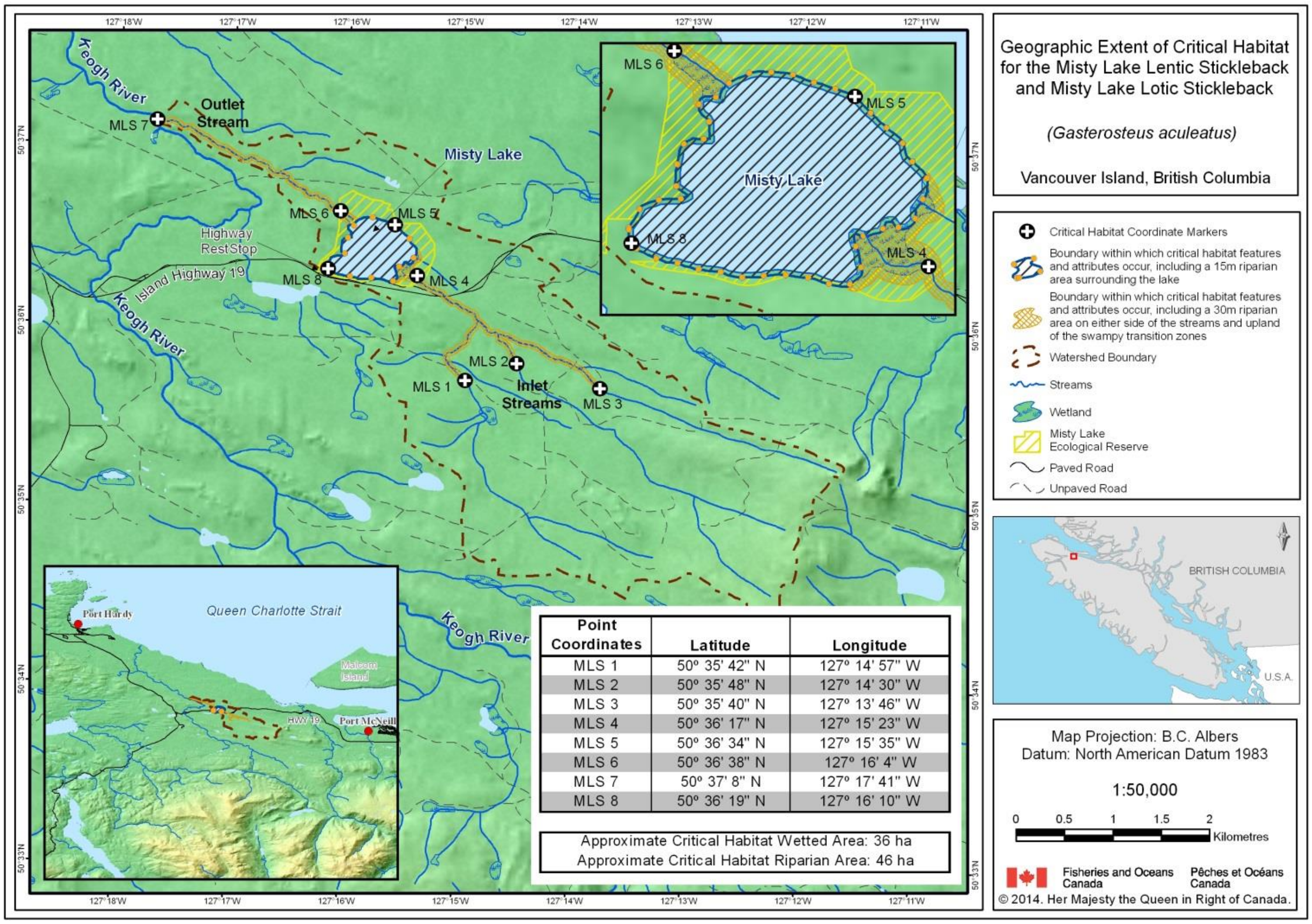

Figure 3. Geographic extent of critical habitat for the Misty Lake Sticklebacks.

7.1.3 Identification of Critical Habitat: Biophysical Functions, Features and their Attributes

This section describes the functions, features and attributes of the critical habitat within the geographic extent of the critical habitat. Note that not all attributes must be present in order for the feature to be identified as critical habitat. If the feature is present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside the range indicated. Specific critical habitat biophysical features and attributes that allow the Misty Lake Sticklebacks to perform their essential life functions are based on the best available information. Currently, this information comes from the vast body of research on sympatric and parapatric Threespine Stickleback species pairs that has amassed over several decades, as well as the growing body of directed research and observations on the Misty Lake Stickleback lake-stream pair itself. Due to the unique evolutionary significance of the Misty Lake Stickleback lake-stream pair, biophysical features of the identified critical habitat are those that limit the size and viability of each species (lake and stream), but also include attributes that prevent potential hybridization to protect the two species from collapsing into a hybrid swarm.

The roles of specific habitat attributes have been identified for some specific life functions. Recent examples include: the impact of water clarity on Threespine Stickleback foraging (Webster et al. 2007) and mate choice (Engström-Öst and Candolin 2007); the impact of introduced Signal Crayfish on reproductive behaviour and juvenile growth rate in Paxton Lake Benthic and Limnetic Stickleback species pair (Velema 2010), and; the biotic and abiotic lake characteristics of benthic-limnetic stickleback species pair lakes (Ormond 2010). However, many of the attributes listed in Table 3 have been extrapolated to other functions based on expert scientific opinion.

In spite of the valuable information provided below, the lack of quantitative data from the application of objective research methods that directly relates habitat features and attributes of the Misty Lake watershed to some specific functions for these particular parapatric lake-stream stickleback species pairs should be recognized. However, due to the understanding that Misty Lake is part of a natural ecosystem and the populations of the lake and stream sticklebacks were not historically larger than they are at present (COSEWIC 2006; Hatfield 2009), the limits and ranges of the attributes are currently assumed to be the natural ranges in the Misty Lake system. As well, as a group, sticklebacks are a relatively hardy species tolerant to a fairly large range of water quality conditions. Until more information becomes available, the Province of B.C. Water Quality Guidelines (en anglais seulement) serves as a general guideline to the water quality parameters for Misty Lake Sticklebacks critical habitat (Hatfield 2009, wherein they were referred to as the “provincial guidelines for protection of aquatic life”).

Lake habitat

Lake habitat is an essential feature of the critical habitat used in all life stages of the lake form of the Misty Lake Sticklebacks. It contains the littoral habitat with attributes including physical structural complexity, sand substrate which is believed to be used by the stickleback to make nests, as well as macrophytes which help to shelter the newly hatched juveniles (Hatfield 2009). The two main macrophytes in the littoral zone are *Potomogeton* spp. (pondweed) and *Nuphar* spp. (water lily) (COSEWIC 2006). The lake form of the Misty Lake Sticklebacks feeds at the surface of the lake in both the littoral and pelagic zones on zooplankton and other small organisms, and are assumed to use the deeper hypolimnetic water for overwintering habitat (Berner et al. 2008; Hatfield 2009). Additional attributes of the lake habitat relate to stability of various water quality parameters including temperature range, oxygen content, pH and depth, as well as a stable faunal community including the specific macrophyte community, fish, zooplankton and macroinvertebrates which all contribute to the lake ecosystem as a whole. Stable light transmission is also considered an important attribute of the lake habitat for mate recognition although it is not known how significant this attribute is for the Misty Lake Stickleback lake-stream pair in comparison to other stickleback species pairs as the light transmission properties are already poor due to the dark stained water of the lake (Hatfield 2009).

Inlet and outlet stream habitat to the extent currently known occupied by sticklebacks

Stream habitats (both inlet and outlet streams) are an essential feature of the critical habitat used in all life stages of the stream populations of the Misty Lake Sticklebacks. Similar to the lake habitat for the lake form of stickleback, the streams provide habitat to rear and overwinter specifically in pools and sloughs with low water velocity which is suitable for adults to forage for benthos and inputs from overhanging riparian plants (Hatfield 2009). Stream individuals were commonly found in water 0.5 – 1.0 meters deep where current was slow (Hendry et al. 2002). Much is unknown about newly hatched and young juveniles but it is assumed that they also utilize pools with no or minimal flow (velocity) to rest and forage presumably on small benthos and invertebrates. Some assumed attributes of the shallow pools based on stickleback stream residents from Little Campbell River are no flow, fine substrate (mud) for nest building and heavy vegetation (McPhail 1994). Stable water quality parameters including oxygen content, pH, and temperature range are important attributes of the streams to support a healthy population of Misty Lake Sticklebacks. And again, similar to the lake habitat, if there is a mechanism required for reproductive isolation it is not known, however stable water clarity and transmission of light could play a role and are included as attributes for the streams to support the function of spawning. It is also assumed that riparian and vegetation covers are essential attributes as they provide food and nutrient inputs as well as shelter for Misty Lake Sticklebacks to hide from land based predators (see also explanation below in the Riparian Area feature). In addition, the combination of faster flowing sections of the stream and low velocity pools are essential for maintaining a healthy stream ecosystem and for providing habitat for benthos and invertebrates on which the stream form of the Misty Lake Stickleback feed (COSEWIC 2006) as do the outlet stream population (Berner et al. 2008).

Swampy transition zones

The swampy transition zones between the lake and both the inlet and outlet streams also provide critical habitat for various life stages of both forms of the Misty Lake Sticklebacks. The stability of this habitat in particular is important because it is where the two forms of stickleback come into contact. This habitat is used by both forms for breeding, nursery and rearing (Lavin and McPhail 1993). Attributes include factors important for maintaining selective mate recognition so that the two forms of stickleback do not interbreed. While these attributes are not known for certain, it is assumed that stable light transmission, stable water clarity, and dynamic littoral habitat structure with emergent vegetation all help the two forms to recognize mates and nest in different microhabitats in the area. Again, because the water in the Misty Lake system is darkly stained with tannins (COSEWIC 2006), it is unknown how significant the attribute of stable water clarity and stable light transmission are for mate recognition. Stable water quality parameters including oxygen content, pH and temperature range are also important for the occupants rearing in the habitat.

Riparian area surrounding the lake, inlet and outlet streams to the extent currently known occupied by the species, and the swampy transition zones

Riparian habitat forms the physical transition zone between aquatic and terrestrial ecosystems and there are often strong physical and biological interactions between the two. A 15 meters riparian area has been identified as critical habitat along the lake shore, 30 meters on both sides of the inlet and outlet streams to the extent currently known occupied by the species pair, and 30 meters around the swampy transition zone for the role it plays in stabilizing the lake and stream environments. The riparian buffer provides functions such as bank stabilization, reducing the amount of erosion and subsequent sediment-loaded runoff entering into the water potentially reducing water clarity (Hatfield 2009). The riparian vegetation also provides terrestrially supplied food and nutrients (Hatfield 2009) deposited either directly into, or transported down the streams into, the areas of the streams and lakes where the Misty Lake Sticklebacks rear. Along the streams the riparian buffer also provides cover and shade which gives protection from predators when sticklebacks are in shallower water (when breeding or newly hatched) and regulates the amount of sunlight reaching the water and thus the temperature range. An increase in sunlight and temperature resulting in increased algae growth in the stream can result in the temporary loss of habitat for the stream form of Misty Lake Stickleback (COSEWIC 2006). The specific types of riparian vegetation necessary to provide these functions are uncertain but the presence of such vegetation is essential. Also, while the riparian areas are not necessarily considered “no-go” zones, it is essential that they be managed to conserve the attributes to ensure functionality of the critical habitat is not compromised.

Table 3. Summary of Critical Habitat Biophysical Functions, Features, and Attributes of the Misty Lake Sticklebacks

Life Stage	Function	Feature (s)	Attributes
Adult and older juvenile (older juveniles are assumed to rear in the same areas as adults)	Rearing (includes foraging and resting)	Inlet and outlet stream habitat to the extent currently known occupied by stickleback	• Presence of pools and sloughs e.g. 0.5-1 meter deep • Low water velocity • Adequate food supply of benthos / invertebrates • Stable water quality parameters including oxygen, pH and temperature range
		Lake habitat	• Stable faunal community including fish • Adequate food supply of zooplankton and macroinvertebrates • Stable water quality parameters including oxygen, pH and temperature range • Physical structural complexity including the presence of macrophyte beds
		Riparian area surrounding the lake, and the inlet and outlet stream habitat to the extent currently known occupied by stickleback	• Provision of terrestrially supplied food and nutrients • Stable riparian banks • Stable quality and quantity of surface water run-off during high rainfall conditions • Adequate/stable shade cover for stream habitat
Adult	Spawning	Inlet and outlet stream habitat to the extent currently known occupied by stickleback	• Presence of pools and sloughs; specific depth unknown • Low to zero water velocity • Fine substrate (mud) • Vegetation cover • Stable water quality parameters including oxygen, pH and temperature range • Stable transmission of light • Stable water clarity
		Lake habitat	• Presence of littoral habitat • Stable faunal community, particularly other fish and macroinvertebrates • Sand substrate • Stable water quality parameters, including oxygen, pH and temperature range • Stable transmission of light • Stable water clarity • Physical structural complexity including the presence of macrophyte beds

Life Stage	Function	Feature (s)	Attributes
		Swampy transition zones	• Stable transmission of light • Stable water clarity • Stable water quality parameters, including oxygen, pH and temperature range • Physical structural complexity including the presence of fallen logs and macrophyte beds
		Riparian area surrounding: the lake, the inlet and outlet stream habitat to the extent currently known occupied by stickleback, and the swampy transition zones	• Stable riparian banks • Stable quality and quantity of surface water run-off • Presence of overhanging vegetation on stream banks for cover
Eggs / Juveniles	Nursery	Inlet and outlet stream habitat to the extent currently known occupied by stickleback	• Presence of pools and sloughs of adequate depth • Likely slow to zero water velocity • Adequate food supply, type unknown but likely small benthos and invertebrates • Stable water quality parameters, including oxygen, pH and temperature range
		Lake habitat	• Shallow littoral habitat • Stable faunal community including fish • Adequate food supply of zooplankton and macroinvertebrates • Stable water quality parameters, including oxygen, pH and temperature range • Physical structural complexity including the presence of fallen logs and macrophyte beds
		Swampy transition zones	• Shallow water with emergent vegetation
All life stages	Overwintering	Inlet and outlet stream habitat to the extent currently known occupied by stickleback	• Presence of pools and sloughs of adequate depth • Stable water quality parameters, including oxygen, pH, and temperature range
		Lake habitat	• Presence of pelagic water, hypolimnetic zone of adequate depth • Stable water quality parameters, including oxygen, pH and temperature range

7.2 Schedule of Studies to Identify Critical Habitat

Further research is required to identify and/or refine additional critical habitat necessary to support the species' population and distribution objectives and protect the critical habitat from destruction. This additional work includes the studies found in Table 4 below.

Table 4. Schedule of Studies

Description of Activity	Rationale	Timeline
Study population and distribution.	Full understanding of population and distribution of inlet form would assist in determining any needed modifications to the geographic extent of critical habitat.	3 years 2016-2019
Develop a monitoring program to determine summer and winter habitat use by adults and juveniles, population size, and life history information.	Improve understanding of the features and attributes of critical habitat that are important for Misty Lake Sticklebacks life-cycle and give a baseline population estimate for future comparisons.	3 years 2016 -2019
Continue researching mechanism of reproductive isolation.	Define if there are any attributes of critical habitat that play a role in maintaining reproductive isolation. This will inform if a strategy is required to prevent the species pair from collapsing into a hybrid swarm.	5 years 2017-2022

7.3 Activities Likely to Result in the Destruction of Critical Habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For Misty Lake Sticklebacks critical habitat, it is anticipated that this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat. It is important to keep in mind that critical habitat can be destroyed from activities both within and outside of its geographic extent.

Because the identified critical habitat is for both the lentic and the lotic forms of the Misty Lake Sticklebacks which together make the species complex, the destruction of critical habitat for one species could have significant consequences for the other species, in terms of effects on the health of individuals, their residences and their identified critical habitat. The legal protections provided by SARA apply equally to both the lentic and lotic species of Misty Lake Sticklebacks.

The activities likely to destroy critical habitat described in Table 5 below are neither exhaustive nor exclusive and have been guided by the threats described in section 4 of this recovery strategy. The absence of a specific human activity in Table 5 does not preclude or restrict the Department's ability to regulate it pursuant to SARA. Furthermore, the inclusion of an activity in Table 5 does not result in its automatic prohibition since it is the destruction of critical habitat that is prohibited. Activities that impact critical habitat but do not result in its destruction are not prohibited. Since habitat use is often temporal in nature, every activity is assessed on a case-by-case basis and site-specific mitigation is applied where it is reliable and available. In every case, where information is available, thresholds and limits are associated with attributes to better inform management and regulatory decision making. However, in many cases the knowledge of a species and its critical habitat may be lacking and, in particular, information associated with a species or habitat’s thresholds of tolerance to disturbance from human activities is lacking and must be acquired.

Table 5. Activities likely to result in the destruction of critical habitat of the Misty Lake Sticklebacks

Activity	Effect – Pathway	Functions Affected	Features Affected	Attributes Affected
Exotic, Invasive, or Introduced Species: Introduction leading to subsequent establishment of non-native aquatic species into lake or streams	Alteration of water quality which could impact water clarity possibly required for mate recognition while spawning Change in vegetation community composition or structure which may affect reproductive isolation and nesting sites Change in the faunal community potentially reducing abundance of prey	Rearing Spawning Nursery	Lake habitat Inlet and outlet stream habitat to the extent currently known occupied by stickleback Swampy transition zones	• Stable water quality parameters, including oxygen, pH, and temperature range • Stable light transmission • Stable water clarity • Stable faunal community, particularly other fish and macroinvertebrates • Adequate food supply of benthos/invertebrates • Adequate food supply of zooplankton and macroinvertebrates • Adequate food supply, type unknown but likely small benthos and invertebrates • Physical structural complexity including the presence of macrophyte beds • Physical structural complexity including the presence of fallen logs and macrophyte beds
Water Pollution: Point source pollution from road run-off and rest stop Non-point source pollution and changes in water quality resulting from land use practices (e.g., road construction, and poorly maintained roads, stream crossings, and transmission routes)	Reduction in water quality affecting both the species' and their prey's ability to function Increase in sediment inputs to water could impact water clarity possibly required for mate recognition while spawning	Rearing Spawning Nursery	Lake habitat Inlet and outlet stream habitat to the extent currently known occupied by stickleback Riparian area surrounding: the lake, the inlet and outlet stream habitat to the extent currently known occupied by stickleback, and the swampy transition zones Swampy transition	• Stable water quality parameters, including oxygen, pH and temperature range • Stable faunal community including fish • Stable faunal community, particularly other fish and macroinvertebrates • Adequate food supply of benthos/invertebrates • Adequate food supply of zooplankton and macroinvertebrates • Adequate food supply, type unknown but likely small benthos and invertebrates • Stable transmission of light • Stable water clarity

Activity	Effect – Pathway	Functions Affected	Features Affected	Attributes Affected
			zones	
Habitat Loss and Degradation: Excess riparian vegetation removal related to utility and transport corridors and land use within the riparian areas Non-conforming recreational use of Misty Lake Ecological Reserve (e.g., consumptive resource uses such as fishing with live bait, the use of motorized boats, and cutting trees)	Reduction in bank stability leading to an increase in sediment inputs to water which could impact water clarity possibly required for mate recognition while spawning Reduction in vegetative cover from predators and terrestrially derived food Increase in amount of sunlight reaching the stream(s) enhancing algal production leading to temporary loss of habitat Alteration of water quality (e.g., nutrients, sediment, turbidity, etc.) See pathway for Exotic, Invasive or Introduced Species activity, and Water Pollution activity	Rearing Spawning Nursery	Lake habitat Inlet and outlet stream habitat to the extent currently known occupied by stickleback Riparian area surrounding: the lake, inlet and outlet stream habitat to the extent currently known occupied by stickleback, and the swampy transition zones Swampy transition zones	• Stable riparian banks • Stable quality and quantity of surface water run-off during high rainfall • Provision of terrestrially supplied food and nutrients • Adequate food supply of benthos/invertebrates • Adequate food supply of zooplankton and macroinvertebrates • Adequate food supply, type unknown but likely small benthos and invertebrates • Stable water quality parameters, including oxygen, pH, temperature range and clarity • Stable faunal community including fish • Stable faunal community, particularly other fish and macroinvertebrates • Physical structural complexity including the presence of macrophyte beds • Physical structural complexity including fallen logs and macrophyte beds • Stable transmission of light • Stable water clarity

8. MEASURING PROGRESS

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. A successful recovery program will achieve the overall aim of maintaining two distinct forms in self-sustaining populations and the current distribution of both the lake and stream forms of the Misty Lake Sticklebacks. Listed here are performance indicators for the two population and distribution objectives.

1. Maintain self-sustaining populations and the current distribution of the lake and stream forms of the Misty Lake Sticklebacks. Assuming that the population appears to be stable (Hatfield 2009; COSEWIC 2006) and in the absence of quantitative population estimates, the objective is to maintain current population levels and distribution, through maintaining current habitat area and habitat quality. Once an empirical estimate of population sizes exists, it will become the standard against which to measure this objective.
   - By 2026, there has been no reduction in the population sizes.
   - By 2021, there has been no reduction in the species distribution in the inlet and outlet streams and lake.
   - By 2026, lake and stream habitat quality is maintained.

2. Maintain the two distinct forms (lentic and lotic) of Misty Lake Stickleback by preventing an increase in hybridization that could lead to the collapse of the species pair into a hybrid swarm.
   - By 2021, the two forms (lentic and lotic) of Misty Lake Stickleback are still distinctly separate.
   - By 2026, there has been no increase in the amount of hybridized individuals in the populations.

9. STATEMENT ON ACTION PLANS

An action plan will be completed within five years of posting the final recovery strategy on the Species at Risk Public Registry.

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APPENDIX A: EFFECTS ON THE ENVIRONMENT AND OTHER SPECIES

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[12]. The purpose of an SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy (FSDS)[13] goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies 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 strategy itself, but are also summarized below in this statement.

This recovery strategy will clearly benefit the environment by promoting the recovery of Misty Lake 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 of 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 recovery strategy and the Misty Lake Sticklebacks potentially link to, or interact with, other species and the ecosystem, refer to the following sections of the document, in particular: Species Description, Needs of the Misty Lake Sticklebacks, Strategic Direction for Recovery, and Identification of Critical Habitat: Biophysical Functions, Features and their Attributes.

Specifically, within the range of the Misty Lake Sticklebacks, it is unlikely that broad strategies to recovery recommended within this document will negatively impact other fish or wildlife species. The population and distribution objectives do not aim to increase the population size of Misty Lake Sticklebacks, and enhancing protection of the Misty Lake ecosystem outside of the currently protected Misty Lake Ecological Reserve will likely benefit other species of fish, wildlife and vegetation. The broad strategies to recovery suggested in Table 2 will help to address threats to the Misty Lake Sticklebacks and their habitat, such as water quality, which will also benefit other native species. Furthermore, recovery efforts are unlikely to affect species

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[12] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[13] http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=A22718BA-1

outside of the current range of Misty Lake Sticklebacks as the distribution of the species is limited and introduction into new areas is not a recommended recovery action.

APPENDIX B: RECORD OF COOPERATION AND CONSULTATION

Misty Lake Lentic Stickleback and Misty Lake Lotic Stickleback (Misty Lake Sticklebacks) were listed as Endangered species on Schedule 1 of the *Species at Risk Act* (SARA) in February 2010. The Minister of Fisheries and Oceans (DFO) is the competent Minister under SARA for the Misty Lake Sticklebacks and prepared the recovery strategy, as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Province of British Columbia as per section section 39(1) of SARA. Processes for coordination and consultation between the federal and British Columbian governments on management and protection of species at risk are outlined in the *Canada-B.C. Agreement on Species at Risk* (2005). The draft document was also sent to the Parks Canada Agency and Environment and Climate Change Canada for review and comment. Finally, letters were sent out to First Nations, whose claimed traditional territories overlap with the Misty Lake watershed, soliciting their participation in the development of this recovery strategy.

In March 2011, a technical workshop was held to seek comments and input on the draft recovery strategy, and ensure the document incorporated the best technical and scientific expertise on these species. Participants are identified in the table below.

Name	Affiliation
Chelsey Haselhan	Fisheries and Oceans Canada (Chair)
Michael Jackson	Acroloxus Wetlands Conservancy (contractor to Fisheries and Oceans Canada)
Michelle Evelyn	Acroloxus Wetlands Conservancy (contractor to Fisheries and Oceans Canada)
Eric Chiang	Fisheries and Oceans Canada
Martin Nantel	Fisheries and Oceans Canada
Tom G. Brown	Fisheries and Oceans Canada
Jordan Rosenfeld	BC Ministry of Environment
Doug Biffard	BC Ministry of Environment - Parks
Chrissy Chen	Kwakiutl First Nations – Fisheries Coordinator
Dolph Schluter	University of British Columbia
Timothy Atwood	Texada Stickleback Group Coordinator

Consultations on the draft recovery strategy occurred between March 21 and April 23, 2012. Consultation activities included:

- on-line posting to DFO’s Pacific Region Consultation website of the draft recovery strategy, background information and a feedback form,
- letters, e-mails and faxes with information on the draft recovery strategy consultation and offering opportunities for bilateral meetings sent to five First Nation organizations whose claimed traditional territories overlap with Misty Lake, and
- e-mail notification regarding the recovery strategy consultation sent to approximately 25 stakeholders, including industry (forestry), academia, environmental non-government

organizations, government representatives (municipal, regional, provincial and federal) and the technical workshop participants.

The two sets of comments received during the regional consultation period focused on the uncertainty pertaining to the threat of hybridization, population estimates, the extent of the identified critical habitat and the potential implications to industrial operations. All feedback was considered in the finalization of the recovery strategy.

Appendix C: Photographs from the Misty Lake watershed

Photo 1: Looking west along the Misty Lake southern shore-line.

Photo 2: Misty Lake (lower) inlet stream taken from the intersection of the stream with Highway 19 looking south.

Photo 3: Misty Lake outlet.

All photos courtesy of Chelsey Haselhan.