Species at Risk Act
Recovery Strategy Series

Amended Recovery Strategy for the Atlantic Whitefish (Coregonus huntsmani) in Canada

Atlantic Whitefish

2018

Canada

About the Species at Risk Act recovery strategy series

What is the Species at Risk Act (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003 and one of its purposes is "to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment and Climate Change Canada, Parks Canada Agency and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37-46 of SARA spell out both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the Species at Risk Act and recovery initiatives, please consult the SAR Public Registry.

Amended Recovery Strategy for the Atlantic Whitefish (Coregonus huntsmani) in Canada

2018

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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 SAR Public Registry.

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Declaration

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 federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada.

The Minister of Fisheries and Oceans is the competent minister under SARA for the Atlantic Whitefish and has prepared this strategy, as per s. 37 of SARA. It has been prepared in cooperation with the Atlantic Whitefish Conservation and Recovery Team, the Province of Nova Scotia, Aboriginal organizations, and any others as per s. 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 (DFO), or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Atlantic Whitefish 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 DFO 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.

Responsible jurisdictions

Under the Species at Risk Act, the responsible jurisdiction for the Atlantic Whitefish is DFO. Atlantic Whitefish occur only in Nova Scotia, and the Province of Nova Scotia also cooperated in the production of this recovery strategy.

Authors

This document was prepared by DFO in collaboration with the Atlantic Whitefish Conservation and Recovery Team.

The Atlantic Whitefish Conservation and Recovery Team (the Recovery Team or AWCRT), hereafter referred to as 'the Recovery Team', was formed in the fall of 1999 in response to concerns regarding the survival of the Atlantic Whitefish in Nova Scotia. Successful recovery is dependent on a transparent and inclusive approach that is acceptable to a variety of community interests; therefore, the Recovery Team draws membership from all sectors that have an interest in protecting the species. The

Recovery Team is comprised of relevant federal and provincial governments: DFO, Nova Scotia Department of Natural Resources (NSDNR), and Nova Scotia Department of Fisheries and Aquaculture (NSDFA), their clients, industry, stakeholders, and Aboriginal groups.

Meetings are held at least twice a year (spring and fall). Member organizations and active participants on the Recovery Team during the development of the 2006 recovery strategy and this amended version are listed in Table 1. Key functions of the Recovery Team include:

- advising DFO on specific themes and content in the development of a recovery strategy and action plan
- coordinating Recovery Team member/organization involvement in recovery actions including environmental, biological, technical, and social (educational and stewardship) program initiatives
- communicating recovery activities to others

Table 1. Atlantic Whitefish Conservation and Recovery Team membership during development of the recovery strategy in 2006/07 and this amended recovery strategy.

Member Organization	Members (2006/07)	Members (current)
Bluenose Coastal Action Foundation	Cook, Brooke	Nodding, Brooke Breen, Andrew Longue, Philip
Bridgewater – Public Service Commission	Feener, Larry Fox, Mike	Hiltz, Tim Hood, Larry
Canadian Association of Smallmouth Anglers	Weare, Mark	
Dalhousie University	Cook, Adam Hasselman, Dan	
DesBrisay Museum	Selig, Gary	
DFO, Science	Bradford, Rod Davison, Bev Longard, David Longue, Philip Marshall, Larry (former co-chair) O’Neil, Shane O'Reilly, Patrick Whitelaw, John	Showell, Mark
DFO, Fisheries Management	Burton, Clifford Manderville, Darin Marshall, Ian (co-chair) Purdy, Jeff Stevens, Greg Sweeney, Anne	Stevens, Greg

Member Organization	Members (2006/07)	Members (current)
DFO, Species at Risk Management Division	Barnes, Bob (former co-chair) Cullen, Lynn Loch, John (former co-chair) McPherson, Arran Querbach, Kirsten Robichaud-LeBlanc, Kim	Robichaud-LeBlanc, Kim Burbidge, Chris(topher)
DFO, Fisheries Protection Program	Hamilton, Anita Schaefer, Heidi Wheaton, Thomas	Delaney, Leanda
DFO, Conservation and Protection		Wolfe, William Burgess, Roland
DFO, Communications	Myers, Carl McKinnon, Chastity	MacLean, Melanie
DFO, Policy and Economics	Rudd, Murray	MacIntosh, Robert
Environment and Climate Change Canada	Davidson, Kevin	
Hebbville Village Commission	Barkhouse, Murray	
Maritime Aboriginal Peoples Council		McNeely, Joshua
Native Council of Nova Scotia – Zone 5	Martin, Tim	Stevens, Jeff
Nova Scotia Dept. of Fisheries and Aquaculture	LeBlanc, Jason	LeBlanc, Jason
Nova Scotia Dept of Environment	Green, Bob Helmer, Leif	
Nova Scotia Dept. of Natural Resources	Elderkin, Mark	Elderkin, Mark
Nova Scotia Museum of Natural History	Gilhen, John (co-chair) Hebda, Andrew	Gilhen, John
Nova Scotia Power Corporation	Burgess, Carys Meade, Ken	Nicolas, Jean-Marc
Petite Rivière Watershed Advisory Group	Bell, Doug Brown, Wally Bryant, David	
Nature Nova Scotia	Comolli, Jill	Comolli, Jill
Tusket River Environmental Protection Assoc.	Dukeshire, Danny Patten, Patrick	

Acknowledgements

The amendments to this recovery strategy have been led by DFO, in cooperation and consultation with the AWCRT. The development of the 2006 recovery strategy drew heavily on a draft recovery strategy prepared under the Recovery of Nationally Endangered Wildlife (RENEW) Working Group by Doug Rowland on behalf of the AWCRT in 2001. DFO is grateful to the Recovery Team and Mr. Rowland and the many individuals who provided information and advice contributing to the development of this document as well as the 2006 document. We also thank DFO employees Dave Longard, Stanley Johnston, and Donald Sam for preparing the maps in these documents. Furthermore, DFO wishes to recognize the invaluable input provided by the broader interested public in the consultation process (see Appendix II for the Record of Cooperation and Consultations).

Environmental considerations

Environmental considerations must be incorporated into the development of public policies, plans, and program proposals to support environmentally-sound decision making.

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 recovery planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats. The environmental considerations for this strategy are summarized as follows:

This recovery strategy will benefit the environment by promoting the recovery of the Atlantic Whitefish. Although there is the limited knowledge about the species biology and its role in the ecosystem, the potential for the strategy to inadvertently lead to adverse effects on other species was considered. Providing the conditions to facilitate anadromy of Atlantic Whitefish in the Petite Rivière and re-introduction of the species into other watersheds, potentially including the Tusket River, could have ecological consequences. Negative consequences to other recreational fisheries and/or species will be mitigated to the extent possible and socio-economic costs of implementing this recovery strategy are estimated in the associated action plan. Potential impacts are expected to be site-specific and strategies to address impacts will be developed in advance of taking recovery actions. The environmental risks associated with re-introductions were concluded to be acceptable considering the consequences of inaction.

Residence

Section 2(1) of SARA defines 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".

Available information indicates that the residence concept does not currently apply to Atlantic Whitefish (DFO 2009a). The action plan (DFO 2018), however, proposes to re-evaluate the applicability of the residence concept for Atlantic Whitefish once further information is acquired on the existence of precise structures as well as location and use of any such structures that would support the species habitat functions.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted when available on the SAR Public Registry.

Preface

The Recovery Strategy for the Atlantic Whitefish (Coregonus huntsmani) in Canada (DFO 2006a) was published as final on the SAR Public Registry in February 2007. This recovery strategy was amended mainly for the purpose of:

- restructuring the section on threats (i.e. Section 1.6) to better separate past and current threats and updating it to include new information
- including population and distribution objectives based on new information from the 2009 Recovery Potential Assessment
- including an identification of critical habitat and examples of activities likely to result in its destruction
- including progress measures to assist in 5-year reporting on the implementation of the recovery strategy
- revising the activities permitted by the recovery strategy (Section 2.9) to exempt DFO-led conservation and recovery activities, authorized electrofishing, and authorized fishing activities for other species that result in incidental capture of Atlantic Whitefish
- clarifying DFO's approach to, and timing of, the development of a SARA action plan for Atlantic Whitefish
- making updates throughout the document to provide new information, including that from the 2009 Recovery Potential Assessment, 2010 Status Report from the Committee on the Status of Endangered Species in Canada (COSEWIC), and recovery activities undertaken and/or underway since the publication of the 2006 recovery strategy
- revising the recovery feasibility determination and other relevant components of the document to accommodate new information as well as a change in context due to the conclusion of the DFO Science Atlantic Whitefish captive-breeding program in the spring of 2012
- revising where appropriate to take into account recent changes to the Fisheries Act

Executive summary

The Atlantic Whitefish, Coregonus huntsmani (Scott 1987), is an endemic[1] Canadian species historically known to occur only in the Tusket River and Petite Rivière watersheds in southwestern Nova Scotia[2] (Figure 1). The species is the sole and founding representative of a unique lineage of Whitefish in North America; it is therefore an important component of Canadian biodiversity.

Historically retained in recreational and commercial fisheries in both of its native watersheds and once an anadromous species (i.e., migrating from sea to fresh water to spawn), the Atlantic Whitefish is now believed to be extirpated from the Tusket River (Figure 2) and its reproduction largely restricted within three small, interconnected, semi-natural lakes (1600 total hectares) in the upper Petite Rivière drainage area (Figure 3). Wild Atlantic Whitefish are not found anywhere else in the world and the exact size of the remaining population is not known but believed to be low (DFO 2009a; COSEWIC 2010). As a result of the species' reduced distribution and presumed low abundance, the Atlantic Whitefish was assessed as 'Endangered' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1984; a designation which means the species is at imminent risk of extinction. This 'Endangered' status was re-confirmed by COSEWIC in 2000 and 2010.

Knowledge of which factors have contributed to the decline and continued low abundance of Atlantic Whitefish is imprecise. Unregulated, excessive harvesting in the past may have been a factor in the decline of Atlantic Whitefish populations. Acidification of the aquatic habitat as a result of acid rain has occurred throughout the known range for the species and may be a factor limiting the species' recovery. Fish habitat has been altered as a result of human land and watercourse use (in particular the construction and operation of dams and associated fishways) and non-indigenous fish predators (such as Smallmouth Bass (Micropterus dolomieu) and Chain Pickerel (Esox niger)) have been introduced illegally into the watersheds. The threat posed by non-native fish species, acidification from land-based activities, and the threat posed by barriers to fish passage are believed to be the principle factors currently impeding the survival and recovery of the remaining Atlantic Whitefish population (COSEWIC 2010). Improvements to fish passage have been made in the Petite Rivière lakes in recent years; however, the impact of these improvements on Atlantic Whitefish survival and recovery remains to be evaluated. Other potential threats and factors limiting survival or recovery are also discussed.

The Atlantic Whitefish was among the species included as 'Endangered' on Schedule 1 of the Species at Risk Act (SARA) when it was enacted in June 2003. One of the key requirements under this legislation is the development of a recovery strategy which details what is known about the species and the broad strategies and general

[1] Appendix I provides a Glossary of Terms.
[2] The former distribution of the species (e.g., prior to the arrival of Europeans in the 1600s) is unknown.

approaches that need to be taken to protect and recover the species. Accordingly, Fisheries and Oceans Canada (DFO) prepared a recovery strategy in cooperation with the Atlantic Whitefish Conservation and Recovery Team (AWCRT) which was published in February 2007 (DFO 2006a). Since publication of the 2006 recovery strategy, DFO has undertaken a Recovery Potential Assessment (RPA) to consolidate new information on Atlantic Whitefish in preparation for the species reassessment by COSEWIC in 2010, as well as to support decisions on SARA permitting, and to support ongoing recovery planning efforts (DFO 2009b). This recovery strategy is therefore revised accordingly to consider this new information, and replaces the previous recovery strategy for the Atlantic Whitefish (i.e., DFO 2006a).

This amended recovery strategy restates the overall goal and broad strategies that continue to be relevant and realistic to protect and recover Atlantic Whitefish. Some of the general approaches were revised to take into account changing conditions. This document also includes interim (i.e., 5-year) population and distribution objectives recommended by the RPA.

The overall goal of the recovery strategy is to:

> ”Achieve stability in the current population of Atlantic Whitefish in Nova Scotia, reestablishment of the anadromous form, and expansion beyond its current range.”

This broad recovery goal will be achieved by addressing the following interim population and distribution objectives, which can be revisited once knowledge about the dynamics of a recovering population is obtained:

Population objective: A minimum population size of > 1,275 mature individuals in the Petite Rivière.

Distribution objective: Establishing self-sustaining anadromous populations in several watersheds in the Nova Scotia Southern Uplands eco-region, including the Petite Rivière.

The supporting broad strategies outline the need to:

1. conserve, protect, and manage the species and its habitat
2. increase the number and range of viable populations
3. address knowledge gaps relating to the species and its habitat
4. increase public involvement in, and acceptance of, measures required for the species survival and recovery

Given their unique attributes, including their Canadian endemic nature and their ancient and distinct evolutionary significance, the imminent danger of Atlantic Whitefish becoming extinct adds weight to the importance of ensuring the survival of the remaining wild population and implementing recovery. Some of the specific initiatives for recovery have already begun. Providing the conditions to ensure the survival of the lake population, facilitating anadromy on the Petite Rivière, and extending the range of Atlantic Whitefish are important components of recovery for this species. Efforts to evaluate the feasibility of using captive-reared individuals to establish lake populations and concurrently minimize the species' risk of extinction by attempting to establish a back-up population have been undertaken. Captive-reared Atlantic Whitefish were released into a new waterbody outside of the species' current range (i.e., Anderson Lake, Dartmouth, Nova Scotia) from 2005 to 2008 (with an additional small allotment of fish in 2012), but an established population has not yet been confirmed in this new location. Efforts are also underway to ensure survival and promote anadromy on the Petite Rivière by improving fish passage, including the completion of a fish passage facility at Hebb Dam in 2012, and implementing mitigation plans for the control of non-native species. The ultimate success of these efforts will not be known for several years. This recovery strategy will focus on survival of the existing wild population and direction required for recovery, including the need for range expansion. Efforts accomplished to date and underway are highlighted in Section 2.10 of this document.

The recovery of Atlantic Whitefish is considered to be both biologically and technically feasible (see Section 2.1); however, it is recognized that survival of the species and the time needed for its recovery is dependent both upon the current status of the remaining population and the timing and extent of human intervention. Going forward, identifying viable mechanisms, partnering opportunities, and arrangements will be essential to implement the recovery measures required to mitigate threats and achieve the distribution objective for this species. Adopting an adaptive management approach to the recovery of Atlantic Whitefish will be essential to the ongoing survival of the species within its existing habitat, particularly to address current and any new emergent threats, and to the success of range expansion into the marine realm and additional freshwater sites. Specific measures required to fully implement recovery, as well as the socio-economic costs and benefits of recovery implementation, are detailed more specifically in the associated action plan (DFO 2018).

SARA prohibits the killing, harming, harassing, capturing or taking of individuals of an endangered, threatened, or extirpated species. Although the prohibitions associated with SARA protect Atlantic Whitefish, SARA enables recovery strategies to exempt persons engaging in certain activities from these general prohibitions if the following two conditions are met. First, the activity must be consistent with the goal of the recovery strategy (which means that it cannot jeopardize survival or recovery of the species) and secondly, the activity must be authorized under an Act of Parliament. Human activities that may contribute to mortality or harm to Atlantic Whitefish were reviewed and evaluated during the 2009 RPA which included information to support decisions on permitting. Considering advice from this advisory process, this recovery strategy includes a number of exempted activities which are detailed in Section 2.9 of this document.

SARA also requires the protection of critical habitat once it is identified in a recovery strategy and/or action plan. Critical habitat was not identified in the 2006 recovery strategy, but advice from the 2009 RPA did provide the information necessary to inform the identification of critical habitat for Atlantic Whitefish. Accordingly, critical habitat for Atlantic Whitefish survival is identified in this recovery strategy as the water column and substrate features of the following three lakes in the upper Petite Rivière and the waterways inter-connecting these three lakes: Milipsigate Lake, Minamkeak Lake, and Hebb Lake, as well as the fish passage facility at Hebb Lake Dam which was built to provide passage of Atlantic Whitefish into Hebb Lake. Examples of activities likely to result in the destruction of critical habitat are described in Section 2.5.7. A Schedule of Studies is included to outline the research activities required to refine the current description of critical habitat in order to support its protection, and to identify any additional critical habitat required for the species' subsequent recovery.

Subsequent to the development of a recovery strategy, SARA requires the development of one or more action plans which identify the specific recovery measures necessary to support the strategic direction set out in the recovery strategy. The socio-economic impacts of implementing the action plan are also included. Accordingly, concurrent with this amended recovery strategy, DFO has prepared an action plan for Atlantic Whitefish which addresses the species' entire known historical global distribution (DFO 2018). This document is published on the SAR Public Registry.

SARA also requires reporting on the implementation of the recovery strategy, and the progress towards meeting its objectives, within five years after it is included in the SAR Public Registry. The original recovery strategy for Atlantic Whitefish was published in February 2007. Accordingly, a Report on the Progress of Recovery Strategy Implementation for the Atlantic Whitefish (Coregonus hunstmani) in Canada for the Period 2007-2012 (i.e., 'progress report') has been prepared and is also published on the SAR Public Registry (DFO 2016). DFO will continue to assess the feasibility and effectiveness of recovery efforts and work cooperatively with the Recovery Team, stakeholders, Aboriginal Peoples, and other interested parties towards the recovery of Atlantic Whitefish.

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Introduction

Atlantic Whitefish (Coregonus huntsmani) is found only in Nova Scotia, Canada, and occurs in the wild as a single population distributed among three small, inter-connected, semi-natural lakes. It is presently at critically low levels, assessed as 'Endangered' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and is protected under the federal Species at Risk Act (S.C. 2002, c. 29) (SARA).

The Atlantic Whitefish[3] is a member of the salmon and trout family Salmonidae, and belongs to the subfamily Coregoninae. It appears dark green or blue on its back with silvery sides and a silvery to white underbelly. They possess a deeply forked tail and an adipose fin (Figure 4). Historically, the fish has been used by humans for food and have been angled for recreational purposes (Scott and Scott 1988). It has been described as an excellent table fish and a gamey fighter (COSEWIC 2010).

Atlantic Whitefish can be distinguished from other Whitefish species by their genetic structure (Bernatchez et al. 1991; Murray 2005; Bradford et al. 2010; Cook 2012) and physical characteristics (Edge et al. 1991; Hasselman et al. 2007, 2009; Hasselman and Bradford 2012). Thought to represent the sole living representative of the early form of Whitefishes (Smith and Todd 1992) and a basal lineage of the widespread northern hemisphere genus Coregonus (Cook 2012), the species represents a unique component of local, national, and global biodiversity.

First described by Huntsman (1922), the Atlantic Whitefish is a Canadian endemic species known historically to occur in the Tusket River and Petite Rivière watersheds in southwestern Nova Scotia (Scott 1987; Edge and Gilhen 2001) (Figure 1). An anadromous population was reported from the Tusket River (Figure 2) (Edge and Gilhen 2001); however, there is no documented record of a fall run in the Petite Rivière (Bradford et al. 2004a). Since the impoundement of the lakes and construction of dams on the Petite Rivière beginning in the late 1790s, Atlantic Whitefish have been documented downstream in both the freshwater and marine portions of the watershed (Figure 3) (Edge and Gilhen 2001). It is presumed that these fish passed downstream over the Hebb Lake Dam, and were able to tolerate marine conditions.

Declining numbers in both the Tusket River and Petite Rivière watersheds in recent decades (Edge 1984a), and a global distribution restricted to two river drainage areas, resulted in the Atlantic Whitefish being assessed as 'Endangered' by COSEWIC in 1984. Atlantic Whitefish was the first fish species in Canada to be designated 'Endangered' by COSEWIC. Re-assessment of the species' status by COSEWIC in 2000 concluded that a remnant anadromous population may exist in the Tusket, that the land-locked Petite Rivière population continues to persist, and that there is uncertainty concerning the status of any anadromous run to the Petite Rivière (COSEWIC 2000). A

[3] This fish was historically referred to as Acadian Whitefish, Sault Whitefish, Round Whitefish, and Common Whitefish (Edge and Gilhen 2001).

continued decline in abundance, a continuation of threats identified in the previous assessment, and new threats (Edge and Gilhen 2001) were cited in support of the continued designation of the species' status as 'Endangered'.

Information acquired since the 2000 COSEWIC assessment has confirmed the existence of the lake-resident population in the Petite Rivière, cast uncertainty on the existence of an anadromous run to that river (Bradford et al. 2004a), and indicated that the species has been extirpated from the Tusket River (the last confirmed specimen was captured in 1982) (Edge 1984b; DFO 2009a; COSEWIC 2010). The species' range is currently restricted within the 16 km^2 aggregate area of three small, semi-natural lakes (Hebb, Milipsigate, and Minamkeak) within the upper Petite Rivière (Figure 3) (Bradford et al. 2004a; DFO 2004a; DFO 2009a; COSEWIC 2010). Atlantic Whitefish were reassessed by COSEWIC in 2010 and its 'Endangered' status was again re-confirmed.

Canadians recognize that our natural heritage is an integral part of our national identity and history, as well as part of the World's heritage. We further recognize that wildlife (including fish) has existence value (value in and of itself) as well as being valued for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological, and scientific reasons. Therefore, when a species becomes at risk, as is clearly the case with Atlantic Whitefish, both Canada and Nova Scotia have responsibilities through their respective conservation mandates to protect, conserve, and recover the species. These jurisdictions have determined that preparation of a recovery strategy for Atlantic Whitefish is the appropriate first formal step to meeting these responsibilities.

In summary, the Atlantic Whitefish is found only in Nova Scotia, recognized to be of considerable evolutionary significance, at risk of extinction from several threats, and in need of immediate recovery actions. Intended to provide a common direction to be followed by participating parties, the purpose of this document is to lay out a strategy for the recovery of the Atlantic Whitefish by setting an overall goal and broad strategies to arrest or reverse the decline of the species and identifying the main areas of activities to be undertaken. Measures required to fully implement recovery are detailed more specifically in the associated action plan (DFO 2018).

1. Background

1.1 Species status

1.1.1 Canadian status

The Atlantic Whitefish was the first fish species in Canada and Nova Scotia's first endemic fish to be classified as 'Endangered' by COSEWIC in 1984. This status was re-examined and re-confirmed by COSEWIC in both 2000 and 2010.

Atlantic Whitefish was among the species included as 'Endangered' on Schedule 1 of SARA when it was enacted in June 2003.

COSEWIC assessment summary

Date of assessment: November 2010

Common name (population): Atlantic Whitefish

Scientific name: Coregonus huntsmani

COSEWIC status: Endangered

Reason for designation: This species, a unique Canadian endemic present in only a single location, is restricted to three interconnected lakes in Nova Scotia. Its viability is threatened by illegal introduction of exotic fishes.

Canadian occurrence: Nova Scotia

COSEWIC status history: Designated Endangered in April 1984. Status re-examined and confirmed in November 2000 and November 2010.

1.1.2 Global status

In 1996, the International Union for the Conservation of Nature (IUCN) assessed the Atlantic Whitefish as 'Vulnerable'[4] on their Red List of Threatened Species (Gimenez Dixon 1996). This designation implies the species is not endangered, but facing a high risk of extinction in the wild in the medium-term future due to its highly restricted area of occupancy.

[4] This assessment was based on IUCN criteria, which differs from the criteria used by COSEWIC. Furthermore, the distribution of the species was erroneously identified as being the Great Lakes region of North America. The status of this species on the Red List has been flagged for an update.

NatureServe, an international network of biological data inventories, has developed a species status assessment procedure in which at-risk species are assigned a global, national, and/or subnational 'Conservation Status Rank' (NatureServe 2012). Under this system, Atlantic Whitefish has been assigned a global ranking of 'G1-Critically Imperiled' due to its very restricted range, historical declines, and several threats.

1.2 Species distribution

1.2.1 Global range

The Atlantic Whitefish is endemic to Nova Scotia, meaning that it is found nowhere else in the world. It is known to have occurred only in the Tusket River and Petite Rivière watersheds, and their adjacent estuaries and bays (Figure 1), but the species' historical range is expected to have extended to other watersheds in Nova Scotia (DFO 2009a). Atlantic Whitefish was extirpated from the Tusket River system sometime after 1982 (Bradford et al. 2004a; DFO 2009a).

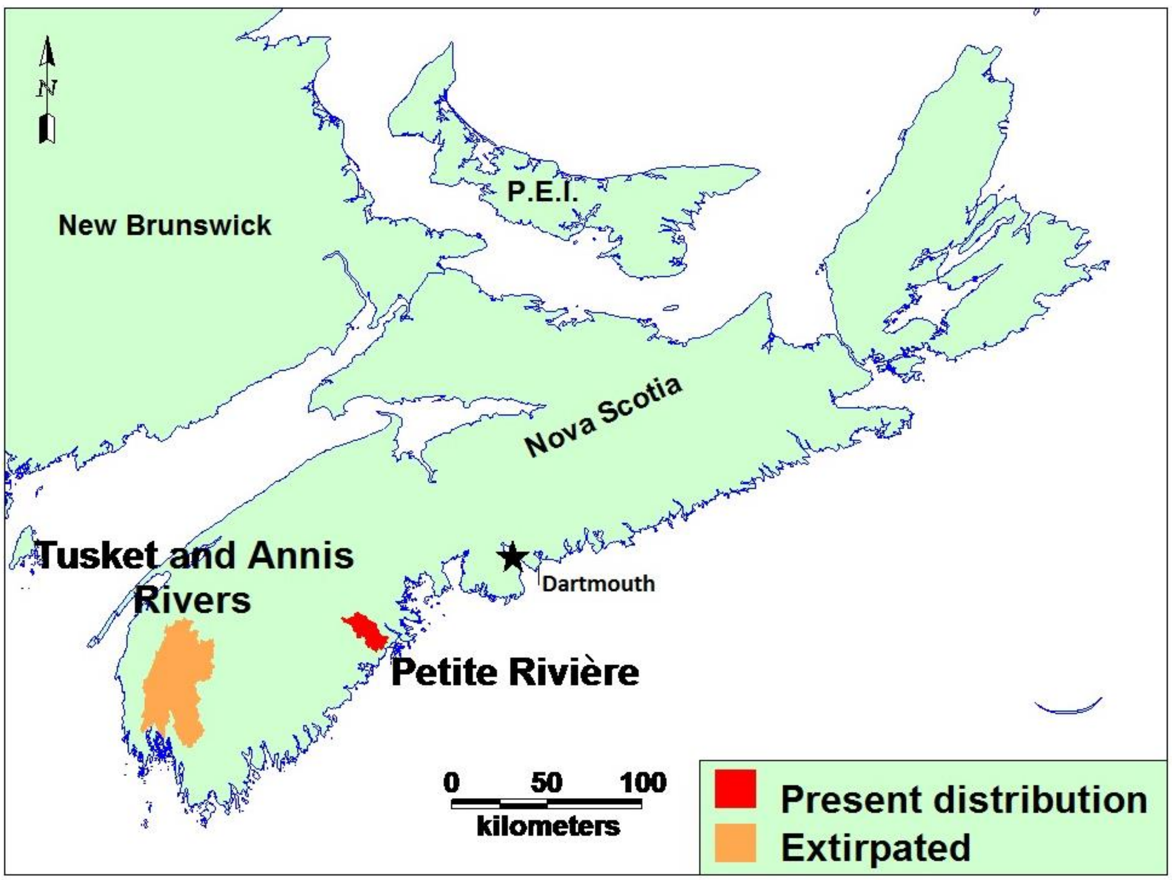

Figure 1. Present and known historical Canadian watershed distribution of Atlantic Whitefish. The general location of Anderson Lake (Section 1.2.4) is also indicated by a star.

Despite extensive commercial and recreational fisheries in fresh and coastal waters throughout Nova Scotia, as well as extensive province-wide fish surveys, Atlantic

Whitefish populations have not been reported outside these two watersheds (DFO 2009a). Isolated captures of specimens identified as Atlantic Whitefish were reported at the mouth of the Sissiboo River in southwestern Nova Scotia in 1919 (Scott and Scott 1988), at Halls Harbour on the Minas Channel in 1958 (Edge and Gilhen 2001), and in the LaHave Estuary in 1995 and 1997 (Edge and Gilhen 2001). These specimens may have been members of either the Tusket or Petite populations.

1.2.2 Tusket River watershed

The Tusket River population of Atlantic Whitefish appears to have been entirely anadromous. Historical occurrences were recorded in the non-tidal lower portions of both the Tusket River and the Annis River, as well as in the estuary that these two rivers share. Individuals have also been reported in Yarmouth Harbour located several kilometers to the west of the Tusket River (Figure 2). There is no information concerning the distance ascended by Atlantic Whitefish in either the Tusket or Annis Rivers (Bradford et al. 2004a; Figure 2). Atlantic Whitefish have not been recorded in the Tusket since 1964 and in the Annis since 1982. The Tusket River population is considered to be extirpated (Bradford et al. 2004a; DFO 2009a).

1.2.3 Petite Rivière watershed

The Petite Rivière system supports a small resident Atlantic Whitefish population largely restricted within three small, interconnected, semi-natural lakes in its upper watershed: Minamkeak, Milipsigate, and Hebb (Edge and Gilhen 2001; DFO 2009a; COSEWIC 2010; Figure 3). These three lakes, which collectively cover a surface area of approximately 16 km^2, form the water supply for the Town of Bridgewater. The dam at the foot of Hebb Lake, constructed as early as 1901, forms a barrier to upstream fish passage and has restricted access to the sea since its construction (Figure 3). Fish passage at this site has only recently been provided (see Section 2.10). The first confirmed specimen of Atlantic Whitefish was found at the outlet from Milipsigate Lake in 1923 (Piers 1927).

There is no documented record of an anadromous run of Atlantic Whitefish on the Petite Rivière prior to or after the construction of the dams on the Petite system. However, the species is anadromous by nature and there are anecdotal reports of Atlantic Whitefish in the Petite Rivière watershed below the lakes as early as the 1870s (Edge and Gilhen 2001). Since the construction of the dams, there have been reported occurrences of Atlantic Whitefish below the three lakes in Fancy Lake, and in the tidal portions of the Petite Rivière (Figure 3). As resident populations were not found in any recent surveys of the lakes below the dams (Bradford et al. 2004a), it is presumed that these fish either passed or were swept over the Hebb Lake Dam and moved from there into downstream areas. There is no evidence to document this movement over the dam, including when or at what age Atlantic Whitefish might pass over it. Specimens, likely strays from the lake-resident population (Bradford et al. 2004a), have been captured in the LaHave River estuary (Edge and Gilhen 2001) which lies to the east of the Petite Rivière (Figure 3).

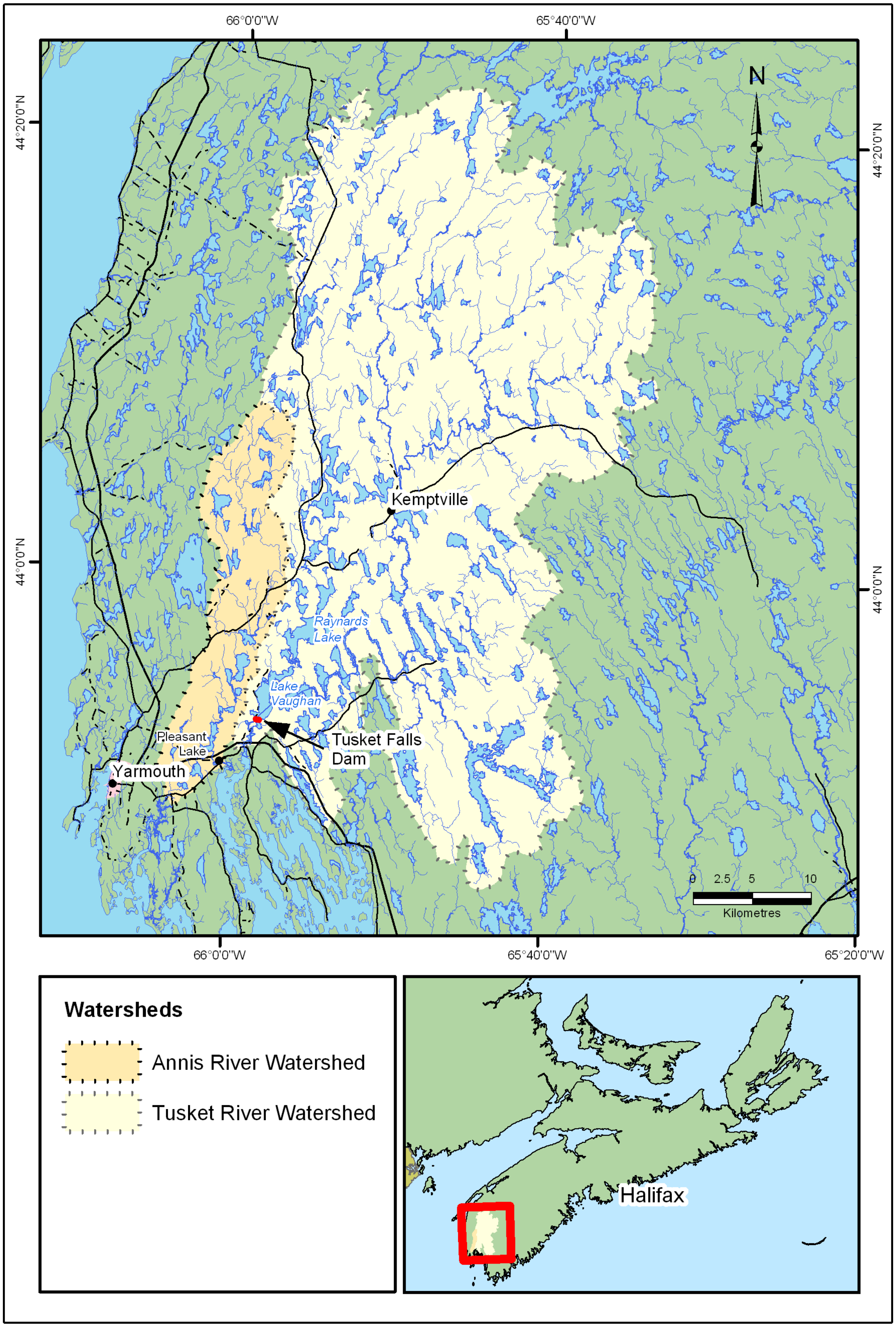

Figure 2. Tusket-Annis rivers watershed and estuary.

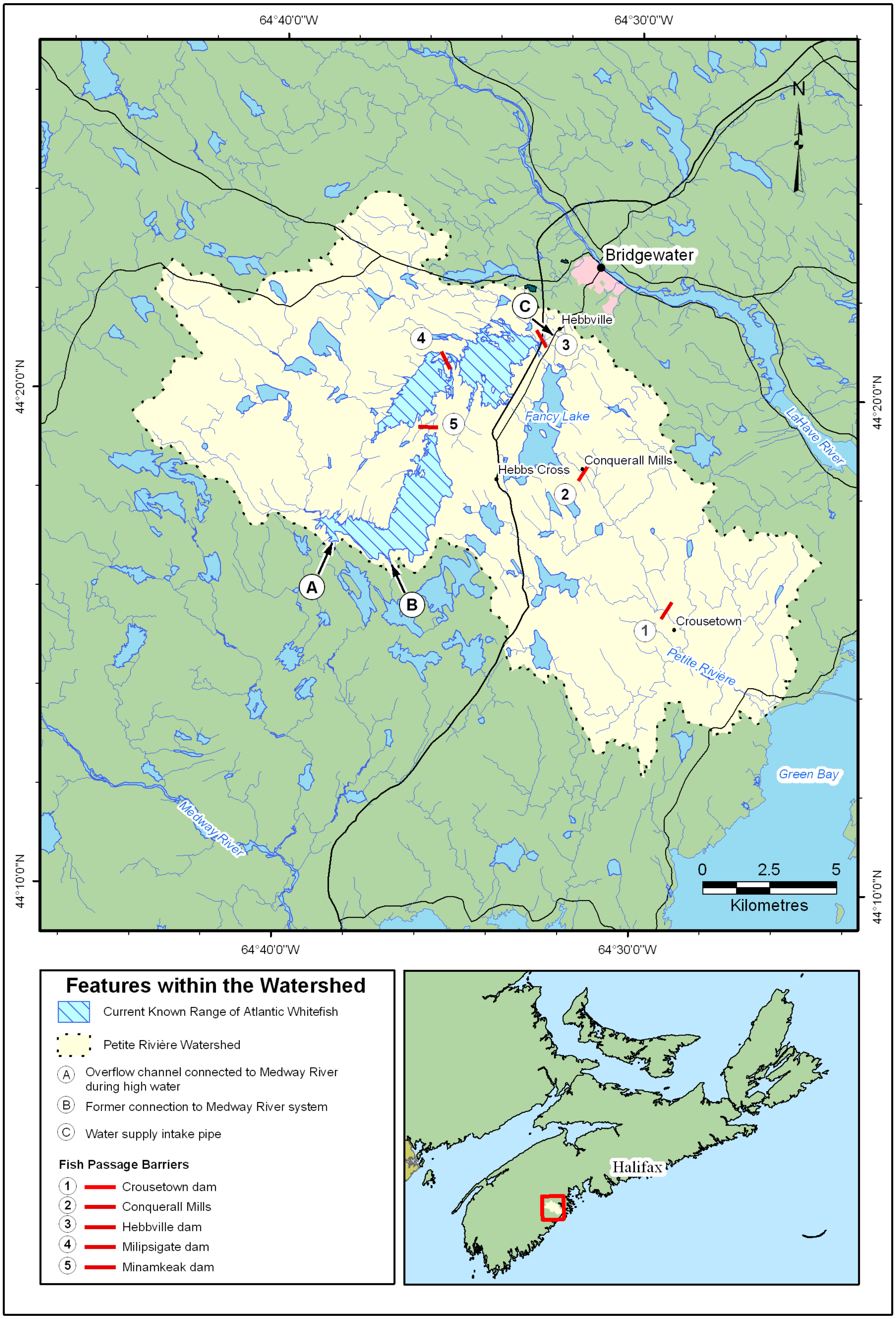

Figure 3. Petite Rivière watershed and Green Bay estuary.

Additionally, releases of captive-reared Atlantic Whitefish have been recently undertaken (2007-2009) in the lower Petite Rivière as part of recovery efforts and released individuals may persist in this location (DFO Science, unpublished data). Details on this action are described in Section 2.10.

The presence of Atlantic Whitefish in Minamkeak Lake has particular significance in light of the 1903 diversion of this lake from the Medway River (Figure 3) to the Petite Rivière (Edge and Gilhen 2001). Recent surveys indicated that Atlantic Whitefish are not resident within the Medway River, including the sub-drainage into which Minamkeak once drained (Bradford et al. 2004a). Presence of Atlantic Whitefish in Minamkeak Lake is likely a consequence of colonization from Milipsigate and Hebb Lakes sometime after the diversion (Bradford et al. 2004a).

1.2.4 Anderson Lake

Captive-reared Atlantic Whitefish have been introduced into a small (< 1 km^2) selected lake, Anderson Lake (2005-2008, 2012) in Dartmouth, Nova Scotia (Figure 1), as part of an experiment to evaluate the feasibility of using captive-reared fish to establish successfully reproducing lake-resident populations of Atlantic Whitefish (Bradford et al. 2015). Whether these releases have resulted in successful reproduction is not presently known; however, released individuals have been confirmed as late as 2012 to persist in this location (Broome and Reddin 2012). Details on these releases and the current status of this effort are described in Section 2.10.

1.3 Legal protection

The legal protection discussed in this section applies to all Atlantic Whitefish, including those captive-reared individuals released in Anderson Lake and the lower Petite Rivière.

1.3.1 Species at Risk Act

Atlantic Whitefish are listed under Schedule 1, Part 2 of SARA, and are therefore subject to the SARA general prohibitions against the killing, harming, harassing, capturing, or taking of individuals (s. 32), and the damage or destruction of the species' residence (s.33).

SARA requires protection against the destruction of a species' critical habitat once it has been identified in a recovery strategy or action plan; this is anticipated to be accomplished through a SARA Critical Habitat Order, pursuant to s. 58(4) or s. 58(5) of SARA. See Section 2.5 for details about the identified critical habitat for Atlantic Whitefish and examples of activities likely to result in its destruction.

1.3.2 Fisheries Act

In addition to SARA, components of the federal Fisheries Act (R.S.C. 1985, c. F-14) and its supporting regulations may have a direct and/or indirect application to Atlantic Whitefish.

Section 35(1) of the Fisheries Act reads as follows:

> No person shall carry on any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery.

This prohibition is administered in the Maritimes Region by Fisheries Protection Program (FPP), formerly the Habitat Management Program.

Section 36(3) of the Fisheries Act, known as the pollution prevention provision, prohibits the deposition of deleterious substances in water frequented by fish or in any place where the deleterious substance may enter any such water. Sections 36(3) to 36(6) of the Fisheries Act are largely administered and enforced by Environment and Climate Change Canada (ECCC) as per a designation order signed in 2014, with the exception of deposits related to aquaculture and the control or eradication of aquatic species and pests.

Supporting regulations under the Fisheries Act, i.e., the Fishery (General) Regulations (F(G)Rs), the Maritime Provinces Fishery Regulations (MPFRs), the Atlantic Fishery Regulations, 1985 (AFRs), the Aboriginal Communal Fishing Licences Regulations (ACFLRs), and the Aquatic Invasive Species Regulations provide the tools to protect, conserve, and manage fisheries.

With respect to fisheries, three of the most important regulatory provisions are:

a) Section 6 of the MPFRs, which prohibits the retention or possession of Atlantic Whitefish
b) Section 6 of the F(G)Rs, which provides for the issue of variation orders to vary close times, fishing quotas, or the size or weight of fish that has already been established in regulations for an area or any portion of an area
c) Section 22 of the F(G)Rs, which provides for the issue of licence conditions

There have been no legal directed or bycatch fisheries for Atlantic Whitefish since at least 1978. Section 6 of the MPFRs which specifically prohibits the retention or possession of Atlantic Whitefish came into effect in 1993.

Recreational fishing activities are regulated through the provisions of the MPFRs but managed and licensed by the Province of Nova Scotia. After discussions with stakeholders, DFO and the Province have agreed to implement additional management measures on the Petite Rivière to protect Atlantic Whitefish individuals, primarily from incidental capture in the recreational angling fishery. By variation order in 2000, all angling is prohibited annually from April 1 to June 30 in the inland waters of Minamkeak, Milipsigate and Hebb Lakes (Figure 3), including the thoroughfares joining them. As of 2005, only unbaited lures and artificial flies (no bait) are permitted during the open angling season from July 1 to October 31. In 2011, the angling season in these three lakes was further shortened to be from July 1 to September 30. Recreational angling licenses are issued by the Province of Nova Scotia. Fishing seasons and restrictions for all recreational angling fisheries are outlined in the Nova Scotia Anglers' Handbook, which is published annually and can be found on the Nova Scotia Department of Fisheries and Aquaculture website.

As an additional measure, implemented in the early years following the inception of the Recovery Team, one commercial Gaspereau (i.e., Alewife (Alosa pseudoharengus) and Blueback Herring (Alosa aestivalis)) gill net licence holder in the estuary of the Petite Rivière was required, by licence condition, to relocate his fishing gear to avoid incidental captures of Atlantic Whitefish.

1.3.3 Provincial legislation

The Atlantic Whitefish and its habitat are also protected by provincial legislation including the Nova Scotia Endangered Species Act (1998) and the Nova Scotia Environment Act (1994-95, c. 1, s. 1). Minamkeak, Milipsigate, and Hebb Lakes form the water supply for the town of Bridgewater, and as such receive environmental protection as a designated Watershed Protected Water Area under the Environment Act since 2006. This type of designation involves a combination of regulations and best management practices which are rolled-out through a 'Source Water Protection Plan' and address all activities in the watershed that could impact water quality (e.g., forestry, agriculture, road construction, recreational use, mining, etc.). Prior to this designation, the watershed area surrounding Hebb Lake and Milipsigate Lake were designated a Protected Water Area under provisions of The Water Act in 1964, and the area surrounding Minamkeak Lake was similarly designated in 1981.

1.4 General biology and description

1.4.1 Physical description

The Atlantic Whitefish is a member of the salmon and trout family (Salmonidae) (Scott and Scott 1988) and belongs to the Whitefish subfamily (Coregoninae). It appears salmon-like, with silvery sides, a silvery white underbelly, and a back that is dark bluish-black or dark green (Figure 4). There are no spots or upper body markings. It has a deeply forked caudal (tail) fin and an adipose fin (a small, fleshy fin between the dorsal and caudal fins, typical of salmonids).

Scott and Scott (1988) describe Atlantic Whitefish as having between 91 and 100 scales along the lateral line, a terminal mouth (lower and upper jaws equal), and small but well developed teeth.

While growth of the species in the wild has not been studied, archived anadromous specimens from the Tusket River indicate that individuals from this population were of larger size than the individuals within the Petite Rivière lakes (Bradford et al. 2010). Records suggest adults can reach 50 cm (20 in) in fork length (FL) and up to 3.63 kg (8 lb.) in weight (Edge and Gilhen 2001). However, anadromous adults typically average 38 cm FL (15 in) while the smaller lake-resident individuals range 20 to 25 cm FL (8-10 in) (Bradford et al. 2010).

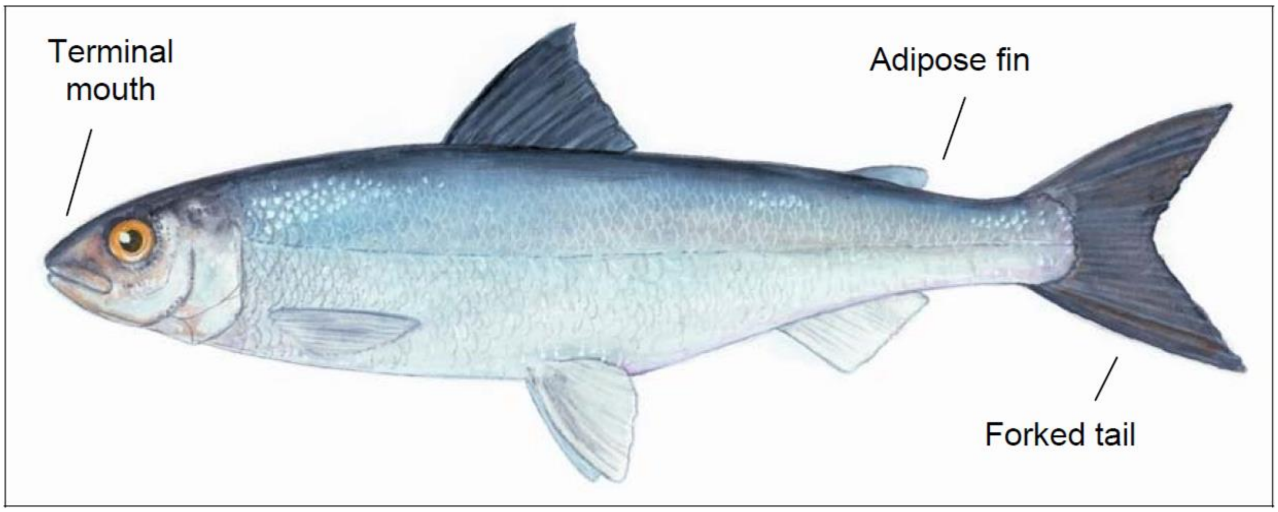

Figure 4. Schematic depicting an adult Atlantic Whitefish.

1.4.2 Common and scientific names

The common name Atlantic Whitefish was employed by Scott (1967) and Scott and Crossman (1973) in reference to its regular occurrence in salt water off Yarmouth County, Nova Scotia, and its upstream fall migration in the Tusket River (Scott 1987). Originally described scientifically as Coregonus canadensis by Scott (1967), the species name canadensis was later found to be already in use. Hence the name Coregonus huntsmani was recommended by Scott (1987) in honour of the late Dr. A.G. Huntsman, noted Canadian marine biologist, who was aware of the presence of an unusual whitefish in Nova Scotia waters at least as early as 1921 (Huntsman 1922). The species was also referred to in the past as Acadian Whitefish, Sault Whitefish, Round Whitefish, and Common Whitefish.

1.4.3 Distinguishing external traits

Atlantic Whitefish can be recognized on the basis of their external appearance (Hassleman et al. 2007, 2009; Hassleman and Bradford 2012). The species can be distinguished from most other salmonids by its larger scales. It can be distinguished from the more commonly occurring Lake Whitefish (Coregonus clupeaformis), a species similar in appearance but genetically distinct from the Atlantic Whitefish, on the basis of several external characteristics outlined in COSEWIC (2010) and on p. 36 of the 2016 Anglers' Handbook. These distinguishing characteristics are summarized in Table 2.

Table 2. Distinguishing characteristics of the Atlantic and Lake Whitefish, as described in COSEWIC (2010) and summarized in the 2016 Nova Scotia Anglers' Handbook.

Characteristic	Atlantic Whitefish	Lake Whitefish
Number of lateral line scales	88-100	63-95
Mouth shape	Near-terminal	Sub-terminal
Well-developed teeth	Present	Not present
Number of vertebrae	64-67	58-64
Length of pectoral fin ray*	Relatively shorter	Relatively longer
Size of scales*	Relatively smaller	Relatively larger

*When comparing two fish of roughly the same size.

1.4.4 Genetic distinctiveness

Genetically, Atlantic Whitefish differ from all other forms of coregonids examined to date (Bernatchez et al. 1991; Murray 2005; Bradford et al. 2010) and results of recent genetic work suggest that Atlantic Whitefish represent a basal lineage of the genus Coregonus which has species throughout the temperate and polar regions of the northern hemisphere (Cook 2012).

There are no detectable genetic differences among Atlantic Whitefish within the three Petite Rivière lakes (DFO 2009a). Additionally, recent analysis (Cook 2012) has confirmed that Atlantic Whitefish not only possess very low genetic diversity but further suggest that Atlantic Whitefish are among some of the most genetically depleted species examined to date. However, there is no evidence of a recent genetic bottleneck, suggesting that Atlantic Whitefish have possessed low genetic diversity for more than 100 years, possibly resulting from population size reductions through the loss of preferred habitat from the blockage of upstream fish passage and residence in three small oligotrophic lakes (Bradford et al. 2004; Cook 2012).

1.4.5 Life history

Little is known about the life history of Atlantic Whitefish and what is known relates primarily to adults.

Anadromous population

The Atlantic Whitefish was anadromous (sea-going) in the Tusket River (Figure 2) and, despite the lack of recorded evidence, likely occurred as an anadromous population historically in Petite Rivière as well (Figure 3). Historical data suggest that dams with inadequate fish passage pre-date the description of the species and may have caused the demise of an anadromous component (Bradford et al. 2010). Individuals on the Tusket were known to occur in the estuary and sea waters in the summer, migrate into freshwater in the early fall (around September), move upstream in October and November with spawning probably occurring in the late fall or winter, overwinter, and return to the sea in the spring (Edge and Gilhen 2001). Specimens captured in the Tusket River during October and November had well developed gonads but had not yet spawned, while specimens collected in May and June had poorly developed gonads (Edge and Gilhen 2001). Neither specific locations nor characteristics of the spawning habitat of the anadromous Atlantic Whitefish population that once existed in the Tusket watershed are known (Bradford et al. 2004a).

Atlantic Whitefish specimens captured in the marine environment contained shrimp, amphipods, fish and marine worms (Edge 1987).

Lake-resident population

Spawning of the lake-resident population in the Petite Rivière lakes also probably occurs in early winter. Neither specific locations nor characteristics of the spawning habitat of the lake-resident Atlantic Whitefish are known (DFO 2009a). No eggs or larvae have been collected from the wild but recently young-of-the-year were intercepted in a rotary screw trap set at the base of Milipsigate Lake in both May of 2015 (4 individuals) and again in May of 2016 (53 individuals) (BCAF, unpublished data). A single juvenile was also sampled from an aggregation of Atlantic Whitefish of similar size on one occasion in June 2000 in Hebb Lake (Hasselman et al. 2005). The paucity of information on these life stages precludes any precise understanding of age structure and mortality rates, but the maximum age for individuals in the existing wild population is estimated to be 4-5 years, with the age at first maturity being 2 years (DFO 2009a).

Adults feed on a wide variety of aquatic organisms. Stomach analyses of specimens from the lake-resident Petite Rivière population indicated a diet that includes aquatic insects and small fish but not benthic organisms (Edge and Gilhen 2001).

While there have been reports of Atlantic Whitefish below the Hebb Lake Dam (likely the result of individuals descending over the dam but unable to re-join the lake-resident population due to the absence of upstream fish passage until the construction of the fish passage facility in 2012), there is no evidence to indicate that these fish represent a viable population (DFO 2009a).

1.4.6 Habitat requirements

Little is known of the habitat requirements of Atlantic Whitefish. Precise spawning, nursery, and rearing ground locations and preferences are not known, and migration areas are not understood, but sampling to date has shown that the species occurs throughout the upper three Petite Rivière lakes (Hebb, Milipsigate, and Minamkeak) as well as within the streams that connect the three lakes (DFO 2009a). In the Tusket River population, adults were frequently caught in the estuary. Atlantic Whitefish in the Petite Rivière lakes appear to be more prevalent in warmer surface waters than are Lake Whitefish (Edge and Gilhen 2001). Recent modeling and thermal sensitivity analyses has found that Atlantic Whitefish have intermediate thermal sensitivity compared to other salmonids and prefer to utilize the deeper water regions of the lakes, perhaps as a thermal refuge during the warmer summer months (Cook 2012). Recent field and laboratory research has demonstrated that the species can tolerate full sea water from an early stage of development (Cook et al. 2010). The current extent of knowledge on the habitat requirements for Atlantic Whitefish is summarized in DFO (2009a) and COSEWIC (2010). A description of associated functions, features, and attributes of the lake environment that support the identification of critical habitat is provided in Section 2.5.4.

1.5 Population size and trends

The absolute abundance of wild Atlantic Whitefish is unknown but is considered to be low (DFO 2009a; COSEWIC 2010). Recent work suggests that the genetic effective population size for Atlantic Whitefish is among the lowest of any coregonid fish species examined, with estimates between 18 and 38 individuals. These estimates are among the smallest reported for single populations of fish, let alone an entire fish species, and provide support for the presumed small population size of the species (Cook 2012).

Although the historical range of Atlantic Whitefish is known to have included the Tusket River and Petite Rivière watersheds and their adjacent estuaries and bays, the Tusket River population is considered extirpated and there is insufficient information available at this time to provide an accurate quantitative estimate of the population size and trend in the Petite Rivière. However, recent genetic work suggests that the population in the Petite Rivière has been at a low effective population size for most of its recent history (Cook 2012). Captive-reared Atlantic Whitefish have also been introduced into a new waterbody, Anderson Lake, but there is no estimate of the present abundance of these releases and no confirmation of their self-sustainability. The Atlantic Whitefish in Anderson Lake are not confirmed to be reproducing in the wild, therefore they are not part of COSEWIC's quantitative assessment of the species' status at this time. Despite this, the following general qualitative information can be provided about Atlantic Whitefish in these three locations.

1.5.1 Tusket River population

Reportedly once abundant, the Tusket River population apparently declined rapidly in the 1940s and 1950s, likely a result of the combined effects of construction and operation of the Tusket hydro-electric facility, poaching, and river acidification (Gilhen 1977; Edge and Gilhen 2001). The last confirmed evidence of a spawning run on the Tusket River was in 1964 (Bradford et al. 2004a), and no remnant individuals have been observed or captured in any of the years of monitoring since 1995 (Bradford et al. 2004a). No observations of Atlantic Whitefish were reported in the most recent surveys in 2001 and 2002 (DFO 2009a). It is believed that this population no longer exists and is now considered extirpated from this watershed (Edge and Gilhen 2001; Bradford et al. 2004a; DFO 2009a).

On the adjacent Annis River, catch also decreased over time, to the point that by the late 1970s a combined catch of fewer than ten individuals per year in the Gaspereau fishery was typical (Edge and Gilhen 2001). There are no reports of Atlantic Whitefish being captured in the Annis River since 1982 (Edge and Gilhen 2001; Bradford et al. 2004a).

1.5.2 Petite Rivière population

Wild Atlantic Whitefish are currently confined to the Petite Rivière system, with a small resident population largely restricted within three small, semi-natural, connected lakes in its upper watershed: Minamkeak, Milipsigate, and Hebb Lakes (Figure 3; DFO 2009a). Although the recent trend for the Petite Rivière lake-resident population is uncertain, as there is no population estimate for the lakes, sampling within the former decade (2000 - 2008) has confirmed the continued presence of individuals within the three lakes (DFO 2009a). Monitoring in more recent years (2012-2016) have produced variable results, including 19 adults intercepted at the newly constructed fish passage facility at Hebb Dam in 2012 (BCAF 2012), no individuals captured or observed in 2013 during any of the various monitoring activities (Themelis et al. 2014), and observations of a school of adults in Milipsigate Lake in 2014 as well as one large healthy adult captured during experimental monitoring in Minamkeak Lake in 2014. No adult Atlantic Whitefish were intercepted or observed in either 2015 or 2016, but a number of young-of-the-year were intercepted in a rotary screw trap set at the base of Milipsigate Lake in both the spring of 2015 (4 individuals) and spring of 2016 (53 individuals) (BCAF, unpublished data).

Although there have been reports of Atlantic Whitefish occurring in the river below the Hebb Lake Dam since its construction, a research trapnet set in the Petite Rivière estuary in 1999, 2000, and 2008 failed to capture any Atlantic Whitefish (Bradford et al. 2010). Therefore, the presence of a viable anadromous population of Atlantic Whitefish below the Hebb Lake Dam is unlikely, or it exists below the level of detection currently possible. Occasional sightings of released (2007-2009) captive-reared Atlantic Whitefish in the lower Petite Rivière have been reported (see Section 2.10 for further details on this action) and a number of ascending adults (19) were captured at the newly constructed fish passage facility at Hebb Dam in 2012, but there is currently no evidence of a self-sustaining population occurring below the lakes.

1.5.3 Anderson Lake

A total of nearly 12,000 captive-reared Atlantic Whitefish have been released into Anderson Lake, Dartmouth, Nova Scotia (Figure 1) on an experimental basis over a four year period (2005-2008), with additional releases of a small number of individuals in 2012. The goal of this initiative was to evaluate the feasibility of using captive-bred individuals to establish successfully reproducing lake-resident populations of Atlantic

Whitefish outside of the Petite Rivière lakes and therefore the potential for creating a back-up population. Survival and growth have been demonstrated in the introduced fish over a period of at least five years, and sexually mature males and females have been captured during fall monitoring conducted in 2009, 2010 and 2012 (Bradford et al. 2015). It is not presently known whether these releases are reproducing successfully in this new location, therefore their status as a self-sustaining population cannot be confirmed at this time. No monitoring has been undertaken in Anderson Lake since 2012. Details on these releases and the current status of these efforts are described in greater detail in Section 2.10 and in Bradford et al. 2015. Associated recovery measures required to address follow-up actions related to this activity are outlined in the action plan (DFO 2018).

1.6 **Threats**

1.6.1 Background

Modification of the Tusket River and Petite Rivière watersheds through human activities has altered their physical habitat, hydrography, and water chemistry. Species abundance has also been affected by past over-harvesting. Past and present significant threats and habitat alterations include (in a non-prioritized order) (Bradford et al. 2004b; DFO 2004b: DFO 2009a; COSEWIC 2010):

- construction and operation of hydroelectric dams and water supply impoundments resulting in direct mortality, fluctuating water levels, and the elimination or restriction of fish passage
- acidification of habitat from acid rain resulting in pH levels not conducive to Atlantic Whitefish survival
- poor land use practices resulting in siltation, eutrophication, and habitat degradation by shoreline alteration
- unregulated historical fishing activities resulting in direct mortality
- introduction and spread of non-native fish species (e.g., Smallmouth Bass (Micropterus dolomieu), Chain Pickerel (Esox niger)) resulting in competitive and/or predation risks to Atlantic Whitefish

These threats were reviewed during a DFO Regional Science Advisory Process meeting undertaken in 2009 (DFO 2009b) to update and replace the previous Allowable Harm Assessment (DFO 2004a). This advisory process consolidated new information on Atlantic Whitefish and provided up-to-date information and advice on the relative level of impact of described human activities on the species and possible alternatives and management measures to mitigate these impacts. Current and potential threats to Atlantic Whitefish are ranked and summarized in Appendix 1 of the resulting Science Advisory Report from that meeting (DFO 2009a). Future Atlantic Whitefish populations, should they become established in other watersheds, may face additional threats beyond those described for the current population.

1.6.2 Factors responsible for the species' decline

Historical fishing activities

Past harvesting practices, including poaching and incidental captures, may have been a factor in the decline of Atlantic Whitefish populations. Captured primarily by gill and dip nets, and occasionally by angling, the fish were used for human consumption, reportedly supporting a minor sport fishery and yielding an excellent table fish. They may also have been utilized for other purposes including bait for lobster traps and fertilizer (Scott and Scott 1988).

Atlantic Whitefish were once very abundant in the Tusket and Annis Rivers. Prior to 1940, it was reportedly not uncommon to catch 200 in a net when fishing for Gaspereau on the Tusket River (Edge and Gilhen 2001). The accumulation of Atlantic Whitefish in the upper pools of the Tusket hydro facility fish ladders facilitated poaching in the 1950s (Gilhen 1977; Scott and Scott 1988). Similarly, on the Annis River, incidental catches of 50 to 100 individuals during the Gaspereau fishery were reportedly common as late as 1970.

In the Petite Rivière system, a small angling fishery around Milipsigate and Hebb Lakes may have existed as early as the 1870s (Edge and Gilhen 2001). Atlantic Whitefish were reported as occasional bycatch in the May-June Gaspereau fishery in the Petite Rivière estuary. There have been no legal directed or bycatch fisheries for the species since at least 1978. See Section 1.3 for further details on timelines of measures implemented to protect Atlantic Whitefish from capture.

Hydroelectric development

The construction and operation of hydroelectric dams on the Tusket River and Petite Rivière systems likely played a role in the decline of Atlantic Whitefish by causing mortality of individuals passing through turbines. Fish ladders and a fishway have been constructed and improved over the years since the damming of the Tusket River at Tusket Falls in 1929 to facilitate downstream passage of diadromous species and reduce turbine mortality. No Atlantic Whitefish have been observed migrating through the monitoring device, and the species is now considered extirpated from the Tusket River system; this extirpation from the Tusket system is noted to have occurred prior to the 2000 COSEWIC status assessment.

Hydroelectric generation no longer takes place on the Petite Rivière; however, dams constructed initially to power mills had assumed a role by 1939 in managing water flows for hydroelectric generation. Powerhouses were located at Conquerall Mills and the Hebb Lake outlet. Hydroelectric operations ceased at both of these sites on the Petite Rivière in 1971. The Conquerall Mills Dam was breached in 1977. The Hebb Lake Dam remains in place and was equipped with a fish passage facility in 2012 (Table 3).

1.6.3 Current threats

While the threats faced by Atlantic Whitefish in the two historical watersheds (Tusket and Petite) exhibit common traits, the significance of the threats varies between the two systems (DFO 2004b). In the Tusket, habitat alteration and inadequate fish passage due to hydroelectric dam construction and operation, acidification, Chain Pickerel and Smallmouth Bass predation, and past over-harvesting are identified as the most significant threats. By contrast, the Petite Rivière is better buffered and thus less affected by acidification from acid rain; however, the construction and operation of water supply facilities and unknown impacts of the presence and spread of invasive species (i.e., Smallmouth Bass and the very recent emergence of Chain Pickerel) are identified as the two most significant factors currently threatening the remaining wild population (DFO 2009a). Acidification from future land-based activities in the planning stage (e.g., road construction, quarries, mining) may also pose a threat to the survival of Atlantic Whitefish in the Petite Rivière lakes.

Barriers to fish passage

The construction and operation of hydroelectric dams and water supply impoundments have transformed lake and riverine habitat to reservoir habitat, and the resulting fluctuating water level regimes have altered the original habitat and the dams have either blocked or impeded fish passage. A chronology of hydroelectric generation on the Tusket and Petite rivers in relation to fish passage and habitat requirements can be found in Bradford et al. (2004b).

The damming of the Tusket River at Tusket Falls (Figure 2) in 1929 is thought to have interfered with the migratory movement of the Atlantic Whitefish for many years (Gilhen 1977; Edge and Gilhen 2001). Despite improvements to the fishways and changes in operation schedules and maintenance flows over the years to improve fish passage for diadromous species, the Atlantic Whitefish is now considered extirpated from the Tusket River system. Were Atlantic Whitefish re-established on the Tusket River, the existing fishway should be suitable providing its operation accommodates Atlantic Whitefish migration times.

In the Petite Rivière system, waterbodies have been impounded and diverted for various reasons since the late 1790s; three of the lakes in the upper watershed (i.e., Milipsigate, Minamkeak, and Hebb) now constitute the Town of Bridgewater water supply. The construction of a hydroelectric dam without fish passage at the foot of Hebb Lake as early as 1901 effectively blocked any upstream migration of fishes beyond this point. Although the hydroelectric generating facility at Hebb Lake was decommissioned in 1971, the dam remains (without fish passage until 2012) and the lakes have been managed as the municipal water supply for the Town of Bridgewater since at least the mid-1960s. Dams without fish ladders are also present on the Petite Rivière at the outlets of Minamkeak and Milipsigate Lakes (Figure 3). While it is not known if adult anadromous Atlantic Whitefish migrated to these lakes to spawn prior to the existence of the dams, until the construction of a fish passage facility in 2012 at the outlet of Hebb

Lake, the Hebb Lake Dam effectively eliminated any likelihood of upstream migration to the lakes, including any individuals attempting to rejoin the lake-resident population after having descended over the dam. This represented a loss from the population. Lack of fish passage also precluded any increase in productivity that might arise from anadromy including the greater reproductive potential of larger anadromous females. Fish passage is also considered somewhat impeded at the former dam site at Conquerall Mills and around an existing dam at Crousetown. The dams at Milipsigate and Minamkeak Lakes remain without fish ladders; however, 2011 upgrades included rehabilitating the spillways and the installation of maintenance flow orifices to facilitate some fish passage in both directions (Figure 3). A brief description of each barrier to fish passage on the Petite Rivière is provided in Table 3. Efforts related to the provision of fish passage at Hebb Dam are outlined in Section 2.10. Dam upgrades by the Bridgewater Public Service Commission were completed for all dams in the Petite Lakes in 2011 to ensure all dam facilities meet the Dam Safety Guidelines put forth by the Canadian Dam Association (Sikumiut Environmental Management Ltd. 2011). These upgrades were also designed to aid in flood control during minor storm events. All construction was reviewed for compliance with both the Fisheries Act and SARA.

Table 3. Description of barriers to fish passage in the Petite Rivière (adapted from Conrad 2005). Refer to Figure 3 for the locations of these barriers.

Dam	Description
Crousetown	A 2.4 m high timber dam located at a former sawmill site. The dam includes a run-around type of fishway constructed from loose native stone that is considered to be inefficient for fish passage.
Conquerall	The dam at the former Conquerall Mills hydro site was partially dismantled, allowing a 9 m space between the remaining concrete abutments. The resulting short series of rapids constitutes a 1.2 m drop which may present a small in-stream barrier to Atlantic Whitefish passage upstream.
Hebb	The Town of Bridgewater water supply storage dam at Hebb Lake consists of a concrete flow-control structure and two long rock and earth fill berms which extend on either side of the concrete spillway. The berm opposite the spillway is approximately 100 m long. The berm on the other side is approximately 800 m long and includes a large pond within the first 50-100 m. The pond is supplied by steady seepage through the berm and is drained by way of a meandering outlet channel and 1.5 m diameter culvert, finally emptying into the main channel of the river about 60 m downstream of the main concrete flow control structure. An upstream and downstream fish passage facility was completed in the spring of 2012. This facility is a concrete structure consisting of 26 stepped pools with an overall length of approximately 80 m. Downstream passage is also possible at the rehabilitated Weagles concrete spillway which is situated adjacent to Hebb Dam on a secondary brook connecting Hebb Lake and Fancy Lake.

Dam	Description
Milipsigate	A concrete dam structure with two spillways operated by the Town of Bridgewater for flow regulation purposes. This is an overtopping dam by design, therefore some downstream fish passage was possible. During recent dam upgrades (2011) the spillways were rehabilitated and maintenance flow orifices were installed that now facilitate some fish passage in both directions at this dam.
Minamkeak	The uppermost storage dam for the Town of Bridgewater and is used for flow regulation purposes. The concrete structure consists of two openings, plus a concrete channel on the right bank. It is also an overtopping dam by design and some downstream fish passage was possible. During recent dam upgrades (2011) the spillways were rehabilitated and maintenance flow orifices were installed that now facilitate some fish passage in both directions at this dam.

Interactions with non-native fish species

Non-native fish predators, particularly Smallmouth Bass and Chain Pickerel, have been identified as threats to Atlantic Whitefish (Edge and Gilhen 2001; DFO 2009a). Smallmouth Bass has been introduced into both the Tusket River and Petite Rivière systems and has become naturalized. Chain Pickerel are found in the Tusket system and have recently (May 2013) been found in the Petite Rivière lakes for the first time. The introduction and increasing range of these invasive species in both watersheds is of significant concern. The presence of Smallmouth Bass in Minamkeak Lake, one of the three upper lakes of the Petite Rivière watershed which collectively may support the only remaining population of Atlantic Whitefish, is of particular concern. Recent surveys undertaken by the Province of Nova Scotia and the Bluenose Coastal Action Foundation, both member organizations of the Recovery Team, have confirmed the presence and reproduction of Smallmouth Bass in all three lakes (BCAF 2015). The recently confirmed presence of Chain Pickerel in both Hebb and Milipsigate lakes in 2013 (Themelis et al. 2014) is of significant concern given their likely introduction a few years previous to their detection, logistical challenges around mitigation such as containment to prevent their further spread (in particular if they are to expand their range into Minamkeak Lake), and given their overlapping distribution with Atlantic Whitefish. The Recovery Team is particularly concerned for the survival of Atlantic Whitefish in the presence of both invasive species. The relationship of these introduced species to Atlantic Whitefish is not well understood, but needs serious consideration due to the documented negative impact that introduced Smallmouth Bass and Chain Pickerel has had on lake communities (Jackson 2002; Mitchell et al. 2010). Invasive species (e.g., Smallmouth Bass and Chain Pickerel) in the Petite Rivière system may pose competitive, disruptive, and predation risks for Atlantic Whitefish (Bradford et al. 2004b, DFO 2009a). Associated recovery measures required to address actions related to this threat are outlined in the action plan (DFO 2018). Aquatic invasive species mitigation efforts accomplished to date and underway are highlighted in Section 2.10 of this document.

Acidification from land-based activities

Acid run-off from mines and quarries can pose a threat to fish and fish habitat by impacting the water quality in the lakes and creating an acidic environment. The lands around the three Petite Rivière lakes and in a large proportion of the Petite Rivière watershed are underlain by geological rock formations made up of greywacke and slates. There are 92 abandoned gold mines[5] and slate quarries in the catchment basin of the three Petite Rivière lakes that currently support Atlantic Whitefish. These mines were abandoned over 50 years ago and many are no longer owned by the operators. Given the present movement of water through the watershed system and the current buffering capacity of the watershed, habitat effects from the abandoned mines and quarries are thought to be largely localized, and there are no indications that the cumulative run-off from these sites have reduced water quality within the lakes themselves to the extent that threatens the survival of Atlantic Whitefish (DFO 2004c). The relative ranking of this threat is therefore low to moderate at current levels (DFO 2004c, 2009a); however, activities in the planning stage as well as potential future construction activities (such as road construction) and excavation activities (e.g., quarries or mining) could expose acid-generating slates to air and surface runoff, which may pose a greater threat to the Atlantic Whitefish and its habitat in the three Petite Rivière lakes if not properly mitigated or remediated. Additional threats to lake water quality from these potential future activities can include run-off of deleterious substances, such as road salt, silt (measured in TSS), oil, and heavy metals. This threat would be low to moderate if the appropriate mitigation measures are implemented during the construction phase.

1.6.4 Other potential threats

A number of additional threats potentially limiting survival of the existing population in the Petite Rivière have been identified (Bradford et al. 2004b; DFO 2009a). These include incidental catch by anglers and commercial fishers, fluctuating water levels, entrainment of fish into water intakes, removal/mortality associated with scientific sampling, siltation, eutrophication, and habitat degradation by shoreline alteration or infilling. These factors are currently considered to have relatively low threat potential and several mitigation measures are already in place (e.g., changes to fisheries regulations, adoption of scientific sampling protocols to minimize handling mortality, and installation of screens to the municipal water intakes in the Petite Rivière lakes effective at preventing entrainment of Atlantic Whitefish of all sizes).

Poor land use practices can contribute to aquatic habitat degradation. Sectors such as agriculture, residential development, and forestry undertake land-based activities in the Petite and Tusket watersheds. While there are no studies linking these activities specifically to effects on Atlantic Whitefish, and no indications of non-compliance in current practices around the three Petite Rivière lakes, it can be inferred that should

[5] Number of abandoned mines as identified in the Abandoned Mines Database from the NS Department of Natural Resources

common activities not be properly mitigated, they could result in effects to fish and fish habitat. Kendall and Llewellyn (2001) provided information on historical land usage and watershed management issues in the Petite Rivière watershed.

Acidification from acid rain may be a limiting factor for Atlantic Whitefish. The rivers most affected by acidification in Nova Scotia are in the Southern Upland eco-region, which include both the Petite and Tusket rivers. A combination of hard-rock geology, inadequately buffered soils, and prevailing weather patterns has resulted in severe acidification of the rivers and lakes in this region. The Tusket is more affected by acid rain than the Petite. Laboratory research on the effect of low pH on various life stages of Atlantic Whitefish (Cook et al. 2010) indicates the impacts are comparable to those of other salmonids for all early (age 0+) life history stages. Low pH decreases the survival of Atlantic Whitefish, with eggs and early larval stages being the most sensitive. Acid toxicity has been identified as a major factor in low wild salmon abundance in Southern Upland rivers (DFO 2000). Data from Clair et al. (2004), however, indicate that the Petite Rivière, as well as portions of the Tusket River, possess sufficient buffering capacity for Atlantic Whitefish survival (Bradford et al. 2004b). Furthermore, recent research by Cook (2012) suggests that the current pH levels in the Petite Rivière will likely not negatively impact that population’s persistence, nor should the pH for the Tusket River be detrimental to repatriating fish to this river, particularly as levels are expected to increase over the next several decades (Clair et al. 2004), and given that low pH was not the sole contributing factor to the loss of the Tusket River population.

Warming temperatures have also been examined as a potential future environmental threat to the persistence of the species in its current habitat within the Petite Rivière lakes (Cook 2012). Given the small thermally bounded habitat of the Petite Rivière lakes and the Atlantic Whitefish’s thermal preference, as global mean temperatures are predicted to rise over the next century, it is suggested that this may cause a decrease in the usable lake habitat (Cook 2012). However, this threat may be partially alleviated through the restoration of anadromy on the Petite Rivière, providing later life stages access to more thermal refugia in the cooler estuary and coastal waters (Cook 2012). Predictions of more frequent and intense storm events may also have both direct and indirect effects on the Atlantic Whitefish population and its habitat.

2. Recovery

For Atlantic Whitefish, survival and recovery have specific meanings that are defined as follows:

Survival is ensuring that Atlantic Whitefish continue to exist in the wild in Nova Scotia within their current known habitat, i.e., the three upper Petite Rivière lakes (DFO 2009a). Survival would also require establishing additional freshwater resident populations to reduce the risk of extinction should some accidental or random event result in the extirpation of the existing population in the Petite Rivière lakes.

Recovery requires establishing anadromy and range extension outside the Petite Rivière lakes. Recovery also inherently requires that survival is achieved. Options for achieving anadromy include facilitating anadromy on the Petite Rivière, the repatriation of the anadromous run to the Tusket River, and/or the promotion of anadromy elsewhere in Nova Scotia, particularly in the Southern Uplands eco-region. Range extension could also include additional freshwater resident populations.

Adopting an adaptive management approach to recovery for Atlantic Whitefish will be essential to the ongoing survival of the species within its existing habitat, particularly to address any new emergent threats, and to the success of range expansion into the marine realm and additional freshwater sites.

2.1 Recovery feasibility

The underlying basis for the decline in geographic range and the concurrent loss of anadromy of the Atlantic Whitefish is most likely past human interference, particularly with migration. For the past 30 years, federal fisheries regulations have prohibited fishing Atlantic Whitefish. Prior to this, minimal protection existed for the species. In spite of historical factors responsible for their decline, the species has survived. Given their life history traits (relatively high fecundity and short generation times) and amenability to fish culture, Atlantic Whitefish are likely to respond positively to recovery efforts aimed at mitigating and correcting past human interference, including fish passage improvements to encourage anadromy, and recent fisheries regulations and SARA prohibitions that provide added protection for this species and its habitat.

2.1.1 Biological feasibility

Availability of individuals with reproductive capacity

Although the absolute abundance of wild Atlantic Whitefish is unknown but considered to be low, monitoring has shown that wild individuals persist in the Petite Rivière lakes. Furthermore, although the status and self-sustainability of captive-bred individuals released in Anderson Lake are also unknown, monitoring conducted to date indicates that individuals are showing positive signs of growth and maturity. Given this, it is not possible to say whether individuals capable of reproduction are available in sufficient numbers to sustain the population or improve its abundance. Future work to acquire a population estimate for the Petite Rivière lakes, an evaluation of the status of releases in Anderson Lake, and identifying a viable mechanism to support range expansion objectives are needed and outlined as priority recovery measures in the action plan.

Availability of suitable habitat: Survivorship in current environment

The biological feasibility of Atlantic Whitefish recovery inherently depends upon their continued survival within their current environment, in particular their response to the eventual spread and establishment of invasive species (e.g., Smallmouth Bass and Chain Pickerel) in all three Petite Rivière lakes and the success of mitigation measures implemented. The Petite Rivière drainage area is naturally moderately buffered from acid rain, and the species' continued persistence in the three Petite Rivière lakes suggests that the current lake habitat is suitable. Furthermore, several mechanisms are in place, or being considered, to provide protection of the lake habitat. The three Petite Rivière lakes receive protection as a municipal water supply through a Watershed Protected Water Area designation. These three lakes are also identified as critical habitat in this recovery strategy and will be afforded protection from activities that could result in their destruction. Nova Scotia Environment is also leading efforts to consider the lands in the Watershed Protected Water Area as a Wilderness Protected Area, thus potentially providing additional protection to the habitat. Water quality is not considered to pose either a current or future threat to the survival of Atlantic Whitefish in the Petite Rivière, provided current water management practices continue.

Availability of suitable habitat: Availability and adaptability to new environments

The Atlantic Whitefish Recovery Potential Assessment (RPA) concluded that the historical range of Atlantic Whitefish is expected to have extended to other watersheds in Nova Scotia (DFO 2009a). There are several reasons, based on the species' life-history, to expect that establishing several populations in diverse habitats in the Southern Upland eco-region will increase the probability that the species will be self-sustaining in the long term. The Southern Upland eco-region includes over 500 watersheds with 72 of the larger ones recognized as salmonid rivers. The Recovery Team has confidence that the Atlantic Whitefish is biologically capable of survival in areas beyond its current range, including estuarine and marine habitats. Atlantic Whitefish can potentially adapt to new freshwater and marine environments: they were anadromous on the Tusket, they naturally colonized Minamkeak Lake, releases in Anderson Lake showed positive signs of growth and maturation (Bradford et al. 2015), and there is historical evidence of their presence in estuaries, including that of the Petite Rivière and adjacent estuaries. This, along with recent field and laboratory research that indicates the species can tolerate full sea water from an early stage of development (Cook et al. 2010), suggests Atlantic Whitefish are adaptable to new environments and are physiologically and behaviourally capable of anadromy.

Ability to be cultured

Culture techniques for Atlantic Whitefish captive-breeding have been developed over the last decade (Whitelaw et al. 2015). Atlantic Whitefish can tolerate capture and removal from the wild, and transportation to facilities where they survive for several years in captivity. These techniques have also demonstrated that Atlantic Whitefish are amenable to being cultured and captive-bred individuals can tolerate transportation to, and survival in, release sites, at least over several years. The successful culture of Atlantic Whitefish have provided individuals in sufficient numbers necessary for trial introductions (e.g., Anderson Lake), research (e.g., cryopreservation, tolerance trial studies, releases into the lower Petite Rivière), and outreach purposes (e.g., live fish display at the Fisheries Museum of the Atlantic).

2.1.2 Technical feasibility

Availability or ability to develop techniques required for range expansion

Recovery of the species requires stability in the current population (i.e., survival), re-establishment of the anadromous form, and expansion beyond its current range. To achieve these aspects of recovery, it must be technically feasible to establish genetically and ecologically viable populations. Technical options to expand the species range may include:

1. Direct transplants: Direct transplants from the existing population within the Petite Rivière to new locations may be an option, provided it can be demonstrated that the existing population can withstand removals of individuals in the numbers required to support natural production elsewhere (DFO 2009a). Biologically, the species can tolerate capture and removal from the wild and transportation to release sites. Technically, the platforms exist to capture the species (e.g., trapnets, fish passage facility at Hebb Lake Dam). However, enhanced certainty regarding the number of individuals that could be removed without jeopardizing survival and recovery of the existing wild population should first be achieved. Removals, particularly in large numbers required to support direct transplants, could potentially represent a significant loss of productivity to a species of small population size and subsequently cause further harm (i.e., demographic, environmental, genetic) to the population. The full status and abundance of Atlantic Whitefish in Anderson Lake are also unknown at this time. Therefore, the ability of individuals in Anderson Lake to support direct transplants without jeopardizing its own potential ability to be self-sustaining in the immediate short term remains unknown. Similar to the wild population in the Petite Rivière lakes, the use of individuals from Anderson Lake for direct transplants may be possible, but should be approached with caution.
2. Natural dispersal: Given the lack of populations outside Canada, which precludes the possibility of recovery via trans-border dispersal, and given that all remaining wild Atlantic Whitefish are restricted to a single, unknown but small population size, population recovery via natural dispersal is not a viable mechanism at this time (COSEWIC 2010). Future natural dispersal could arguably be facilitated with the recent provision of fish passage at Hebb Lake Dam, but the effectiveness of this facility is yet to be fully evaluated and barriers to fish passage continue to exist at other locations on the watershed. For such a passive mechanism of natural dispersal to be successful, several obstacles would need to be overcome, including a significant amount of time to naturally colonize and establish a self-sustaining population in another watershed.
3. Captive breeding and introduction program: Captive breeding and subsequent introduction programs of an endangered species can, in some cases, be successful in stabilizing, re-establishing, or increasing populations that have suffered significant declines, particularly when the basic causes of the decline can be addressed by management intervention. From 2000 to 2012, a DFO captive-breeding program for Atlantic Whitefish was successful in moving wild Atlantic Whitefish into a facility and subsequently to release sites. This program was also successful in developing the

expertise and techniques to spawn and rear Atlantic Whitefish in abundance in captivity, including the ability to recondition wild-caught fish to spawn frequently in consecutive years (Whitelaw et al. 2015). Recent experimental releases of captive-reared Atlantic Whitefish into Anderson Lake have shown that some cultured fish can survive for several years, grow in body size, and sexually mature (Bradford et al. 2015). This indicates that it is technically feasible to culture and transport Atlantic Whitefish, and that moving the species into areas beyond its current range is technically possible. Removal of individuals for broodstock in numbers required to support a captive-breeding program would, however, be contingent upon evidence that the existing population in the Petite Rivière (or individuals from Anderson Lake) can withstand such removals.

4. Future technologies: Other potential technical alternatives to captive-breeding which may hold promise in the future may include surrogate broodstock technologies and cryopreservation methods. Species-specific protocols and cryopreservation techniques have been developed for Atlantic Whitefish (de Mestral Bezanson et al. 2010); however, neither of these technologies have been tested in a real world conservation situation and both require some level of captive breeding.

Availability or ability to develop introduction site selection criteria

The development of selection criteria for introduction sites (lakes and watersheds) is also technically feasible. DFO developed a Decision Support Tool (DST) to assess candidate lakes for introductions and it was used to select Anderson Lake as the first trial release site. The results of temperature and pH tolerance experiments and modeling of watersheds (Cook et al. 2010) provide some of the criteria necessary to evaluate habitat suitability in candidate rivers. Additionally, the recent (May 2012) Southern Upland Atlantic Salmon (Salmo salar) RPA compiled and reviewed information on watershed habitat spatial extent, threats, quality and quantity, and potential for mitigation of identified threats which could provide useful information in evaluating candidate rivers for Atlantic Whitefish introductions (DFO 2013).

Ability to mitigate threats

Recovery is also technically feasible because the known human induced threats that impact Atlantic Whitefish can be mitigated. Activities posing a threat are also subject to regulation by federal, provincial, and municipal governments. For example, more recent federal fisheries regulations (i.e., the Maritime Provinces Fishery Regulations) offer added protection to Atlantic Whitefish by providing greater flexibility (through the variation order process) to regulate fisheries directed at other species by closed seasons in any area and by gear type. This flexibility will benefit Atlantic Whitefish by reducing their vulnerability to incidental catch. Mitigation and management tools also exist to control the abundance of the invasive species; however, these have yet to be implemented on the Petite Rivière and their performance evaluated. Additionally, any future acid mitigation efforts in selected Southern Upland rivers for the purpose of Atlantic Salmon recovery may provide an additional benefit to Atlantic Whitefish introduction efforts.

The threat posed by barriers to fish passage on the Petite Rivière can also be mitigated. As mentioned above with respect to the biological feasibility of recovery, the remaining population of Atlantic Whitefish may have survived due to the refuge provided by the dams on the Petite Rivière. There are some concerns that restoring open migration routes on this system could actually pose a risk to survival. The Recovery Team maintains that providing fish passage at the foot of the lakes is a significant step towards ensuring the survival of the wild lake-resident population by allowing fish that have descended over the dam to return to Hebb Lake. The Recovery Team also supports restoring free access to the ocean on the Petite Rivière to create the conditions necessary to enable anadromy as a positive outcome in the context of survival and recovery (Schaefer et al. 2006; DFO 2006b). Fish passage improvements or facilities can technically be constructed at barrier sites. Recommendations for functional designs have been drafted (Schaefer et al. 2006). The first fish passage facility on the Petite Rivière was constructed in the spring of 2012 by the Town of Bridgewater Public Service Commission at Hebb Dam. Although a precautionary approach to providing fish passage is required in initial phases, this approach is technically feasible via the installation of a temporary monitoring facility and implementation of a monitoring plan to study and respond to the movements of Atlantic Whitefish, as well as the abundance, movements, and ecological effects of other species in the system. Installation of a monitoring facility would also facilitate the management and controlled passage of both native and non-native invasive species. This has been accomplished at the Hebb Dam site as outlined in Section 2.10, although the facility's effectiveness for Atlantic Whitefish is yet to be fully assessed.

Existence of a support network

A support network to implement and adhere to recovery measures is also required for recovery to be technically feasible. Local non-government organizations, community groups, Aboriginal peoples, and industries that operate in Atlantic Whitefish habitat, as well as provincial and municipal governments are key players in this regard. These organizations are members of the long standing Atlantic Whitefish Conservation and Recovery Team. In addition to its SARA status, the Atlantic Whitefish is also listed as an endangered species under the Nova Scotia Endangered Species Act. This listing should help facilitate the implementation of recovery actions between federal and provincial governments.

2.1.3 Recovery feasibility conclusion

The recovery of Atlantic Whitefish is considered to be both biologically and technically feasible; however, the time to recovery will be dependent both upon the current status of the remaining wild population in the Petite Rivière lakes (and potentially the status of releases in Anderson Lake) and the timing and extent of human intervention (DFO 2009a). Going forward, the success in mitigating current threats to the species and identifying viable range expansion mechanisms that can be implemented in a timely manner, including partnering opportunities and arrangements, will be essential to achieving the population and distribution objectives for this species.

2.2 Recovery goal

The overall goal of the Atlantic Whitefish recovery strategy is to:

Achieve stability in the current population of Atlantic Whitefish in Nova Scotia, reestablishment of the anadromous form, and expansion beyond its current range.

2.3 Population and distribution objectives: Interim targets

Advice from the 2009 RPA (DFO 2009a) states that current information about the past abundance and productivity of Atlantic Whitefish populations is insufficient for establishing watershed-specific abundance targets, or for assessing the number of populations required to ensure long-term viability. The RPA does, however, provide information that can guide decisions, including an estimate of the minimum population size required by many vertebrate species to maintain genetic diversity as a coarse abundance target. The value used in the RPA to estimate this minimum population size for Atlantic Whitefish is comparable to that derived for the species in a more recent study using the relationship between habitat size and the effective population size for a similar species, Lake Whitefish (Cook 2012). The RPA also indicates that there are reasons to expect that establishing several populations in diverse habitats will increase the probability that the species will be self-sustaining in the long term. Accordingly, the following interim objectives are adopted in this recovery strategy:

> **Population objective:** A minimum population size of >1,275 mature individuals in the Petite Rivière.
>
> **Distribution objective:** Establishing self-sustaining anadromous populations in several watersheds in the Nova Scotia Southern Uplands eco-region, including the Petite Rivière.

Both the interim watershed-specific abundance target and distribution target will need to be revisited once knowledge about the dynamics of the recovering population is obtained.

2.4 Broad strategies for recovery

Creating and maintaining the necessary conditions to achieve a viable population of Atlantic Whitefish in Nova Scotia will be accomplished by implementing the prioritized broad strategies for recovery discussed below. Following each broad strategy is a set of non-prioritized general approaches that, when implemented, will contribute to the fulfillment of their corresponding broad strategy. These approaches are designed to provide sufficient detail to facilitate the application of SARA, and have assisted in the development of the associated action plan (DFO 2018). Many other actions have already been taken and those are reflected in the 2007-2012 progress report (DFO 2016).

The four broad strategies for recovery and their respective approaches are as follows:

Broad strategy 1: conserve, protect and manage the species and its habitat

Rationale:
The Atlantic Whitefish in the Petite Rivière system is currently the only known self-sustaining population of the species in the wild. The survival of this species depends on the protection of remaining wild fish, and the habitat that they occupy (i.e., three semi-natural lakes in the upper Petite Rivière watershed). Conservation, protection, and management of the species and its habitat will also be required in any range extension to ensure the species' survival and progress towards recovery.

Approaches:

a) address current and emergent threats to survival:
    - initiate contingency planning to deal effectively with these threats
    - develop and implement mitigation measures to reduce, control or eliminate these threats (e.g., measures to control invasion of non-indigenous species)
b) develop and implement mitigation measures to minimize human-induced harm to the species and its habitat
c) ensure regulatory compliance:
    - enforcement of regulations to protect Atlantic Whitefish and their habitat
    - report instances of non-compliance
    - assess adequacy of enforcement (i.e., whether regulations are being adequately applied to protect Atlantic Whitefish and their habitat), and make adjustments as appropriate
d) develop and implement watershed and site-specific habitat quality management and protection

Broad strategy 2: increase the number and range of viable populations

Rationale:
This broad strategy is key to ensuring both the survival and the recovery of Atlantic Whitefish. Recovery of this species inherently requires that survival of what remains is achieved, but also entails increasing the number and range of viable populations.

Given the current existence of only a single self-sustaining wild population of Atlantic Whitefish, its restricted distribution to three small lakes in the upper Petite Rivière watershed, and its unknown but low absolute abundance, this species is extremely vulnerable to extinction from catastrophic events, environmental variability within the lakes, or from any acute or chronic threat that remains unaddressed within its current habitat. Due to this vulnerability, it is important to not only protect the last remaining population but to also establish additional freshwater populations of Atlantic Whitefish elsewhere, outside its current range to help ensure the species' survival.

Recovery also requires enabling anadromy and range extension outside the Petite Rivière lakes. Historical evidence indicates that there were once at least two populations of Atlantic Whitefish (Petite Rivière and Tusket River) and that the population on the Tusket River was anadromous. Advice from the RPA (DFO 2009a) suggests that establishing several Atlantic Whitefish populations in different watersheds will increase the probability that the species will be self-sustaining in the long term. Therefore, to consider this species recovered, range expansion must occur, which would involve the establishment of viable anadromous populations in several watersheds in the Southern Upland eco-region, including the promotion of anadromy on the Petite Rivière and possibly the repatriation of an anadromous population in the Tusket River.

Expanding the species range into new or former habitats would be contingent upon a number of factors, the foremost of which would be the availability of life-stages of fish in numbers that can establish genetically and ecologically viable populations. Captive breeding and introduction programs can be a successful tool in achieving this end, particularly for populations such as the Atlantic Whitefish, a species that has suffered significant declines, is amenable to culture, and for which timely human intervention is crucial. Criteria for guiding the selection of candidate rivers for the establishment of anadromous populations will also be important and should include socio-economic, ecological, and management considerations.

Approaches:

a) document and identify the knowledge and means to support range expansion needs
b) establish Atlantic Whitefish populations in locations beyond their current range
c) enable the Petite Rivière population to become anadromous

Broad strategy 3: address knowledge gaps relating to the species and its habitat

Rationale:
The current state of knowledge about the basic biology and ecology of Atlantic Whitefish and its habitat requirements is limited. Pressing research concerns include the lack of a quantitative population estimate for this species, the potential impacts of introduced species on the remaining wild population of Atlantic Whitefish, and the paucity of basic information on habitat use and preferences by life stage. More information is required to support survival and recovery efforts, threat assessments, and the application of the SARA prohibitions that protect the species, its habitat, and habitat use.

Approaches:

a) implement scheduled quantitative assessments of species status (information is required to assess threats and evaluate effectiveness of actions)
b) develop and undertake research programs to identify habitat requirements (freshwater, estuarine and coastal), including a determination of the applicability

of the residence concept to Atlantic Whitefish and studies to refine or identify new areas of critical habitat

c) continue to conduct research to address knowledge gaps relating to the species including, but not limited to, genetics, health (including disease and parasites), nutrition, life cycle history, behavior, and physiology
d) assess the degree of risk posed by current and emergent threats

Broad strategy 4: increase public involvement in, and acceptance of, measures required for the species survival and recovery

Rationale:
Unlike many other endangered species, the Atlantic Whitefish is very localized in its interest and does not currently have a high level of charismatic appeal, and is not particularly well known among the general public. Increasing the level of stakeholder concern and sense of responsibility for the survival and recovery of this species is critical to ensuring the success of recovery efforts. This will be a particular challenge when considering the repatriation or introduction of this Endangered species into water bodies. Communication and education are important tools for promoting recovery efforts with both stakeholders and the general public. This could include involving local groups to the extent possible (e.g., Aboriginal groups/organizations, recreational and commercial fishers, shoreline property owners, volunteer-based and non-government organizations, industry, the community at large) that have interest in the aquatic resources in the watersheds and estuaries.

Approaches:
a) develop a communications plan
b) develop a strategy to encourage public support for survival and recovery actions
c) encourage partnering and stewardship initiatives aimed at conserving, protecting, and managing the species and its habitat
d) promote Recovery Team meetings as opportunity for communication and collaborations among all team members

2.5 Critical habitat

Critical habitat is defined under s. 2(1) of 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 the recovery strategy or in an action plan for the species".

Habitat for aquatic species at risk is defined under the same section of SARA 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."

2.5.1 General identification of Atlantic Whitefish critical habitat

Atlantic Whitefish can occur as either anadromous or freshwater resident populations (DFO 2009a). Wild Atlantic Whitefish are currently largely restricted to the upper watershed of the Petite Rivière where they complete their life cycle in three small freshwater lakes: Milipsigate, Minamkeak, and Hebb. This represents approximately 16 km^2 of surface area. How Atlantic Whitefish use the habitat types within those three freshwater lakes is not well known and requires further study. However, the RPA (DFO 2009a) acknowledged that the species survival presently depends upon its continued reproduction within these lakes. The fish passage facility at the Hebb Dam was constructed to provide passage of any Atlantic Whitefish attempting to ascend from below the dam into the upper Petite lakes. It therefore serves as an important migration corridor and is hence required for both the species current survival and future recovery. The habitat requirements for this species in rivers, estuaries, and the marine environment are also largely unknown and these areas may be required for the species subsequent recovery.

Accordingly, critical habitat for Atlantic Whitefish is identified in this recovery strategy to the extent possible, using the best information currently available, as follows:

The water column and substrate features of the following three lakes in the Petite Rivière Watershed and the waterways inter-connecting these three lakes: Milipsigate Lake, Minamkeak Lake, and Hebb Lake, as well as the Hebb Dam fish passage facility (i.e., fishway). The combined area of Atlantic Whitefish critical habitat equals 16 km^2, and excludes the physical water impoundment structures (dams and their respective associated structures) on Hebb Lake Dam, Milipsigate Dam, and Minamkeak Dam.

The above statement identifies the geographical area that contains habitat necessary for the survival of the Atlantic Whitefish; i.e., provides the functions and features necessary to support the species' life cycle processes. The area identified is, however, insufficient to fully achieve the population and distribution objectives for the species. The identified critical habitat may be better described in terms of its biophysical functions, features, and attributes and expanded in terms of its spatial extent as activities to enable anadromy and range expansion are successfully implemented. The Schedule of Studies (Section 2.5.6) outlines the research required to refine the description of critical habitat within the Petite Rivière watershed in order to support its protection and identify any additional habitat areas required for the species subsequent recovery; i.e., required to achieve the species' population and distribution objectives.

2.5.2 Information and methods used to identify critical habitat

The geographic location and associated biophysical functions, features, and attributes of the critical habitat were identified using the best available information, including advice from the RPA (DFO 2009a), the COSEWIC status report (COSEWIC 2010), and other supporting documents. These sources represent the most recent and complete consolidation of information on Atlantic Whitefish.

The RPA advice includes the following statements which informed the identification of critical habitat for Atlantic Whitefish as outlined in this recovery strategy:

- The absolute abundance of wild Atlantic Whitefish is unknown but is considered to be low. The population is currently thought to be restricted to the Petite Rivière watershed, with reproduction occurring primarily within the approximately 16 km^2 combined area of Minamkeak, Milipsigate, and Hebb Lakes.
- The utilization of the various habitats within these three lakes by the different life-history stages of Atlantic Whitefish is not well understood, but sampling to date has shown that the various life stages occur throughout the lakes and the streams that connect the three lakes.
- Atlantic Whitefish survival depends upon its continued reproduction within Minamkeak, Milipsigate, and Hebb Lakes; thus, this habitat is considered necessary for its survival and subsequent recovery. There is no evidence to suggest that any part of this small area is not utilized by Atlantic Whitefish, and further habitat fragmentation or loss of function should be avoided.

The 2010 COSEWIC status report supports the RPA in stating that “Atlantic Whitefish in the Petite Rivière are land-locked and complete their life cycle in these lakes and connecting streams”. COSEWIC (2010) also indicated that the biological area of occupancy for Atlantic Whitefish is considered to be the combined area of the three lakes and interconnecting waterways (i.e., 16 km^2).

Because detailed knowledge of the specific functions, features, and attributes of the critical habitat for Atlantic Whitefish are not known, and the RPA supports full use of the population’s current area of occupancy (i.e., the three upper Petite Rivière lakes), critical habitat for Atlantic Whitefish is identified using the biological area of occupancy approach, which for Atlantic Whitefish is equivalent to its extent of occurrence as defined by COSEWIC (i.e., the total area of habitat occupied by all existing populations of the species).

2.5.3 Areas of identified critical habitat

Three interconnected geographic areas are identified as critical habitat for Atlantic Whitefish. Following the biological area of occupancy approach, critical habitat for Atlantic Whitefish is being identified in this recovery strategy as the water column and substrate features of the following three lakes in the upper Petite Rivière and the waterways inter-connecting these three lakes: Milipsigate Lake, Minamkeak Lake, and Hebb Lake, as well as the Hebb Dam fishway which was constructed to provide passage of the species into Hebb Lake. This represents a combined area of approximately 16 km^2. It is assumed that within this area, the functions and features necessary for the species’ survival exist, and while they cannot be described at this time, understanding them is the focus of the Schedule of Studies (Section 2.5.6). The general location of the identified critical habitat for Atlantic Whitefish is shown in Figure 5. The central coordinates and surface area of each individual lake and the fishway are provided in Table 4.

While these are areas that DFO considers necessary to attain the species' objectives in the Petite Rivière watershed (i.e., survival), they only constitute a partial critical habitat identification. Fully achieving the recovery objectives for the Atlantic Whitefish requires the establishment of anadromy in the Petite Rivière, as well as establishment of other viable populations within the historic range of the species. Additional areas of habitat required to fully achieve the population and distribution objectives for the species' recovery would therefore include additional riverine, estuarine, and marine habitat areas.

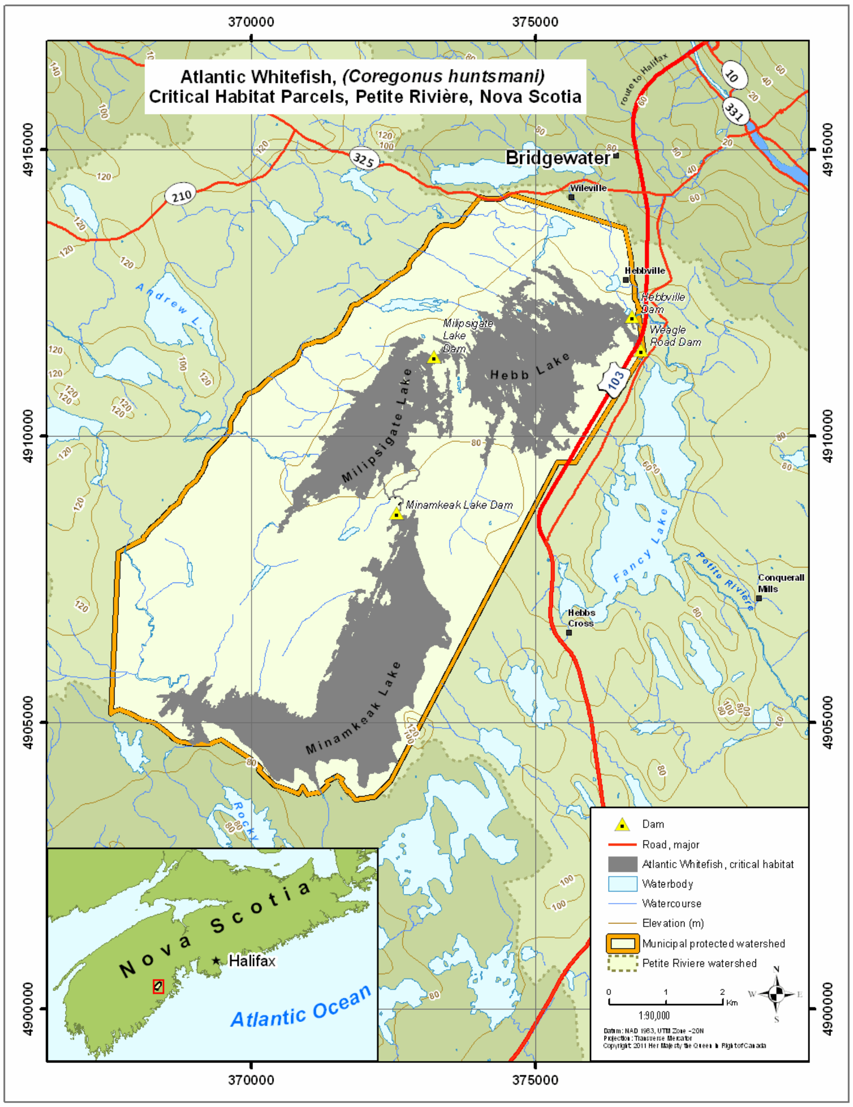

Figure 5. Atlantic Whitefish critical habitat within the Petite Rivière watershed.

The following anthropogenic features (other than the Hebb Dam fishway) that occur in the specified geographic boundaries are excluded from critical habitat because they do not contribute to the specified biophysical functions necessary for the species survival as outlined in Table 5:

- Hebb Dam (and associated structures other than the fishway), located at N44°21’05”, W64°32’50”
- Weagles Spillway, located at N44°20’47”, W64°32’42”
- Milipsigate Dam (and associated structures), located at N44°20’41”, W64°35’26”
- Minamkeak Dam (and associated structures) located at N44°19’12”, W64°35’54”

Descriptions of the Hebb, Milipsigate, and Minamkeak Dams, as well as the Weagles Spillway are provided in Table 3.

Table 4. Central coordinates and surface area for each lake identified as Atlantic Whitefish critical habitat.

Lake	Central Coordinate (DMS)	Surface Area (km^2)
• Milipsigate	N44° 19’ 57” W64° 36’ 12”	3.47
• Minamkeak	N44° 17’ 33” W64° 36’ 10”	7.55
• Hebb	N44° 20’ 41” W64° 34’ 5”	4.31
• Fishway	N44°21’06” W64°32’48”	0.26

2.5.4 Biophysical functions, features, and attributes of critical habitat

Critical habitat for the Atlantic Whitefish has been identified using the biological area of occupancy approach. The specific features and attributes of the critical habitat within the area identified as necessary for the species survival are not well understood. Understanding the specific locations, functions, and associated features of the identified critical habitat is the subject of the Schedule of Studies.

The information provided below describes what is known about the habitat characteristics of the Petite Rivière lakes that support Atlantic Whitefish, what is known of the species’ physical and chemical habitat preferences in the wild, and what has been learned through laboratory studies. This information, as well as the summary provided in Table 5, summarizes the limited available knowledge of the functions, features, and attributes for each life stage of the Atlantic Whitefish. Areas within which critical habitat is found must be capable of supporting one or more of these habitat functions. Note that not all attributes in Table 5 must be present in order for a feature to be identified as critical habitat. If the features, as described in Table 5, are present and capable of supporting the associated functions, the feature is considered critical habitat to the species, even though some of the associated attributes might be outside of the range indicated in the table. All attributes may be used to help inform management decisions for the recovery and/or protection of habitat.

Habitat functions for Atlantic Whitefish

Because the Atlantic Whitefish is presently believed to be largely restricted to Hebb, Milipsigate, and Minamkeak Lakes in the upper Petite Rivière watershed, it is assumed that the species' entire life cycle is presently completed within these lakes and the streams inter-connecting these three lakes. It is further assumed that the following functions are therefore accordingly provided by the Atlantic Whitefish critical habitat: spawning, nursery, rearing, feeding, and overwintering. Precisely where or when these functions are performed in the Petite Rivière lakes or their connecting streams is, however, not fully understood. The Hebb Dam fishway was constructed to provide passage of any upstream migrating Atlantic Whitefish ascending from below the dam, therefore this structure serves as an important migration corridor into the Petite lakes where the Atlantic Whitefish complete their life-cycle. Other possible migration areas are not well understood, including the use of the many streams that feed into the lakes, nor is it understood whether the life history function of the streams is affected by the presence of the water impoundment structures that occur there. Much remains to be learned about habitat use throughout the species' life history but information to date indicates that the different life stages occur throughout the lakes and connecting streams (DFO 2009a).

In captivity, eggs are demersal so, in the wild, it is believed eggs are deposited on the lake bottom on shoals (within approximately the first two metres of water) where they remain during incubation (Dr. Rod Bradford, DFO Science Maritimes Region, personal communication). Juveniles have been sampled from the shallows, while adults and subadults have been sampled from at least one of the connecting streams, along the shorelines, and from the main bodies of the three lakes. This indicates that all parts of the lakes are used by Atlantic Whitefish during their life cycle. The timing and location of spawning and the characteristics of suitable spawning habitat are unknown, although it appears Atlantic Whitefish in the Petite Rivière likely spawn in the late fall/early winter within the lakes (DFO 2009a).

Physical features of the Petite Rivière lakes

The upper Petite Rivière lakes can be characterized as small (~16 km^2 in total), relatively shallow, and thermally stratified during the summer months. Bathymetric surveys of Minamkeak, Milipsigate, and Hebb Lakes indicated maximum depths of 13 m, 16 m, and 17 m respectively, although much of the area of these lakes is shallower

(Wessel 2006). The lake bottoms are silt in the deeper areas. The shoals and shoreline areas are rocky and subject to the influence of water level management. Hebb Lake is a warm water lake with bottom temperatures ranging between 14°C to 20°C during the spring-summer period (COSEWIC 2010).

Physical and chemical preference parameters (attributes)

Almost nothing is known about the attributes of the Petite Rivière lakes that make them suitable habitat for Atlantic Whitefish; however, Atlantic Whitefish habitat preferences for salinity, pH, and temperature have been studied using controlled laboratory experiments (Cook et al. 2010), and are summarized below:

- Salinity: Although Atlantic Whitefish in the Petite Rivière watershed presently complete their life cycle entirely in freshwater, juvenile through adult life stages are seawater tolerant, with juveniles exhibiting a preference for seawater. Studies have determined that fertilized eggs cannot tolerate saltwater, therefore spawning can only proceed in freshwater. However, larvae can survive in brackish and marine environments.
- Freshwater pH: The lakes in the Petite Rivière watershed maintain a mean annual pH greater than 5.6 (DFO 2009a). For all life history stages, low pH decreases the survival of Atlantic Whitefish. Eggs and early larval stages are the most sensitive to low pH and tolerance increases through the life history stages with juveniles being the most tolerant. Generally pH < 5.0 decreases survival of eggs, whereas pH < 4.5 decreases survival of both larval and juvenile Atlantic Whitefish.
- Temperature: Atlantic Whitefish juveniles exhibit growth in water temperatures between 11.7°C and 24°C, with optimum growth occurring at 16.5°C.

Table 5 provides a summary, to the extent known, of the functions, features, and attributes of the habitat in the Petite Rivière lakes. This table may not be exhaustive and the information provided may be refined pending the results of the Schedule of Studies.

Table 5. Summary of the functions, features, and attributes of the habitat in the three upper Petite Rivière lakes.

Life stage	Function	Feature(s)	Attribute(s)
Eggs	Incubation	Precise characteristics and locations unknown within the three lakes but believed lake bottom on shoals as eggs are demersal in laboratory	pH < 5.0 caused decreased egg survival in laboratory **Hebb**: mean depth 6.6 m, max 16.7 m mean pH 6.0, min 5.6, max 6.6 temperature bottom 16.8°C **Minamkeak**: mean depth 4.8 m, max 6 m mean pH 6.3, min 5.8, max 7.4 temperature surface 23°C, bottom 16°C

			Milipsigate: mean depth 4.5 m, max 16 m mean pH 6.1, min 5.8, max 6.3 temperature surface 22^{o}C, bottom 13^{o}C
Juveniles (young of the year and immature)	Rearing	Nearshore areas in all three lakes (observed in June in Hebb Lake) Precise characteristics and locations unknown	Shoals and shoreline areas are rocky pH < 4.5 decreased survival of larval and juveniles in laboratory Mean annual pH > 5.6 Hebb mean pH 6.0, min 5.6, max 6.6
Adults	Growth, Feeding, Maturation, Spawning, Migration	Lake bottom Water column – adults are pelagic Hebb Dam fish passage facility – for migration into the Petite lakes Observed in all three lakes Precise characteristics currently unknown	Bottom temperatures range 14-20^{o}C, May to August Minamkeak: max depth 13 m Milipsigate: max depth 16 m Hebb: mean depth 6.6 m max 16.7 m Mean annual pH > 5.6 Hebb mean pH 6.0, min 5.6, max 6.6 Silt bottom in deeper areas Sufficient water depth and flow through the Hebb Dam fish passage facility during the Atlantic Whitefish migration window (currently believed to be October – November)

2.5.5 Potential additional areas of critical habitat

Achieving the population and distribution objectives for species recovery requires range extensions into areas not presently occupied by Atlantic Whitefish. Therefore, habitat that falls outside of the present identification of critical habitat will eventually be recommended as critical in a subsequent amended recovery strategy or action plan once objectives are achieved, unless the objectives are revised.

With respect to the present identification of critical habitat, further research and monitoring is required to better understand and describe the locations of the features and associated attributes that allow the critical habitat to provide its functions. Investigation of the potential use by Atlantic Whitefish of the several small streams that feed into the three lakes is also required. Should future recovery efforts to establish anadromy be successful on the Petite Rivière, or elsewhere, additional areas of critical habitat may accordingly be found in relevant riverine, estuarine, and marine habitat areas. In such a case, the current identification of critical habitat would be revised or amended as required.

2.5.6 Schedule of studies to identify additional critical habitat

This recovery strategy includes an identification of critical habitat to the extent possible, based on the best information currently available. Further research is required to better describe the current identification and identify any additional critical habitat necessary to support the population and distribution objectives for the Atlantic Whitefish. This additional work includes the research studies outlined in the Schedule of Studies (Table 6).

Table 6. Critical habitat Schedule of Studies for the Atlantic Whitefish in Canada.

Description of activity	Rationale	Timeline
Evaluate the spatial and temporal distribution of Atlantic Whitefish in the Petite Rivière watershed for all life history stages, including the population within the three lakes and the anadromous component (contingent on the provision of fish passage and their usage of such).	Determine where and when the functions of critical habitat are performed to better describe the current identification and improve management and protection of critical habitat.	2015-2020
Complete bathymetric surveys of the three lakes to help better describe the identified critical habitat.	Determine a link between depth and function of habitat.	2015-2020
Live trapping and electrofishing surveys of the streams that feed into the lakes to assess population use.	Assess unknown function of streams which feed into the lakes. The streams may be additional areas of critical habitat.	2015-2018
Assess use of river, estuary and relevant marine habitat of the existing population in the Petite Rivière once anadromy is successfully established with the provision of fish passage around Hebb Dam.	Assess function of possible additional areas of critical habitat.	2015-2020

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

Table 7 provides examples of human activities and the associated effects on the biophysical functions, features, and attributes of the identified critical habitat. This information may be refined pending the results of the Schedule of Studies.

Table 7. Examples of human activities and associated effects on the biophysical functions, features, and attributes of the identified critical habitat.

Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Infilling	Loss or change of established lake bottom and water column	Egg incubation, rearing, spawning, growth and/or feeding	Lake bottom, water column	Water depth and temperature, suspended sediment levels and bottom substrate quantity and type
Dredging	Loss or change of established lake bottom and water column	Egg incubation, rearing, spawning, growth and/or feeding	Lake bottom, water column	Water depth and temperature, suspended sediment levels and bottom substrate quantity and type
Significant manipulation of water levels outside standard operations	Decrease in water levels resulting in exposure of previously submerged areas, risk of exposure of eggs, reduced flows, altered thermal refugial habitat, reduced water depth and flow through the Hebb Dam fish passage facility	Egg incubation, rearing, spawning, growth feeding, and/or migration	Nearshore areas, lake water column, watercourses connecting lakes, and migration corridor	Water depth, flow, and temperature and bottom substrate
Persistent and excessive releases of deleterious substances from land based activities (e.g., road construction, quarry excavation or mining)	Degradation of water quality	Egg incubation, rearing, spawning, growth and/or feeding	Lake bottom, lake water column and watercourses connecting lakes	Water chemistry, water pH, temperature, suspended sediment levels and bottom substrate quantity and type

Under SARA, critical habitat for aquatic species not found in a place mentioned in s.58(2) of that Act must be legally protected within 180 days after it is identified in a recovery strategy or action plan. For Atlantic Whitefish critical habitat, it is anticipated that this will be accomplished through the making of a SARA Critical Habitat Order, pursuant to s. 58(4) or s. 58(5) of SARA, which will invoke the s. 58(1) prohibition against the destruction of the identified critical habitat.

The activities described in Table 7 are neither exhaustive nor exclusive, and their inclusion has been guided by the relevant general threats to habitat described in Section 1.6 (Threats). The absence of a specific human activity from the table does not mean that, when carried out, it will not destroy critical habitat. Furthermore, the inclusion of an activity does not result in its automatic prohibition, since it is destruction of critical habitat that is prohibited, not the undertaking of the activity in and of itself. The prohibition against the destruction of critical habitat is engaged if a critical habitat protection order is made.

Since habitat use is often temporal in nature, every activity is assessed on a case-by-case basis and site-specific mitigation measures are applied where they are reliable and available in order to allow some activities described in Table 7 to occur without destroying critical habitat. To this end, the action plan (DFO 2018) indicates that DFO will continue to work collaboratively with other regulators and the Public Service Commission of Bridgewater on the management of lake water levels and appropriate flow regimes at barrier outlets to protect Atlantic Whitefish critical habitat while continuing to meet the Town water supply needs.

In many cases, as is the case with Atlantic Whitefish, the knowledge of a species' and habitat's threshold of tolerance to disturbance from human activities may be lacking, but where information is available, thresholds and limits associated with attributes are beneficial in helping to better inform management and regulatory decision-making.

2.6 **Measuring progress**

Measurable performance indicators are critical to gauge the extent to which recovery activities are successful in contributing to the stated recovery goal and objectives for the species. An ongoing assessment of the efficacy of actions undertaken within a recovery initiative is essential to ensuring both the intelligent use of resources to achieve the greatest likelihood of species recovery, and the ability to adapt future recovery actions.

The performance indicators presented below provide a way to define and measure the progress towards achieving the overall recovery goal and the population and distribution objectives for Atlantic Whitefish within five years:

- critical habitat has been identified and protected
- research activities outlined in the Schedule of Studies have been completed
- abundance of the existing wild population in the Petite Rivière lakes has been estimated and meets target (>1,275 mature adults)
- anadromy has been established on the Petite Rivière
- a self-sustaining population has been established in another freshwater waterbody (e.g., Anderson Lake)
- anadromy has been established in a second watershed in Nova Scotia's Southern Upland eco-region
- the feasibility of repatriating an anadromous run to the Tusket River has been evaluated, and repatriation pursued if appropriate

- the threat posed by Smallmouth Bass and Chain Pickerel is understood, and appropriate mitigation and management measures are in place to control their abundance and ensure the survival of Atlantic Whitefish in the Petite Rivière
- progress has been made towards filling other knowledge gaps identified in this recovery strategy
- an adaptive communication plan has been developed, engaged stewards are active, and public awareness and acceptance of the Atlantic Whitefish has increased and been expanded to new areas selected for introductions
- human activities permitted by this recovery strategy continue to not jeopardize the survival or recovery of the Atlantic Whitefish
- an action plan has been completed and is posted on the SAR Public Registry (DFO 2018)

As per SARA, the competent minister must report on the implementation of the recovery strategy, and the progress towards meeting its objectives, within five years after it is included on the SAR Public Registry, and in every subsequent five-year period. The original recovery strategy for Atlantic Whitefish was published in February 2007; therefore, the first progress report on its implementation has been prepared and is published on the SAR Public Registry (DFO 2016).

2.7 Knowledge gaps

Since the formation of the Recovery Team in 1999, significant progress has been achieved in addressing knowledge gaps of importance to recovery planning and recovery strategy implementation. Information is now available or forthcoming in the following areas:

- phylogenetic status, historic and current range, and status of the species
- genetic health of the remaining members of the species
- accurate field identification of living specimens using external characteristics
- genetic markers to support enforcement efforts and future assessments of species distribution
- captive breeding and rearing protocols
- life-history stage specific assessments of susceptibility to acid (rain) toxicity, thermal preferences, and salinity tolerance
- rophic position of Atlantic Whitefish residing in lakes
- otential for a threat to survival or recovery resulting from the presence of invasive species
- effects of current human activities on Atlantic Whitefish survival
- fish passage requirements around dams
- feasibility of establishing additional freshwater resident populations using seed stock reared in captivity

Specific details on the advancement of these and other activities related to knowledge gaps can be found in the 'Activity Table' maintained by the Recovery Team (Section 2.10).

Although the above acquired information will possibly improve the likelihood that recovery actions will be successful, the adequacy of the existing information base is uncertain. Recovery of the species can only be realized through range extension into the marine realm (i.e., anadromy), and into freshwater habitat not currently occupied by the species. There is currently no existing information on the life history of wild Atlantic Whitefish anywhere other than within the Petite Rivière lakes. New information has been acquired from individuals cultured by the DFO Science captive-breeding program, from the releases in the lower Petite Rivière and Anderson Lake, as well as from monitoring at the fish passage facility at Hebb Dam. An adaptive management approach must be used to ensure survival of the species within existing habitat, and to ensure the success of range expansion into the marine realm and additional freshwater sites. Research and monitoring activities necessary to address knowledge gaps as recovery implementation continues to unfold were reviewed as part of the RPA (DFO 2009a) and include:

- status of the Petite Rivière population:
    - quantitative assessment of population size
    - age composition and age at maturity, and growth and mortality on an inter-annually consistent basis
    - effects of current human activities on Atlantic Whitefish survival
    - scope for negative interaction with Smallmouth Bass and Chain Pickerel at all life-history stages
    - fish passage requirements, including an increased understanding of how trophic structuring with the lakes might respond to the presence of other fish species that do not occur there presently
- captive breeding:
    - likelihood that domestication selection will occur within Atlantic Whitefish spawned and reared in captivity
    - trophic niche selection of captive-reared fish as they naturalize to the habitat into which they are released
- habitat:
    - assessment of habitat suitability within candidate stocking sites

For details on specific activities that target the key habitat knowledge gaps required to refine the current identification of critical habitat for Atlantic Whitefish and identify any additional areas of critical habitat refer to the Schedule of Studies (Section 2.5.6).

2.8 Statement on action plans

SARA action plans are the documents that lay out how recovery strategies are to be implemented. They include the measures that will be taken to implement the recovery strategy, including those that address the threats to the species and those that help to achieve the population and distribution objectives.

Accordingly, and concurrent with this amended recovery strategy, a single comprehensive action plan for Atlantic Whitefish is completed and published on the SAR Public Registry (DFO 2018). This approach replaces the previous approach taken by the Recovery Team to draft action plan 'chapters', with the first chapter intended to be focused on fish passage improvements in the Petite Rivière.

Recovery implementation is an ongoing activity and therefore many of the recovery approaches outlined in this document and their associated recovery measures as outlined in the action plan are already underway and some have been accomplished. Furthermore, the recovery strategy and action plan recognize the need for adaptive management; as new information becomes available, the actions for recovery may be modified as necessary.

2.9 Activities permitted by the recovery strategy

SARA contains a number of provisions to protect a species at risk and its habitat. Section 32 of SARA prohibits the killing, harming, harassing, capturing, or taking of an individual of a wildlife species that is listed as an extirpated, endangered, or threatened species, as well as the possessing, collecting, buying, selling, or trading of such an individual or any of its parts or derivatives. SARA also contains prohibitions against the damage or destruction of the species' residence and the destruction of any part of its critical habitat once identified in a recovery strategy or action plan.

However, as set out in s. 83(4) of SARA, a person can engage in an otherwise prohibited activity if the activity is permitted by a recovery strategy and the person is authorized under an Act of Parliament to engage in that activity. A recovery strategy cannot allow activities that would jeopardize recovery. To do so would be contrary to the purpose of the Act as set out in s.6, and would defeat the purpose of producing such a document.

Advice from the 2004 Allowable Harm Assessment (AHA) (DFO 2004a) informed the activities permitted by the 2006 recovery strategy. Based on the AHA, the 2006 recovery strategy exempted the operation of the Hebb Lake Dam as it presented a barrier to fish passage. Since then a fish passage facility at Hebb Dam has been completed, and has been operational since 2012. Therefore, the Hebb Dam no longer requires a SARA exemption under s. 83(4).

The March 2009 RPA Science Advisory Process was undertaken to replace the advice from the 2004 AHA (DFO 2004a), and inform, among other scientific elements (e.g., population status and trends, habitat requirements, threats), decisions on SARA permitting. Human activities that may contribute to mortality or harm to Atlantic Whitefish were reviewed and evaluated at this meeting and are summarized in tabular format in the resulting Science Advisory Report (DFO 2009a). Alternatives to the activity and possible mitigative measures are also presented.

The results from the RPA were used to develop a list of activities permitted by this recovery strategy in accordance with s. 83(4) of SARA. An explanation for their eligibility, the supporting information that led to that determination, and any conditions under which the permitted activity can be conducted is also included.

In order for the impacts of an activity to qualify for an exemption under s. 83(4), the activities themselves must be authorized under another Act of Parliament. The legislation under which an authorization is required, and provided, is indicated for each activity.

The following authorized activities, as listed and described below, qualify for the SARA s. 83(4) exemption for impacts to Atlantic Whitefish that would otherwise be prohibited by SARA:

1. **scientific conservation and recovery activities led by DFO staff and authorized by license under s. 52 and s. 56 of the Fishery (General) Regulations and s. 4 of the Fisheries Act** including:

    - the collection and release of individuals of Atlantic Whitefish and their retention and utilization in support of DFO authorized recovery efforts and conservation research
    - DFO-authorized sampling by methods including but not limited to, electrofishing, angling, fyke nets, seine nets, trap nets, and fixed traps (e.g., those installed in fish passage facilities to support monitoring), in support of DFO-authorized research, assessment of status, or to determine the presence or absence of the species

Rationale

These scientific activities are permitted by this recovery strategy because the RPA advice concluded that they result in a low level of harm to Atlantic Whitefish, and DFO Science has adopted handling protocols and non-invasive monitoring techniques for any scientific research or handling activities. Furthermore, these activities, which are supported by this recovery strategy, are intended to improve understanding of Atlantic Whitefish, enhance their chances of survival in the wild, and/or mitigate threats to their recovery.

Conditions

No later than May 31st each year, irrespective of whether exempted activities took place, a completed SARA s. 83(4) Exemption Report shall be completed by DFO Science and submitted to DFO Species at Risk Management Division, Maritimes Region. The Report will take account of the previous fiscal year and shall include:

- a list of all activities requiring use of the exemption and the license number for the associated authorization under another Act of Parliament (if applicable)
- a record of interactions with Atlantic Whitefish that occurred while conducting exempted activities
- an assessment of the overall impact of the exempted activities on the Atlantic Whitefish population, including a statement on the cumulative impacts of ongoing or concurrent use of the exemption on the species' survival and recovery

2. **electrofishing authorized by license under s. 52 of the Fishery (General) Regulations**, conducted by qualified individuals for the purposes of i) enforcement, ii) environmental emergencies, or iii) fish rescue in accordance with approvals granted by DFO.

Rationale

Electrofishing for the purpose described above is directed by DFO to mitigate the effects of authorized activities and will generally have a greater benefit to the species than detriment. Electrofishing can result in mortality to individuals; however, the probability of this is low if conducted in accordance with the standards and conditions outlined below. This activity is not expected to jeopardize the survival or recovery of the species.

Conditions

The allowance of electrofishing under license applies only if all feasible measures are taken to minimize the impact of the activity on the species and its habitat. This includes but is not limited to:

- using the lowest effective voltage necessary
- minimizing the handling of live individuals
- releasing individuals as quickly as possible
- undertaking the activity in a manner that causes the least disturbance to habitat

3. **Authorized fishing activities for other species that result in incidental capture of Atlantic Whitefish** as follows: this recovery strategy allows fishers to engage in authorized recreational, commercial, and Aboriginal fishing activities that may incidentally kill, harm, harass, capture, or take Atlantic Whitefish in the following locations: the Petite Rivière and adjacent watersheds, in Anderson Lake and any other place where Atlantic Whitefish may be intercepted or introduced.

Rationale

This activity is permitted by this recovery strategy because the current rate of incidental captures of Atlantic Whitefish individuals is low in existing fisheries and the RPA advice concluded that incidental captures of Atlantic Whitefish in fisheries within the Petite Rivière, under the current management regime, have a low impact on the survival of the existing population of Atlantic Whitefish. Furthermore, evidence to date from recovery efforts suggests that incidental captures outside the Petite Rivière watershed are infrequent and at levels that will not impact the species' survival. Under the current management regime, the rate of incidental captures of Atlantic Whitefish in fisheries targeting other species is not anticipated to increase significantly within the 5-year review timeframe of this recovery strategy. However, where recovery efforts result in an expanded or new population, additional management measures may be implemented to ensure that incidental captures are kept at levels that will not jeopardize the species' survival or recovery.

Conditions

These activities are subject to the following conditions:

- The fishing activities are conducted in accordance with the relevant provisions of the Maritime Provinces Fishery Regulations, the Atlantic Fishery Regulations, 1985, or the Aboriginal Communal Fishing Licences Regulations made pursuant to the Fisheries Act, including any applicable licensing requirements.
- All efforts must be taken to enhance the survival of incidentally captured Atlantic Whitefish in these fisheries, primarily through the mandatory release of Atlantic Whitefish in a manner that will cause them the least harm. The following additional conditions therefore apply to these fishing activities:
    - incidentally caught Atlantic Whitefish must be returned immediately to the place from which they were taken in a manner that causes them the least harm
    - best angling practices, such as those described in the 'Fill Your Memories, Not Your Creel' section of the Nova Scotia Anglers' Handbook, must be used
    - incidental capture information (e.g., location, date, time, fish condition at capture and at release) must be reported to the local DFO, Conservation and Protection, Liverpool detachment at (902) 354-6030 or 1-800-565-1633

This exemption does not, under any circumstance, allow the retention of any live or dead Atlantic Whitefish individuals or their parts.

Other new or existing activities considered likely to result in an impact to Atlantic Whitefish that is prohibited by SARA may be permitted by the Minister of Fisheries and Oceans under a s. 73 permit or agreement if the conditions set out in the provisions of SARA are met. SARA permit applications can be downloaded from the DFO Species at Risk website.

A review of the above-itemized exempted activities and any new information will be undertaken whenever there is significant reason to believe that the activities permitted by this recovery strategy may jeopardize the survival or recovery of the species.

2.10 **Actions completed or underway**

A number of management, research, monitoring, stewardship, outreach, and recovery measures have been initiated by government and non-government organizations over the past 15 or more years. A multi-stakeholder Atlantic Whitefish Conservation and Recovery Team was first formed in 1999 in response to concerns about the endangered Atlantic Whitefish, and contributed to the development of the 2006 SARA recovery strategy that outlined the issues facing the Atlantic Whitefish and the research and approaches required to promote recovery. Some of the actions proposed in that recovery strategy were completed, while others are ongoing or planned and are reflected in this amended recovery strategy and the associated action plan (DFO 2018).

An itemized summary of actions completed or underway is provided in tabular format, and is referred to as the 'Activity Table'. The Activity Table provides a detailed enumeration of the specific actions undertaken, which are cross-referenced to the corresponding broad strategies and approaches outlined in the recovery strategy. The Activity Table has been updated annually by the Recovery Team to reflect progress on ongoing activities and capture any new actions undertaken. It is archived by, and available upon request from, the DFO Species at Risk Management Division, Maritimes Region (contact by email or by phone at 1-866-891-0771). A report on the progress of recovery strategy implementation includes a summary of activities undertaken during the five years since the publication of the 2006 recovery strategy; i.e., the February 2007 to February 2012 time period (DFO 2016).

2.10.1 Stewardship activities

Stewardship efforts led by various members of the Recovery Team have played a significant role in raising public awareness, building strong relationships within the local community, and engaging community volunteers in recovery efforts, as well as advancing knowledge of this species in southwestern Nova Scotia and implementing recovery efforts. For example, the South Shore Naturalists Club were active on the community awareness, education, and engagement front and DFO Conservation and Protection Officers from the Liverpool Detachment have taken advantage of available opportunities to educate the local community on the presence of Atlantic Whitefish and the regulations in place to protect it (e.g., during regular patrols of the Petite Rivière watershed and through presentations at local schools). The Bluenose Coastal Action Foundation (BCAF) initiated an Atlantic Whitefish Recovery Project in 2004 and continues to work collaboratively with DFO and other partners on many new important projects. Summaries and related reports of projects led by BCAF can be found on their website.

2.10.2 Recovery actions

The following provides highlights of three significant recovery actions undertaken to date to address Atlantic Whitefish survival and the need to increase the number and range of viable populations. The detailed Activity Table, in combination with the associated action plan (DFO 2018) and progress report (DFO 2016), provides further information on these and other recovery measures planned or undertaken to date.

Creating back-up populations using captive-reared Atlantic Whitefish: Anderson Lake

Releasing Atlantic Whitefish in selected freshwater waterbodies has been identified as an important component for the survival of the species. A combined experiment to evaluate the feasibility of using captive-reared individuals to establish successfully reproducing lake-resident populations of Atlantic Whitefish and efforts towards establishing a back-up population of Atlantic Whitefish (i.e., a secondary population to ensure that if Atlantic Whitefish were to disappear from the Petite Rivière lakes the species would not go extinct) was among the first recovery initiatives undertaken and one the Recovery Team felt most urgently needed in order to minimize the species' risk of extinction. Since the establishment of populations outside of the current range required a source of seed stock, DFO developed a captive breeding and rearing program at the Mersey Biodiversity Facility (2000-2012). The Atlantic Whitefish culture methods and associated activities conducted at the Mersey Biodiversity Facility between 2000 and 2012 have been detailed in a culture handbook (Whitelaw et al. 2015). This program successfully produced progeny for research, including evaluating the potential for captive-reared individuals to adapt to lacustrine habitat located outside the Petite Rivière drainage area. A DFO Science workshop, which drew upon experts and interested members of the Recovery Team, was held in 2004 to examine decision criteria for introducing this species into freshwater habitat beyond its existing range, and to develop a draft 'decision support tool' framework to guide the decision making process (DFO 2004d). Factors considered in the development of this tool included socio-economic, ecological, and management considerations, and was based on the National Code on Introductions and Transfers of Aquatic Organisms (DFO 2003). This decision support tool was subsequently screened by a technical committee of the Recovery Team to evaluate possible candidate sites. Anderson Lake, near Burnside, in Dartmouth, Nova Scotia, was selected, and subsequently endorsed by the Recovery Team, as an acceptable site based on the parameters of the lake, its limited use and access, land ownership, and limited anticipated socio-economic impacts. DFO held consultations and signed Working Agreements with the land owners prior to undertaking the releases (as outlined in Appendix II).

On November 4, 2005, 1500 captive-reared age 1+ Atlantic Whitefish were released into Anderson Lake. As part of a three-year trial project, subsequent allotments of 750 age 1+ fish were released each in the spring and fall of 2006 and 2007. Additional releases of 3000 and 4000 yolk-sac larvae were undertaken in 2006 and 2007, respectively, as well as approximately 400 older age 3-4+ juveniles in an additional year (i.e., 2008). A final allotment of 80 age 5-6+ fish were released in the fall of 2012 from the remaining Atlantic Whitefish held at the Mersey Biodiversity Facility for a total of nearly 12,000 fish. DFO staff monitored the Atlantic Whitefish in Anderson Lake on an annual basis until fall 2010, and again in the fall of 2012, to determine the success of the introductions. Monitoring to 2010 indicated that the released fish were surviving and showing signs of maturation, but there is not yet evidence of a self-sustaining population (COSEWIC 2010; Bradford et al. 2015). Monitoring in 2012 failed to show any indication of successful reproduction and suggested a decline in numbers of stocked fish. A comprehensive report on the stocking experiment in Anderson Lake, including monitoring results is presented in Bradford et al. 2015. Further measures to continue to monitor the success of these releases and to strive towards the achievement of a self-sustaining population are outlined in the action plan (DFO 2018).

Increasing natural production and promoting anadromy on the Petite Rivière

Historically anadromous, reproduction of the remaining wild population of Atlantic Whitefish is currently largely restricted within three small, semi-natural, and inter-connected lakes in the upper Petite Rivière watershed which form the water supply for the Town of Bridgewater. The population's access to the ocean has been impeded by a series of dams between the lakes and along the river's main stem (Section 1.6). The dam at the most downstream of the three upper lakes, Hebb Lake Dam, effectively blocked any upstream migration beyond this point. Establishing fish passage at Hebb Lake Dam has the primary benefit of ensuring the survival of the wild population by allowing fish that have descended over the dam to return to Hebb Lake and contribute to production. Establishing fish passage at Hebb Lake Dam and other existing barriers on the Petite Rivière is also expected to have the additional benefit of creating the conditions thought to be favourable for enabling anadromy.

Laboratory experiments have demonstrated that the lake-resident population of Atlantic Whitefish has retained its salt water tolerance (Cook et al. 2010). As a first step towards assessing the species potential for anadromy and attempting to increase natural production, DFO released over 12,000 captive-reared Atlantic Whitefish into the lower Petite Rivière between 2007 and 2009. A small portion of these released fish were implanted with hydroacoustic tags (< 50 fish) and their movements monitored via a series of hydrophone tracking arrays installed within the Petite estuary and adjacent Medway and LaHave estuaries. An evaluation of the data resulting from this work is underway, but preliminary results have shown that the released fish have left the estuary and migrated to adjacent rivers. This is consistent with their known historical coastal character.

In addition to the releases, efforts to work with the municipality of Bridgewater on improving fish passage on the Petite Rivière were also accomplished with the construction of a fish passage facility at Hebb Dam completed in spring 2012 (Figure 6). In response to the construction, a DFO-led Working Group of the Recovery Team was established and assisted DFO in developing an adaptive, precautionary, and phased interim monitoring plan including operational control protocols for both native and non-native fish species for the first year of implementation (Robichaud-LeBlanc and Fenton 2011). Details of the specific actions undertaken to date to address this activity are provided in the Activity Table, and relevant recovery measures are outlined in the associated action plan (DFO 2018). Monitoring at the Hebb Dam fish passage facility has been undertaken by BCAF from 2012 to the present and published results to date are included in their Atlantic Whitefish Recovery Project Reports which can be found on their website. The interim monitoring plan was updated in 2013 to accommodate phase 2 of the plan, including a qualitative review of the risks associated with providing passage of diadromous fish and other river-resident fish into the system above Hebb Dam (Robichaud-LeBlanc and O'Neil 2013). A summary of the fishway monitoring operations and associated results will also be summarized in the forthcoming next progress report for the 2012-2017 time period.

Figure 6. Fish passage facility at Hebb Dam on the Petite Rivière.

Mitigation of invasive species in the Petite Lakes

The construction of the Hebb Dam fish passage facility in 2012, in conjunction with ongoing concerns for the presence and spread of Smallmouth Bass and the recent discovery of Chain Pickerel in the upper Petite Rivière lakes, prompted a number of research activities aimed at better understanding the distribution, reproduction and diet of these invasive species. The associated sampling methods also provided a mechanism for their mitigation. Accordingly, all Smallmouth Bass and Chain Pickerel captured within the upper Petite Rivière lakes, during the various monitoring or sampling methods undertaken in recent years (e.g., angling, rotary screw trap, trap net, Hebb Dam fishway, and backpack electrofishing), were removed from the system and retained for a biological study (Themelis et al. 2014; annual reports produced by BCAF which are available on their website).

In July 2013, a focused collaborative exploratory sampling program in Milipsigate and Minamkeak lakes between DFO, the NSDFA and BCAF was implemented to assess the potential for boat-electrofishing to be used as a method for the collection and removal of these aquatic invasive species that threaten the survival of the Atlantic Whitefish. This exploratory boat-electrofishing resulted in captures of both invasive species in Milipsigate Lake and only Smallmouth Bass in Minamkeak Lake. No Atlantic Whitefish were captured in either lake. Further details on the results of this exploratory boat-electrofishing program are outlined in Themelis et al. (2014).

Following the 2013 exploratory program, DFO and the NSDFA established an agreement for a 3-year project during 2014-2016 to use boat-electrofishing to:

- determine the scope for harm to Atlantic Whitefish by evaluating the feasibility of boat-electrofishing to catch Atlantic Whitefish and the potential for population estimate work (to be carried out annually during the 3 years of the agreement)
- evaluate potential to reduce the abundance of invasive fish species in habitat areas previously known to be frequented by Atlantic Whitefish
- capture two aquatic invasive species in the Petite Riviere system, Chain Pickerel and Smallmouth Bass, and assess catch and removal rates
- explore the use of boat-electrofishing as a tool to determine population size of invasive species based on depletion estimates

A preliminary summary of the boat-electrofishing program efforts and results to date was provided to DFO by the NSDFA in February 2016 (NSDFA 2016). Efforts to date evaluated the efficiency of removals from both linear shoreline sites and depletion sites in Hebb Lake. In summary, linear shoreline sites are less time consuming to complete, but are also less efficient than depletion sites. Catch rates varied by species and methodology, but both are more efficient than angling, although angling removals generally target larger individuals. Efforts during the 2014-2015 sampling year resulted in total catches of 1,452 Chain Pickerel and 725 Smallmouth Bass. The boat-electrofishing project in the upper Petite Riviere lakes continued in 2016. A report on the assessment of boat electrofishing as a tool to control invasive Chain Pickerel and Smallmouth Bass in Hebb Lake is being prepared by the NSDFA. A summary of the boat-electrofishing project and associated results, and other invasive species control and monitoring projects in the Petite Rivière undertaken between 2012 and 2016, will also be summarized in the forthcoming next progress report for the 2012-2017 time period.

3. References

BCAF (Bluenose Coastal Action Foundation). 2015. The Atlantic Whitefish Recovery Project . [accessed August 2016]

Bernatchez, L., T. A. Edge, J. J. Dodson, and S. U. Qadri. 1991. Mitochondrial DNA and isozyme electrophoretic analyses of the endangered Acadian Whitefish, Coregonus huntsmani Scott, 1987. Canadian Journal of Zoology 69:311-316.

Bradford, R., D.L. Longard, and P. Longue. 2004a. Status, trends, and recovery considerations in support of an allowable harm assessment for Atlantic Whitefish (Coregonus huntsmani). DFO Can. Sci. Advis. Sec. Res. Doc. 2004/109.

Bradford, R.G., H. Schaefer, and G. Stevens. 2004b. Scope for human-induced mortality in the context of Atlantic Whitefish (Coregonus huntsmani) survival and recovery. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/110.

Bradford, R.G., P. Bentzen, D.M. Campbell, A.M. Cook. A.J.F. Gibson, and J. Whitelaw. 2010. 2009 Update Status Report for Atlantic Whitefish (Coregonus hunstmani). DFO Can. Sci. Advis. Sec. Res. Doc. 2010/005. vi + 39 p.

Bradford, R.G., Themelis, D., LeBlanc, P., Campbell, D.M., O'Neil, S.F., and Whitelaw, J. 2015. Atlantic Whitefish (Coregonus huntsmani) Stocking in Anderson Lake, Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 3142: vi + 45 p.

Broome, J. and A. Redden. 2012. Anderson Lake Whitefish survey for 2012. Unpublished report to Fisheries and Oceans Canada, Dartmouth, Nova Scotia. 4 pp.

Clair, T.A., I.F. Dennis, P.G. Amiro, and B.J. Cosby. 2004. Past and future chemistry changes in acidified Nova Scotian Atlantic salmon (Salmo salar) rivers: a dynamic modeling approach. Canadian Journal of Fish and Aquatic Science 61: 1965-1975.

Conrad, V. 2005. Functional design of fish passage facilities on the Petite Rivière watershed. MS Rep. DFO Oceans and Habitat Branch, Maritimes Region.

Cook, A.M., R.G. Bradford, B. Hubley, and P. Bentzen. 2010. Effects of pH, Temperature and Salinity on Age 0+ Atlantic Whitefish (Coregonus huntsmani) with Implications for Recovery Potential. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/055. vi + 47 p.

Cook, A.M. 2012. Addressing key conservation priorities in a data poor species. Unpublished PhD dissertation, Dalhousie University, Halifax, Nova Scotia, Canada. xvi + 198 pp.

COSEWIC, 2000. Update COSEWIC status report on the Atlantic Whitefish Coregonus huntsmani in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 35 pp.

COSEWIC. 2010. Update COSEWIC status report on Atlantic Whitefish Coregonus huntsmani in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 29 pp.

de Mestral Bezanson, L., P. O'Reilly, B. Lenentine, and J. Whitelaw. 2010. Cryopreservation of milt from two endangered fishes: Atlantic Whitefish (Coregonus huntsmani) and inner Bay of Fundy Atlantic Salmon (Salmo salar). Can. Tech. Rep. Fish. Aquat. Sci. 2911:vi+18p.

DFO. 2000. The effects of acid rain on Atlantic salmon of the Southern Upland of Nova Scotia. DFO Maritimes Regional Habitat Status Report 2000/2E. May 2000. 19pp.

DFO. 2003. National Code on Introductions and Transfers of Aquatic Organisms. Fisheries and Oceans Canada, Ottawa. 60pp.

DFO. 2004a. Allowable Harm Assessment for Atlantic Whitefish. DFO Can. Sci. Advis. Sec. Stock Status Rep. 2004/052.

DFO. 2004b. Proceedings of a Regional Advisory Process Meeting on the level of allowable mortality for Atlantic Whitefish in support of species at risk. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/034.

DFO. 2004c. Scope for human-induced mortality in the context of Atlantic Whitefish (Coregonus huntsmani) survival and recovery. DFO. Can. Sci. Advis. Sec. Res. Doc. 2004/110

DFO. 2004d. Proceedings of a Workshop on a Decision Support Tool for Stocking for Atlantic Whitefish; 24 November 2004. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/044.

DFO. 2006a. Recovery Strategy for the Atlantic Whitefish (Coregonus hunstmani) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. xiii + 42pp.

DFO. 2006b. Minutes of the Petite Rivière Fish Passage Plan for Atlantic Whitefish Workshop. June 16, 2006. 12 pp + appendices.

DFO. 2009a. Recovery Potential Assessment for Atlantic Whitefish (Coregonus hunstmani). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/051.

DFO. 2009b. Proceedings of the 2009 Recovery Potential Assessment for Atlantic Whitefish (Coregonus huntsmani); 24-25 March 2009. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2010/021.

DFO. 2013. Recovery Potential Assessment for Southern Upland Atlantic Salmon. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/009.

DFO. 2016. Report on the Progress of Recovery Strategy Implementation for the Atlantic Whitefish (Coregonus huntsmani) in Canada for the Period 2007 – 2012. Recovery Strategy Report Series. Fisheries and Oceans Canada, Ottawa. v + 16 pp.

DFO. 2018. Action Plan for the Atlantic Whitefish (Coregonus hunstmani) in Canada. Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa. ix + 39 pp.

Edge, T.A. 1984a. Preliminary status of the Acadian Whitefish, Coregonus canadensis, in southern Nova Scotia. Canadian Field-Naturalist 98: 86-90.

Edge, T. A. 1984b. Status report on the Atlantic Whitefish, Coregonus huntsmani in Canada. Prepared for the Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 14 pp.

Edge, T. A. 1987. The systematics, distribution, ecology and zoogeography of the endangered Acadian Whitefish, Coregonus canadensis Scott, 1967, in Nova Scotia, Canada. M. Sc. thesis, University of Ottawa, Ottawa, Canada.

Edge, T. A., D. E. McAllister, and S. U. Qadri. 1991. Meristic and morphometric variation between the endangered Acadian Whitefish, Coregonus huntsmani, and the Lake Whitefish, Coregonus clupeaformis, in the Canadian Maritime Provinces and the State of Maine, USA. Canadian Journal of Fisheries and Aquatic Sciences 48: 2140-2151.

Edge, T. A. and J. Gilhen. 2001. Update COSEWIC status report on Atlantic Whitefish, Coregonus huntsmani. Prepared for the Committee on the Status of Endangered Wildlife in Canada. Canadian Wildlife Service, Ottawa, Ontario. September 12, 2001. 47pp. + Tables.

Gilhen, J. 1977. A report on the status of the Atlantic Whitefish, Coregonus canadensis, in the Tusket River watershed, Yarmouth County, including recommendations to ensure its future survival. Report submitted to the Ichthyology Section, National Museum of Natural Sciences, Ottawa, Ontario. October 30, 1977. 18pp.

Gimenez Dixon, M. 1996. Coregonus huntsmani. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. [accessed August 2013].

Hasselman, D.J. 2003. Discrimination of adult and early life history stage coregonid fishes in Maritime Canada. M.Sc. thesis, Acadia University, Wolfville, Nova Scotia, Canada.

Hasselman, D.J., P. Longue, and R.G. Bradford. 2005. First record of age 0+ Atlantic whitefish (Coregonus huntsmani Scott, 1987) from the wild. Canadian Field-Naturalist 119: 294-295.

Hasselman, D.J., J. Whitelaw, and R.G. Bradford 2007. Ontogenetic development of the endangered Atlantic whitefish (Coregonus huntsmani Scott, 1987) eggs, larvae, and juveniles. Canadian Journal of Zoology 85: 1157-1168.

Hasselman, D.J., T.A. Edge, and R.G. Bradford. 2009. Discrimination of the endangered Atlantic whitefish from Lake whitefish and round whitefish by the use of external characters. North American Journal of Fisheries Management. 29(4): 1046-1057.

Hasselman, D.J. and R.G. Bradford. 2012. Discrimination of the endangered Atlantic Whitefish (Coregonus huntsmani Scott, 1987) larvae and juveniles. Canadian Technical Report of Fisheries and Aquatic Sciences 2993: iii + 24 pp.

Huntsman, A. G. 1922. The fishes of the Bay of Fundy. Contributions to Canadian Biology 1921: 49-72.

IUCN, UNEP and WWF. 1991. Caring for the Earth. A Strategy for Sustainable Living. Gland, Switzerland. 227pp.

Jackson, D.A. 2002. Ecological effects of Micropterus introductions: the dark side of black bass. Pages 221-232 In: Philip, D.P, and Ridgway, M.S. (2002). Black Bass: Ecology, Conservation, and Management. American Fish Society Symposium 31. Bethesda, MD. 724 pp.

Kendall, K. and N. Llewellyn. 2001. Watershed Management and Protection Issues (Phase 2). Prepared for the Public Service Commission of Bridgewater. Bridgewater Engineering Department.

Mitchell, S.C., J.E. LeBlanc, and A.J. Heggelin. 2010. Impact of introduced Chain Pickerel (Esox niger) on lake fish communities in Nova Scotia, Canada. Unpublished report. Inland Fisheries Division, Nova Scotia Department of Fisheries and Aquaculture, Pictou, N.S. 18 pp.

Murray, K.D. 2005. Population genetic assessment of the endangered Atlantic Whitefish, Coregonus huntsmani, and the Lake Whitefish, C. clupeaformis in Atlantic Canada. M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia, Canada.

NatureServe. 2012. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. [accessed August 2013].

Nova Scotia Department of Fisheries and Aquaculture (NSDFA). 2016. Activity Report: electofishing boat activities. Unpublished Report to Fisheries and Oceans Canada, Dartmouth, Nova Scotia. 7 pp.

Piers, H. 1927. Coregonus labridoricus, the sault Whitefish, an interesting addition to the freshwater fish fauna of Nova Scotia. Transactions of the Nova Scotia Institute of Science 16:92-95.

Robichaud-LeBlanc, K., and D. Fenton. 2011. Hebb Lake dam fish passage facility interim monitoring plan: fall 2011 – winter/spring 2012. Internal Report DFO Species at Risk Management Division, Maritimes Region, September 1, 2011. 13 pp.

Robichaud-LeBlanc, K. and S.F. O'Neil. 2013. Hebb Lake dam fish passage facility interim monitoring plan update: Results of fall 2012 monitoring, recommendations for spring – fall 2013. Internal Report DFO Species at Risk Management Division, Maritimes Region, May 2013. 19 pp.

Schaefer, H., Newbould, A., and Fenton, D. 2006. Petite Rivière Fish Passage Plan for Atlantic Whitefish: Discussion Document for a SARA Action Plan. DFO internal report. 32 pp + Appendix.

Scott, W.B. 1967. Freshwater fishes of eastern Canada. 2nd Ed. University of Toronto Press, Toronto, Ontario.

Scott, W. B. 1987. A new name for the Atlantic Whitefish: Coregonus huntsmani to replace Coregonus canadensis. Canadian Journal of Zoology 65: 1856-1857.

Scott, W.B. and E.J. Crossman 1973. Freshwater fishes of Canada. Bull. Fish Research Board of Canada. No. 184.

Scott, W. B. and M. G. Scott. 1988. Atlantic fishes of Canada. University of Toronto Press, Toronto, Ontario.

Sikumiut Environmental Management Ltd. 2011. Petite Rivière watershed dams upgrade and fishway construction fish habitat stewardship plan. Draft Report for the Public Service Commission of Bridgewater, February 4, 2011. 25 pp.

Smith, G. R. and T. N. Todd. 1992. Morphological Cladistic Study of Coregonine Fishes. Polskie Archiwum Hydrobiologii 39:3-4, pages 479-490. In: Todd, T. N. and Luczynski, M (eds.). Proceedings of the Fourth International Symposium on the Biology and Management of Coregonid Fishes. Quebec City, Canada, August 19-23, 1990.

Themelis, D.E., Bradford, R.G., LeBlanc, P.H., O'Neil, S.F., Breen, A.P., Longue, P, and Nodding, S.B. 2014. Monitoring activities in support of endangered Atlantic Whitefish

(Coregonus huntsmani) recovery efforts in the Petite Rivière lakes in 2013. Can. Manuscr. Rep. Fish. Aquat, Sci. 3031. v + 94 p.

Whitelaw, J., Manríquez-Hernández, J., Duston, J., O'Neil, S.F. and Bradford, R.G. 2015. Atlantic Whitefish (Coregonus huntsmani) culture handbook. Can. Manuscr. Rep. Fish. Aquat. Sci. 3074: vii + 55 p.

Appendix I. Glossary of terms

Anadromous
Migrating from sea to fresh water to spawn.

Action plan
Action plans are the second part of a two-part recovery planning process. The first part, which is the recovery strategy, describes scientific baseline information about the species, its critical habitat and threats, as well as establishing objectives that will assist its survival and recovery. These recovery strategies are implemented through action plans, which outline the measures needed to meet the objectives set out in recovery strategies, and indicate when they are to take place.

Biodiversity
The variety of life in all its forms, levels and combinations, including ecosystem, species, and genetic diversity (IUCN, UNEP and WWF, 1991).

COSEWIC
Committee on the Status of Endangered Wildlife in Canada. A body of Canadian government, academic, and non-academic experts that assesses species at risk of extinction nationally.

Effective population size (N_e)
The average size of a population in terms of the number of individuals that can contribute genes equally to the next generation. The effective population size is usually smaller than the actual size of the population.

Endangered
A species facing imminent extirpation or extinction.

Endemic
Restricted to a region or a part of a region, e.g., an island or country.

Extinct
A species that no longer exists.

Extirpated
As used in text, locally extinct species.

Mitigation
Measures to reduce, prevent, or correct impacts.

Morphological
Related to the measurable characters (body shape, form, proportions) of an organism.

Non-indigenous species

Those species that have been transported through human activities from their native ranges into new ecosystems where they did not evolve. Synonymous with ‘introduced species’ and ‘invasive species’.

Phylogenetic

Study of the evolutionary relatedness among various groups of organisms.

Telemetry

The automatic measurement and transmission of data from remote sources, by radio or other means, for recording and analysis.

Trophic

The position that an organism occupies in a food chain.

Appendix II. Record of cooperation and consultations

There are few people in Canada with scientific, traditional, or local knowledge of the Atlantic Whitefish, as its known historical distribution is limited to two watersheds in southwest Nova Scotia.

To assist in the development of the recovery strategy, DFO brought together a group of experts and representatives from multiple levels of government (federal, provincial, municipal), environmental non-government organizations, academia, industry, and Aboriginal Peoples. Specific member representatives of the Atlantic Whitefish Conservation and Recovery Team and their affiliations during the development of this amended version of the recovery strategy and the original 2006 version can be found on pages i-iii of this recovery strategy.

Comments on both the 2006 draft and the current amended recovery strategies were sought from all members of the Recovery Team. The strategies were also reviewed by relevant provincial government directors from the Province of Nova Scotia, including, but not limited to, the Department of Natural Resources, the Department of Fisheries and Aquaculture, the Department of Transportation and Infrastructure Renewal, and the Department of Agriculture. Given the species range expansion objective, comments on the draft recovery strategy were also sought from other potential relevant parties including Parks Canada Agency, the Tusket River Environmental Protection Association, and the Municipality of Argyle in Yarmouth. All comments received during these reviews were considered and addressed as appropriate.

Acadia First Nations elders from three reserves were interviewed early on in an attempt to gain an understanding of the status, trend, and recovery considerations for Atlantic Whitefish from the local Aboriginal community. Other general communication efforts regarding Atlantic Whitefish have been made with First Nations since the establishment of the Recovery Team in 1999. The Recovery Team presently includes representatives from the Maritime Aboriginal Peoples Council and the Native Council of Nova Scotia – Zone 5. Aboriginal peoples' input into the species' recovery and the draft amended recovery strategy was sought through the Recovery Team process. The draft amended recovery strategy was also circulated more broadly to all regional First Nations and other Aboriginal groups to provide an opportunity for additional input into the document. No comments were received during this review phase.

Recreational anglers were surveyed in preparation for the 2004 Atlantic Whitefish Allowable Harm Assessment (Bradford et al. 2004a). The Recovery Team and other interested stakeholders and Aboriginal communities were invited to participate in the 2009 Recovery Potential Assessment (DFO 2009b). Both of these assessments were subject to a full peer review through the Canadian Science Advisory process (DFO 2004a; DFO 2009b).

Communications regarding Atlantic Whitefish were made regularly with the Yarmouth/ Shelburne County Gaspereau Advisory Committee and the Queens/ Lunenburg County

Gaspereau Advisory Committee, particularly during the early years of the formation of the Recovery Team. These advisory committees are chaired by DFO and deal with the commercial and recreational Gaspereau fisheries.

Provincial Recreational Fisheries Advisory Councils (RFACs) held public consultations over the years preceding the publication of the 2006 recovery strategy in the RFAC 3 area (Lunenburg and Halifax counties) on all initiatives that restricted angling in an attempt to prevent harm to Atlantic Whitefish in both the Petite Rivière lakes and in Anderson Lake. Attendees included representatives from local river, angling, and wildlife associations, and other interested individuals. DFO regularly attends the RFAC meetings and is provided with minutes from the meetings. The province’s representative on the Atlantic Whitefish Conservation and Recovery Team provided regular updates on these consultations to Recovery Team members.

Discussion between DFO and the owners of land surrounding Anderson Lake occurred between June 2003 and November 2005 prior to the release of Atlantic Whitefish into Anderson Lake. DFO and the two landholders have signed Working Agreements which will guide a cooperative approach to development activities around the lake, and will aim to mitigate any potential harm to Atlantic Whitefish. Public meetings with the local community of Petite Rivière were also held prior to the release of captive-reared Atlantic Whitefish into the lower Petite Rivière watershed. Additional community meetings hosted by non-government member organizations of the Recovery Team and including participation from DFO were held to inform the general community of the species’ status and recovery efforts underway.

No comments were received on the 2006 recovery strategy during the 60-day public registry comment period. All feedback received on the proposed amended recovery strategy during the 60-day public registry comment period (June 9 - August 8, 2016) was considered and addressed in the final version of the document.