Determining effectiveness of Ecologically Significant Areas (ESAs) for protecting Striped Bass (*Morone saxatilis*) spawning habitat in the Stewiacke River, NS

By

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Submitted in partial fulfillment of the requirements for the degree

of

Master of Marine Management

at

Dalhousie University

Halifax, Nova Scotia

December 2022

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ABSTRACT

Canada's *Fisheries Act* was modernized in 2019 and included added protections to all fish and fish habitat. To implement some of the new provisions in the *Fisheries Act*, Fisheries and Oceans Canada (DFO) is working on a National Framework for Identifying, Establishing, and Managing Ecologically Significant Areas (ESA). An ESA is a spatial regulatory tool for the protection and conservation of fish and fish habitat and can apply to freshwater, estuarine, and marine waters. ESAs are areas of fish habitat that are sensitive, highly productive, rare, or unique. As there are currently no ESAs in Canada, DFO is working on case studies to better understand how ESA provisions could apply in practice and to inform the development of the National ESA Framework. In DFO's Maritimes region, one case study being explored is the Stewiacke River, as it is home to the last spawning ground for the Bay of Fundy Striped Bass (*Morone saxatilis*) population. Striped Bass is an important species in the region. It holds cultural importance to Mi'kmaq and is an important recreational fishery. The DFO *Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk* was used as a guide for completing a risk assessment and adapted for the application to the ESA case study. The risk assessment was used to identify and analyze the human threats to Striped Bass spawning. Recommendations around applicability of the risk assessment for analysis of ESA case studies were made, and next steps for the Stewiacke River ESA case study were identified.

Keywords: Striped Bass, Ecologically Significant Areas, fish habitat, spawning, human impacts

LIST OF ABBREVIATIONS

AIS	Aquatic Invasive Species
BoF	Bay of Fundy
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPO	Conservation and protection objective
DU	Designatable Unit
DFO	Fisheries and Oceans Canada
ESA	Ecologically Significant Area
FSC	Food, Social and Ceremonial
HSP	Habitat Stewardship Program
iBoF	inner Bay of Fundy
LGB	Live Gene Bank
NCNS	Native Council of Nova Scotia
NSSA	Nova Scotia Salmon Association
PoE	Pathways of Effects
RPA	Recovery Potential Assessment
SAR	Species at Risk
SARA	Species at Risk Act
YoY	Young of year
MMM	Master of Marine Management
GP	Graduate Project

ACKNOWLEDGEMENTS

There are many people that supported me throughout this work that I would like to thank. First, thank you to my internship hosts, the Integrated Planning team in the DFO Maritimes Region, for having me this summer. I thoroughly enjoyed my experience working for DFO and learning about fish habitat protection. In particular, thank you to Aimee Gromack for her support and guidance during my term with DFO this summer. Aimee's wealth of knowledge and support helped me in understanding the complexities of the project. Thank you to the rest of the team at DFO for their ongoing support and helpful feedback, including Ben Collison, Sean Butler, and Craig Hominick.

I would also like to thank my academic supervisor, Dr. Danika van Proosdij, for support, guidance, flexibility, and advice with this project. Her ongoing support and feedback throughout are greatly appreciated. Thank you also to the Marine Affairs faculty for their support and guidance throughout the process of completing this project.

CHAPTER 1 INTRODUCTION

Canada's *Fisheries Act* first became law in 1868. One of its aims has been to protect fish and fish habitat to support healthy and productive fisheries, focusing on habitat protection and pollution prevention (DFO, 2019b). The *Fisheries Act* was modernized in 2019 to strengthen protections to all fish and fish habitat (DFO, 2019a). To implement some of the new provisions in the *Fisheries Act*, Fisheries and Oceans Canada (DFO) is working on a *National Framework for Identifying, Establishing, and Managing Ecologically Significant Areas (ESA)* (hereafter referred to as the ESA Framework). An ESA is a spatial regulatory tool for the protection and conservation of fish and fish habitat (DFO, 2022a). ESAs are areas of fish and fish habitat that are sensitive, highly productive, rare, or unique (DFO, 2022a). This area-based management tool can apply to freshwater (including riparian zones), estuarine, and marine waters. The ESA Framework will set guidance on how to establish ESAs throughout Canada. After establishment, each ESA will have its own regulations based on specific conservation and protection objectives (CPOs). These regulations will help to protect, conserve, and restore important fish habitat for the long-term protection and conservation of these important habitats (DFO, 2019a).

As there are currently no ESAs in Canada, DFO is working on case studies to help inform the development of the ESA Framework. These case studies may also be potential ESA candidates for establishment. In DFO's Maritimes Region, one case study being explored is the Stewiacke River, as it is home to many important species. The Stewiacke River is located on the eastern side of the Bay of Fundy (BoF) and drains to Cobequid Bay through its connection to the Shubenacadie River (**Figure 1**). The only remaining spawning habitat that is used annually by BoF Striped Bass (Morone saxatilis) Designatable Unit (DU) is located in the bottom reaches of the Stewiacke River, in Colchester County. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the BoF Striped Bass as ‘endangered’ in 2012 due to the loss of the two other historic spawning populations (COSEWIC, 2012). Spawning runs in other river systems (i.e., Saint John River, New Brunswick and Annapolis River, Nova Scotia) no longer exist. This is a result of passage barriers (dam in the Saint John River; causeway and tidal station in the Annapolis River) and other anthropogenic impacts affecting water quality (DFO, 2014b).

This case study will focus on a single species, the BoF Striped Bass. Striped Bass is an important species in the region. Striped Bass, or Ji’kaw in Mi’kmaq, holds cultural importance to Mi’kmaq in the region and it is an important part of Food, Social and Ceremonial (FSC) fisheries (Alton Natural Gas, n.d.; DFO, 2014b). It is also an important recreational fishery, and anglers throughout the Bay of Fundy fish for Striped Bass in tidal and non-tidal waters (Bradford et al., 2015). There are no current population abundance estimates for adults from the Shubenacadie population (DFO, 2014b). However, it is known that the population is spawning successfully every year (DFO, 2014b). Given the importance of the Striped Bass fisheries in the region, and that there is only one spawning site remaining for the BoF population, protections may be needed to ensure the continued success and potential recovery of the population. Due to the many activities going on in the area, it is necessary to understand what the threats are to Striped Bass and their habitats to conceptualize how an ESA designation could apply regulations to avoid and mitigate the threats to Striped Bass spawning and ensure protection of the habitat for future generations. Environmental non-government organizations (ENGOs), First Nations, and government agencies have invested resources into restoration and stewardship projects in the greater Stewiacke River Watershed in an effort to recover the Stewiacke River to its historical state (NSSA, 2020).

While Striped Bass use the larger Stewiacke and Shubenacadie watersheds, as do many other fish species, the spatial extent of the case study focusses on the only known remaining spawning ground for the BoF Striped Bass population, which is located 0-6 km upstream of the confluence of the Shubenacadie and Stewiacke Rivers (DFO, 2014b; **Figure 2**). The migration corridor was considered for fish passage only, as it connects overwintering habitat that is important for Striped Bass migration. The focus on Striped Bass spawning is an important conservation consideration. Habitats that are used for spawning and early life stages are generally the most important for species recovery and survival (DFO, 2021), and thus warrant proactive protection. An ESA designation for this area could help to ensure survival and continued success of the species for future generations.

CHAPTER 2 BACKGROUND AND LITERATURE REVIEW

2.1 Protected Areas in Rivers

Protected areas are a conservation tool that has long been used in the terrestrial and marine realms (Abell et al., 2007). In general, protected areas aim to regulate human activities within their boundaries in order to conserve or restore ecological features (Bower et al., 2015). Terrestrial and marine protected areas have been applied and studied in case studies throughout the world. However, while rivers are important for biodiversity and ecological function for both marine and freshwater species, protecting them is less understood (Hannah et al., 2019). There are few protected areas that are specifically drawn around rivers. While rivers and other freshwater bodies may get incidental protection through inclusion within a terrestrial protected area, they have generally not been the focus of protection (Bower et al., 2015; Nel et al., 2009). This means regulations are generally not geared towards the protection of freshwater.

While protected areas in rivers and freshwaters are less understood, there is a growing number of studies on the subject. For rivers specifically, boundaries and connectivity are an important consideration in their design (Acreman et al., 2020; Bower et al., 2015; Moilanen et al., 2008). Given that surface water runs over top of land before entering river systems, water and habitat quality in rivers can be impacted by activities that are happening upstream (Collison & Gromack, 2022). One method in protecting river ecology is done on a catchment basis to encompass activities on land and in the most upstream reaches of a system (Acreman et al., 2020; Moilanen et al., 2008). River systems connect important habitats for species that use them. For example, migratory fish species may rely on rivers that connect spawning, foraging and rearing habitat. While protecting one important habitat for migratory species may provide benefits, a more effective protected area would maximize the number of key fish habitats to ensure protection at various life stages (Bower et al., 2015). Thus, considering these habitats and how they connect is necessary when designing protected areas around rivers. These two considerations are important in the case of the Bay of Fundy Striped Bass and the protection of their spawning habitat. Past work will help to inform how to protect this migrating species from human impacts in the watershed.

2.2 National Framework for Identifying, Establishing, and Managing Ecologically Significant Areas

One important aspect of DFO's mandate is the protection of fish and fish habitat (DFO, 2022a). Modifications were made to the *Fisheries Act* in 2019 to include stronger protections for fish and fish habitat (DFO, 2022a). As a result, DFO is currently working on establishing the National ESA Framework. While this framework can apply to freshwater, estuarine and marine waters, the intent is to focus on estuarine and freshwater habitats that currently do not have regulatory conservation tools that can be applied to address non-fishing threats the same way ESAs can; marine waters in Canada can be protected through marine protected area regulations (DFO, 2022a; ECCC, 2022).

The National ESA Framework is currently in the draft stages and has been posted online for public feedback (DFO, 2022a). This framework provides information on how DFO will apply ESA provisions in Canada, and will act as a guide identifying, establishing, and managing ESAs. It includes details on ESA ecological criteria, defining CPOs, prioritization considerations for ESA candidate sites (DFO, 2022a). This document was used as a guide throughout this case study to determine whether the site is a suitable ESA candidate (**CHAPTER 4**).

2.3 Striped Bass Ecological Overview

Atlantic Striped Bass is an anadromous fish, meaning they are born in freshwater, mature in marine waters, and migrate to freshwater to spawn (Jacques Whitford, 2007). They can be found in coastal and estuarine waters along the eastern coast of North America, and in freshwater streams in this region (Andrews, Dadswell, et al., 2019). The range of the species reaches St. John's River, in Florida, to the St. Lawrence River in Canada (Andrews, Dadswell, et al., 2019; Bradford et al., 2015; DFO, 2014b). The Canadian populations of Striped Bass have been assessed by COSEWIC (2012b) and broken up into three DUs, which include the St. Lawrence River DU, Gulf of St. Lawrence DU, and the Bay of Fundy DU. The BoF DU is comprised of three historic river-run populations, which are the Saint John River, New Brunswick population, and the Annapolis River and Shubenacadie River populations in Nova Scotia (DFO, 2014b). The suspected Saint John River spawning site is located near the Mactaquac Dam, built in 1967 (DFO, 2014b). It is suspected that the construction of the dam had extensive impacts on Striped Bass spawning (COSEWIC, 2012). Genetic analyses conducted in 2018 gave evidence of the presence of a spawning population in the Saint John River (Bradford et al., 2012; Leblanc et al., 2018; Smith, 2018). However, no spawning has been observed in the Saint John River in the last 3 decades (DFO, 2014b). Spawning no longer occurs in the Annapolis River since the construction of the Annapolis Royal Causeway in 1960 and the Annapolis Tidal Station in 1980, which impede access to spawning habitat located upstream (Bradford et al., 2015; DFO, 2014b).

The Shubenacadie River population of Striped Bass has been shown to have adapted to the dynamic environment in the tidal river in which they spawn (DFO, 2014b). Characteristics found in the eggs of the Shubenacadie River population include larger diameters, lower specific gravity, and tolerance to a broad range of salinity, all of which increase the survival rates of eggs (Bradford et al., 2012). Additionally, the BoF Striped Bass have higher intrinsic growth rates in the first year of life when compared to other US spawning populations (DFO, 2014b). This is likely an adaptation to survive the long and cold winters in the region (DFO, 2014b). Important habitats for the life stages of Shubenacadie Striped Bass include the spawning site, overwintering site, migration corridor, and rearing habitat (**Figure 2**).

The area located in the Stewiacke River 0-6 km upstream of the confluence of the Shubenacadie and Stewiacke Rivers is the only known Striped Bass spawning habitat used annually by the BoF population (DFO, 2014b; Duston et al., 2018). Adults spawn in tidal freshwater or slightly brackish waters where the fertilized eggs are suspended in the water column for two to three days before hatching (Bradford et al., 2015; COSEWIC, 2012; Duston et al., 2018). The larval stages and early Juveniles remain in fresh or slightly brackish water during their early life stages, and will quickly migrate to coastal, estuarine, and salt waters for maturation in the summer (COSEWIC, 2012). During the fall and winter, they return to the estuaries or freshwater habitats and subsequently to their natal spawning sites in the spring (COSEWIC, 2012).

Age of first spawning is generally 3-4 years for males and 4-6 years for females (DFO, 2014b). In the Stewiacke River, spawning mostly occurs at high tide between 0-6 km upstream of the confluence with the Shubenacadie River (DFO, 2014b; Duston et al., 2018). The eggs are then passively transported downstream into the Shubenacadie River estuary and up and down the estuary by the tide; the eggs will hatch approximately two days later (Duston et al., 2018). The habitat requirements needed for Striped Bass spawning are varied and depend on a wide range of physical and chemical characteristics (COSEWIC, 2012; DFO, 2014b). Physical characteristics include adequate flow velocity and water temperature (Bradford et al., 2015). Spawning usually begins in the spring when water temperatures reach 15-16^{o}C (Dugdale et al., 2018; Rulifson & Dadswell, 1995). In the Stewiacke River, the spawning period usually occurs in the months of April to June (DFO, 2014b). Adequate current and turbulence is needed to keep the eggs in suspension in the water column until they hatch, which is between 30.5-500 cm/s (Andrews, Dadswell, et al., 2019). Chemical characteristics include salinity (≤ 1parts per thousand (ppt)) and dissolved oxygen (DO) concentrations (≥5mg/L) (DFO, 2014b). Eggs can tolerate salinity of up to 20 ppt (DFO, 2014b).

After hatching, larval Striped Bass spend time in estuarine waters within the Shubenacadie and Stewiacke Rivers where they forage for food. The intertidal zone in Cobequid Bay, which has warm water temperatures and low salinities, is suitable habitat for nursery sites (COSEWIC, 2012; DFO, 2014b). Most age 0+ Striped Bass are known to overwinter in brackish tidal waters (Bradford et al., 2015). However, there is little known about specific overwintering sites and how the Striped Bass are using the habitat during this time (Andrews, Buhariwalla, et al., 2019; DFO, 2014b). Some of the age 2+ Striped Bass from the Shubenacadie population overwinter in freshwater in Shubenacadie-Grand Lake (Andrews, Buhariwalla, et al., 2019). Spawning age Striped Bass will then migrate downstream to the spawning site in the spring (Andrews, Buhariwalla, et al., 2019). Adult Striped Bass are not limited to overwintering in freshwater environments. Anglers have made the distinction between “black-back” Striped Bass, which overwinter in freshwater, and “green-back” Striped Bass, which overwinter in marine environments (Andrews, Buhariwalla, et al., 2019). “Green back” Striped Bass will begin their migration in April to reach the spawning ground in the Stewiacke River by the third week of May (Rulifson & Dadswell, 1995). Adult Striped

Bass have been located in the surface waters of the Minas Passage during the winter months (Keyser et al., 2016).

Rearing habitat is any habitat outside of primary spawning habitat that is used by juvenile Striped Bass for feeding and growth (DFO, 2014b). There are still knowledge gaps in the range of habitats used by juvenile Striped Bass, though they are widely dispersed (Bradford et al., 2012; DFO, 2014b). It is known that the Shubenacadie River population occupy the tidal portions of the Shubenacadie and Stewiacke Rivers, the shoreline of Cobequid Bay, and the shoreline of the Minas Basin by the end of the first growth season (DFO, 2014b). Saltmarshes are also important nursery habitat for Striped Bass (Rabinowitz & Andrews, 2022). Young of the year (YoY) Striped Bass prefer water temperatures of 16ºC-20ºC (Bradford et al., 2012). The geographic range of age 1+ Striped Bass is less understood. There is little indication that rearing habitat is limiting for Striped Bass (DFO, 2014b).

Foraging habitat is any habitat used by post-larval fish to forage for feeding. Tidal wetland habitat along the river, including saltmarsh, is important foraging habitat for Age 0+ Striped Bass (Bradford et al., 2015; DFO, 2014b). In the larval stage, Striped Bass feed on zooplankton and small invertebrates (DFO, 2014b; Rulifson & McKenna, 1987). Their diet becomes more diverse with age, and adult Striped Bass prey on mysids, polychaetes, crabs, Rainbow Smelt, Atlantic Silverside, Alewife, Blueback Herring, American Shad, Atlantic Herring, Atlantic Tomcod, and American Eel (Bradford et al., 2015; DFO, 2014b). In the Stewiacke and Shubenacadie Rivers, saltmarsh habitat has been converted to agricultural lands through the construction of dykes, thus removing important foraging habitat (DFO, 2014b). Despite this, there is little indication that foraging habitat is a limiting habitat (DFO, 2014b).

Striped Bass migrate between freshwater and saltwater throughout their life stages. Individuals return from saltwater to their natal streams to spawn (COSEWIC, 2012). For the Shubenacadie population, the migration corridor connecting overwintering, spawning, foraging, and ocean habitats is important for carrying out various life stages and population survival (DFO, 2014b). The migration corridor includes the Shubenacadie River, which connects the Grand Lake overwintering habitat to the spawning site and reaches Cobequid Bay (DFO, 2014b). The migration corridor is important for connectivity and access to habitats.

2.4 Mi'kmaq Social and Cultural Significance

The Stewiacke River is located in the traditional Mi'kmaw district of Sipekne'katik; its placename means "place where groundnuts grow" (Ta'n Weji-sqalia'tiek, 2022). The traditional Mi'kmaw name for the Stewiacke River is Sesiktewiaq, which means "whimpering as it flows out" (Ta'n Weji-sqalia'tiek, 2022). This region is important for Mi'kmaq groups who use the land for traditional use activities, including fishing, game hunting, gathering, and use of medicinal, food, and spiritual plants (Membertou Geomatics Consultants, 2006; Membertou Geomatics Solutions, 2012). There are four reserves in the broader area of the case study, as seen in **Figure 1**. Striped Bass is an important species locally, and it currently supports FSC fisheries in the region (DFO, 2014b).

Given the importance of the area and Striped Bass for Mi'kmaq groups, this case study presents an opportunity for collaborative management. This could include co-management frameworks and education and outreach opportunities. Incorporation of two-eyed seeing in management would allow for Mi'kmaq and Western worldviews to complement each other and provide a more holistic approach (Rayne et al., 2020). While this was beyond the scope for this study, exploring collaborative management approaches is an important next step should this case study be pursued for ESA designation.

2.5 Hydrology

The Shubenacadie River is a tidal bore river that is approximately 50km in length, 30km of which are tidally influenced (Duston et al., 2018). The tidal bore rivers present dynamic environments where water is pushed against the current from tidal surges, resulting in large changes in water quantity and quality within minutes (Rulifson & Tull, 1999). It is believed that the Shubenacadie-Stewiacke river system is the only tidal bore river system that supports a spawning Striped Bass population (Rulifson & Tull, 1999). Similarly, the bottom 12km of the Stewiacke River are tidally influenced (Duston et al., 2018). The tidal portions of the rivers are estuarine in nature and have salinities that range from 0-25 ppt (Jacques Whitford, 2007). Due to the tidal nature of the downstream reach, the river fluctuates in salinity, temperature, water elevation, suspended sediment, and river bottom configuration over short periods of time (Jacques Whitford, 2007; Rulifson & Tull, 1999).

2.6 Human Activities

There are many human activities going on in the Stewiacke River watershed that may impact Striped Bass and their habitat. These human activities have been broken down into five general categories, including impacts to connectivity, water quality, direct physical disturbances, direct mortality of Striped Bass, and other. These human activities are described below.

2.6.1 Connectivity

2.6.1.1 Barriers to Fish Passage

Barriers to fish passage can impede migration of fish between critical habitats, which can then impact their ability to perform critical life functions (DFO, 2010, 2015a; Erkinaro et al., 2017). Barriers to fish passage can reduce the range of the species and cut them off from important foraging, overwintering, and spawning habitats, leading to impacts on population abundance (Erkinaro et al., 2017). Barriers in the ESA case study boundary include culverts, aboiteaux, and water control structures.

Culverts

Culverts are a type of water conduit that can be used under roads in watercourse crossings (Erkinaro et al., 2017). They impact fish passage when they are perched (i.e., the outlet of the culvert is too high for fish to access), have blockages, or have inadequate slope, water depth, or water flow (DFO, 2015a). Fish friendly culvert design considers all these issues. Open bottom culverts and bridges are alternative solutions that can be used to avoid causing fish passage issues (DFO, 2015a). Currently, there are two culverts located along the main stem of the Shubenacadie River between Grand Lake and the spawning site, which is along the Striped Bass migration corridor. There are no culverts present downstream of the spawning site (**Figure 3**). The migration corridor is important for spawning Striped Bass to access overwintering habitat in Grand Lake and subsequently migrate to the spawning site in the Stewiacke River. Thus, it is important to understand if the present culverts are impeding access to fish habitat and ensure any future culverts do not impact Striped Bass migration.

Dykes and Aboiteaux

Dykes are an elevated section of graded land that separates from adjacent water; they are mainly used for flood risk reduction or water conveyance purposes (Nova Scotia Department of Agriculture, 2022). Aboiteaux are a type of water control structure that controls drainage between a tidal area and the drained upland area (Nova Scotia Department of Agriculture, 2022). Together, dykes and aboiteaux form a dykeland system to keep saltwater out of the saltmarsh and make the land usable for agriculture (Landscape of Grand Pre Inc., n.d.). Dykes and aboiteaux were built in the 1600s by French settlers and were most recently upgraded during the 1950s and 1960s (Landscape of Grand Pre Inc., n.d.; Nova Scotia Department of Agriculture, 2022). The combination of dykes and aboiteaux create a system where saltmarsh that was suitable foraging habitat was removed and converted to agricultural land (DFO, 2014b; Landscape of Grand Pre Inc., n.d.). This has historically resulted in loss of possible saltmarsh usable for foraging habitat by Striped Bass (DFO, 2014b). **Figure 4** shows modeled estimates of saltmarsh habitat before dykes were built in the area; these areas are now mainly agricultural dykelands.

Within the Striped Bass spawning area, approximately 55% of the total shoreline length has dykes present (S. Butler, personal communications, August 2022). It is suspected that dykes and aboiteaux result in a build-up of sediment in the watercourse following construction of the structures, which continues until a new equilibrium is reached (van Proosdij et al., 2009). Salt marshes can sequester suspended sediment from tidal waters (Rabinowitz & Andrews, 2022). The construction of dykes on salt marshes can potentially reduce the volume of sediment deposited and sequestered within the marsh (Rabinowitz & Andrews, 2022; R. Bradford, DFO, personal communications, May 11, 2022). Whether the reduction in depositional area following construction of dykes alters the geomorphology of tidal channels, specifically more extensive buildup of sediment within tidal channels, does not appear to be well understood. Thus, it is not known whether the rate of stranding of fertilized striped bass eggs, which are typically pelagic during incubation, is higher as a result unnaturally high sediment build up. However, it is seemingly plausible (R. Bradford, DFO, personal communications, May 11, 2022). Under the scenario of elevated rates of egg settlement, an increase in natural mortality may result from loss of eggs due to heat stress and desiccations (R. Bradford, personal communications, May 11, 2022). The impacts from loss of saltmarshes may be exacerbated by other sources of increased sedimentation as a result of cumulative effects and climate change (Section **2.6.5.2**). Future analysis would be needed to determine the potential for dyke and aboiteaux removal in the area, coupled with salt marsh restoration, and whether this would benefit Striped Bass.

Dams

Dams can cause a barrier across a watercourse, cause changes in flow regime, elevation differences, temperature differences, and impacts to sediment transport (Fielding, 2011; NOAA Fisheries, 2021a). Common applications for dams include power generation, irrigation, flood control, water supply, recreation, and more (Fielding, 2011; NOAA Fisheries, 2021b). Five dams are located within the Stewiacke River watershed, of which there are no fishways present (Fielding, 2011; NOAA Fisheries, 2021a). There are currently no dams located in the Striped Bass migration corridor or spawning area. Within the BoF DU, the construction of the Mactaquac Dam is suspected to be one of the main contributing factors to the decline of the spawning population in the St. John River (COSEWIC, 2012; DFO, 2014b; Smith, 2018). Given their potential to cut off access to fish habitat, protections would be needed to ensure future dams do not impact Striped Bass migration in the Shubenacadie River in the future.

Other Passage Barriers

Other passage barriers have impacted other spawning populations within the BoF DU. The construction of the Annapolis Royal Causeway and the Annapolis Tidal Station have been attributed to the extirpation of the Annapolis River spawning population (COSEWIC, 2012; DFO, 2014b). Thus, other passage barriers must be avoided to prevent a similar outcome for the Shubenacadie spawning population.

2.6.2 Water Quality

2.6.2.1 Forestry

Forestry practices, including clearcutting adjacent to rivers, can have impacts to water quality and quantity. Clearcutting of riparian habitat can result in an increase in water temperatures due to lack of shade, sedimentation, and erosion of river banks due to destabilized banks and increased runoff (Ohira et al., 2021). Best practices in forestry include using riparian buffer zones to maintain water quality in watercourses (Collison & Gromack, 2022). However, this is often not enough to prevent the impacts of increased peak runoffs.

Forestry practices within the Stewiacke River watershed are mainly taking place upstream of the spawning site; Colchester County produces hardwood and softwood products (Stantec Consulting Ltd., 2012). Near the spawning area, approximately 13% of the land within a 100 m buffer of the Striped Bass spawning area is forested (**Figure 5**). Given that much of the land adjacent to the spawning area is agricultural dykeland (**Figure 4**), there is little to no riparian forest habitat remaining in this area.

Due to the little remaining forest cover in the case study boundary, forestry will not be considered in the risk analysis. However, forestry practices upstream of the case study boundary may contribute cumulative effects and thus impact Striped Bass (Collison & Gromack, 2022). Given that ESA regulations do not provide protections beyond riparian habitat, coordination with other regulatory frameworks for land-use activities are needed to manage upstream activities in the watershed (Acreman et al., 2020; DFO, 2022a).

2.6.2.2 Agriculture

Agriculture is one of the main land uses surrounding the spawning area, with approximately 76% of the land within a 100m buffer of the Striped Bass spawning area being used for agriculture (**Figure 5**). Within Colchester County, agricultural lands are primarily used for forage crops, dairy cattle, and beef production (Stantec Consulting Ltd., 2012). However, the specific agricultural uses within the ESA case study boundary are not known. Further investigation is needed to determine the type of agriculture occurring within the case study boundary. Agricultural practices may impact Striped Bass through livestock grazing, chemical application to crops, and other agricultural practices described below.

Streamside livestock grazing can impact Striped Bass eggs through changing the water quality through introduction of feces (DFO, 2010; Province of Nova Scotia, 2017).

Feces in the water results in an increase in pathogens and nutrients; increased nutrients in the water can result in eutrophication and lower dissolved oxygen concentrations (DFO, 2010). Use of chemicals, pesticides, and fertilizers for growing crops can also impact water quality when runoff carries them from adjacent land and into the river. Other agricultural practices, such as tilling the land, can result in higher sediment loads into watercourses (Province of Nova Scotia, 2017). There are best management practices that can be used to minimize the sediment loads and pollutants into the watercourse, including using cover crops over the winter months, erosion control measures, and buffer strips adjacent to watercourses (Province of Nova Scotia, 2017). Due to the proximity and amount of agriculture taking place near the spawning site, it is assumed that agricultural practices are discharging sediments and other pollutants into the spawning area.

2.6.2.3 Other Resource Extraction Projects

Natural Gas

The Alton Natural Gas Storage Project was a project that proposed to build an underground natural gas storage facility near Stewiacke, NS (Alton Natural Gas, 2022). The project involved building a cavern in natural underground salt formations to then store the natural gas (Alton Natural Gas, 2022). To do so, tidal water would be pumped from the Shubenacadie River into underground salt formations. This water would dissolve the salt and create the cavern, producing brine as a by-product to be discharged back into the Shubenacadie River (Manríquez-Hernández et al., 2020b).

This project was halted when the Nova Scotia Supreme court ruled that Sipekne'katik First Nation was not adequately consulted about the project (Grant, 2020). The Nova Scotia Environment Minister was ordered to resume talks with Sipekne'katik

First Nation for 120 days (Ritchie, 2020). The project was cancelled in 2021 (Alton Natural Gas, 2021).

While there were concerns from multiple parties about the impacts of this project to the river ecosystem, studies concluded the discharge of brine would have a low direct threat to Striped Bass (Manríquez-Hernández et al., 2020a). However, these kinds of projects have the potential to alter the physical and chemical components needed for Striped Bass spawning. While the Alton Gas project was cancelled, there is still potential for future projects to be proposed in the region. Thus, any future natural gas projects that may impact Striped Bass spawning should be considered in a future risk analysis.

Mining

Mining activities have the potential to impact fish habitat by diverting water via watercourse realignment, changing flows through extraction, causing sedimentation by use of heavy machinery and riparian vegetation removal, and discharging chemical effluents and exposing naturally occurring chemicals to watercourses through mineral extraction (Nichols, 2014). There are current exploration licenses in the main stem of the Stewiacke and Shubenacadie Rivers, as seen in **Figure 6**. There is potential that these exploration licenses would turn into full scale mining operations in the future, posing a risk to the Striped Bass spawning area; however, there are no current mining activities in this area at this time (Nova Scotia Department of Natural Resources and Renewables, 2018). Future mining activities in the area may cause impacts to Striped Bass spawning habitat and should be considered in a risk assessment.

2.6.3 Direct Physical Disturbance

2.6.3.1 Work In or Near Water

Any work with heavy machinery in or near the water may have detrimental impacts to spawning Striped Bass and their eggs. Heavy machinery has the potential to change the composition of the river bottom (DFO, 2010). Sediments, other contaminants, and erosion could also occur due to work with heavy machinery near water, all of which may lead to unsuitable conditions for spawning (DFO, 2010). More intensive work in water, including dredging and infilling, could significantly alter the river bottom and disturb habitat (DFO, 2010).

2.6.3.2 Habitat Restoration

Some dykes in the BoF region are vulnerable to breaches, particularly due to increasing frequency and intensity of storms due to climate change (Nova Scotia Department of Agriculture, 2022). Upgrades to the dykes are needed to provide flood protection to lands and communities into the future (Nova Scotia Department of Agriculture, 2022). While there are different strategies that can be used for dyke upgrades, some options involve the restoration of tidal wetlands (Nova Scotia Department of Agriculture, 2022). Managed realignment is a technique that has been used in the region, in which a new dyke is built behind the existing dyke, and the existing dyke is breached to allow the land to be reinhabited by native species and re-establish the saltmarsh over time (Sherren et al., 2016).

The Province of Nova Scotia is currently doing work to upgrade the most vulnerable dykes in the province. These dykes are being upgraded to protect valuable land that is vulnerable to climate change risks, including coastal flooding (Nova Scotia

Department of Agriculture, 2022). The case study area has not been identified as one of the priority sites for upgrades, and thus the potential for saltmarsh restoration in the future is unknown (Nova Scotia Department of Agriculture, 2022). While the purpose for upgrading dykes is for the protection against climate impacts, restoring saltmarsh may provide more foraging habitat that could be used by Striped Bass (DFO, 2014b).

2.6.4 Direct Mortality

2.6.4.1 Fisheries

Management of diadromous fish species, including Striped Bass, is the responsibility of DFO (DFO, 2015b; Province of Nova Scotia, 2022). Fishing for Striped Bass in tidal waters is open year-round and requires no license; the fishing season for inland waters corresponds with the longest season for sportfish and requires a license from the Province of Nova Scotia (DFO, 2015b; Province of Nova Scotia, 2020, 2022). The bag limit is 1 fish which must be 68cm in length or longer, except between May 10-June 10 (DFO, 2015b). During this time, it is catch and release only between Grand Lake to the confluence of the Shubenacadie and Stewiacke Rivers and in the Stewiacke River from the Pollock Bridge in Stewiacke East to the confluence with the Shubenacadie River (DFO, 2015b; Province of Nova Scotia, 2022).

The Striped Bass RPA identifies the directed recreational angling fishery, bycatch in commercial fisheries, bycatch in recreational angling fisheries, and FSC fisheries as the primary threat to the Shubenacadie Striped Bass population (DFO, 2014b). While these fishing activities may not be occurring within the case study boundary, they may impact spawning adults. Other recreational fisheries in the region include Gaspereau, trout, Smallmouth Bass, Chain Pickerel, Perch, Striped Bass, Shad, smelt, and American

Eel (Province of Nova Scotia, 2022). Commercial fisheries in the iBoF region and estuary but outside of the study area include Winter Flounder, American Shad, and Gaspereau (Jacques Whitford, 2007). Historically, there were commercial Atlantic Salmon, Striped Bass, and Atlantic Sturgeon fisheries in the region, which have now been closed. These fisheries are now bycatch only (Jacques Whitford, 2007). FSC fisheries for Striped Bass are not subject to a total take (DFO, 2014b). Bycatch from other FSC fisheries in the region also impacts Striped Bass (COSEWIC, 2012).

While the impacts from fisheries to Striped Bass are well documented and are included in the risk assessment, fisheries management and associated regulations go beyond the scope of this study. However, a potential ESA designation would need to consider if fishing could be better managed to address conservation and protection objectives of this area. Thus, future work on this case study should consider a detailed analysis on fisheries management.

2.6.5 Other

2.6.5.1 Aquatic Invasive Species

Aquatic invasive species (AIS) in the river system can threaten native species and decrease overall fish abundance (Mitchell et al., 2010). The two main AIS species in the region include Smallmouth Bass and Chain Pickerel, as seen in **Figure 7**. Although there have been no confirmed sightings within the Striped Bass spawning habitat, these species may still be present in this area.

Smallmouth Bass in Canada is native to the Great Lakes and the St. Lawrence River system. They are a highly competitive species and prey on smaller fish (DFO, 2009). They were intentionally introduced to lakes in Nova Scotia between 1905 to 1953 for the purpose of sportfishing (DFO, 2009; Loppnow et al., 2013). The last known legal introduction in Nova Scotia occurred in 1984 (DFO, 2009). The species has spread in the province due to natural dispersal, illegal introductions, and climate change (Loppnow et al., 2013). Chain Pickerel was illegally introduced to three Nova Scotia lakes in 1945 and have since spread to over 95 known locations throughout the province (Loeza-Quintana et al., 2021; Mitchell et al., 2010). Chain Pickerel is a large predator and their presence in lakes is shown to negatively impact fish communities in lakes (Mitchell et al., 2010).

Management of AIS species is a challenge. There have been several methods used to remove AIS globally with different success rates, including chemicals, physical removal, and biological control (Rytwinski et al., 2019). Many AIS species will never be removed entirely and must instead be managed. Public education campaigns are one tool that can help prevent the spread of AIS (Loppnow et al., 2013). Further work is needed to understand if ESA regulations could be used to manage AIS, but this is beyond the scope of this study. As such, AIS were not included in the risk assessment.

2.6.5.2 Climate Change

Climate change is expected to have impacts on water temperatures and hydrology, which can then impact Striped Bass behaviour and survival. Shubenacadie Striped Bass have been shown to have a greater tolerance to broader temperature ranges when compared to southern populations (Cook et al., 2006; Penny & Pavey, 2021). This adaptation may be beneficial given that river temperatures in the region are expected to increase due to climate change (Dugdale et al., 2018). The spawning season, which is marked by water temperatures reaching 15°C in the spring, may progressively happen earlier (Dugdale et al., 2018). The length of the growth season for YoY Striped Bass, which ends when water temperatures drop below 10°C, may increase (Dugdale et al., 2018). Additionally, changes in weather patterns may result in changes to freshwater hydrology. Studies have shown that larval Striped Bass are more abundant when there are high amounts of freshwater flow (O'Connor et al., 2012). Thus, droughts may impact the survival rates of Striped Bass in the future. Finally, changes in water flow may cause changes in erosion and sedimentation in the water channel. Striped Bass egg development has been shown to be slowed at suspended sediment concentrations above 1,300 mg/L, but hatching of eggs is generally not impacted by higher sediment concentrations (Morgan II et al., 1983).

While these hypothesis on the impacts of climate change on Striped Bass use the best science currently available, there are several knowledge gaps in the understanding of the potential impacts of climate change in this region and how seabed changes can affect the Striped Bass population. Given the complexity of climate change and that it is an indirect pressure, it was not included in the risk assessment. However, climate change impacts to Striped Bass should be well understood for making management decisions. Knowledge gaps regarding climate change are an area for future work.

CHAPTER 3 METHODOLOGY

3.1 Positionality

The work for this case study was supported by DFO through the completion of my Master of Marine Management (MMM) internship, which took place from April-August 2022. As such, I was able to complete this work for the mutual benefit of DFO and the MMM graduate project. Linking the graduate project with the work at DFO allowed me to use knowledge gained during the internship and apply it to my work for the GP. Conversations with colleagues within DFO were instrumental for guiding my work and gaining insights on the progression of the work to date for this case study. The methodology for this report was developed in partnership with DFO, and thus applies an existing DFO risk assessment framework.

3.2 Literature Review

In order to determine whether an ESA is an appropriate tool to address potential future threats to Striped Bass (BoF population) in the Stewiacke River, a literature review was conducted to synthesize available information about biophysical considerations and human interactions for this species in the case study boundary. Collected information includes scientific journal articles, grey literature, spatial datasets, and websites. Discussions with subject matter experts within DFO also provided important context on the subject of Striped Bass, climate analysis of various fish species, FSC fisheries, and ESA design. After information was compiled through the literature review, a preliminary risk assessment was executed to understand the main threats to Striped Bass spawning, described further in Section **3.3**.

Using the results from these processes, ESA feasibility was assessed by determining whether the case study meets the ESA ecological criteria definitions in the Draft ESA Framework, drafting regulatory considerations using ESA provisions in the *Fisheries Act* (s 35.2), comparing the case study with prioritization criteria used in the Draft ESA Framework, and considering challenges for ESA establishment. Next steps and recommendations for this ESA case study were developed using existing published literature suggestions for further research and with input from subject matter experts.

3.3 Risk Assessment

A high-level risk assessment was conducted to identify and analyze the human threats to Striped Bass spawning. The DFO *Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk* (hereafter referred to as the 'SAR Risk Framework') was used as a guide for completing the risk assessment and adapted for the application to the ESA case study (DFO, 2014a). While there are other risk assessment methodologies used by DFO and some that are in development, the SAR risk framework was used for this case study because of the single-species focus.

The scope of the risk assessment was narrowed to include only a threats assessment at the population level, not at the species level (DFO, 2014a). The threats assessment aimed to identify the threats posed by human activities that could cause harm to Striped Bass and their spawning habitat. For analysis of activities, the spatial extent of the case study includes the spawning area; the migration corridor was included only for fish passage considerations. Future analysis may be needed to analyze other threats in the migration corridor. Current and future threats were analyzed to inform whether an ESA designation would protect the Striped Bass spawning area into the foreseeable future. While it is acknowledged that cumulative effects are a major factor in most aquatic species at risk declines in Canada (DFO, 2019b; Impact Assessment Agency of Canada, 2018), the risk assessment did not consider the threat of cumulative effects on Striped Bass. Due to time limitations and a lack of guidance for how DFO currently assesses cumulative effects, this type of assessment was deemed to be beyond the scope of this study. The small boundary set out for the case study also makes it a challenge to analyze cumulative effects, which may require a larger spatial scope. However, cumulative effects may have a significant impact on Striped Bass, and it is recommended that cumulative effects are prioritized for an in-depth risk assessment if this case study proceeds to an ESA candidate in the future.

The *Pathways of Effects* (PoE) diagrams were used to develop a list of activities that could have an effect on Striped Bass spawning habitat in the Stewiacke River (DFO, 2010). While this original list was not exhaustive, using the pathways of effects diagrams allowed for covering a wide range of activities and how they may impact the Striped Bass spawning. This list was narrowed down to overarching activities to consider in the risk assessment. The final list of activities analyzed is found in **Table 1**.

Table 1: List of activities analyzed in risk assessment

Activity
Fish Passage Barriers
Dykes and Aboiteaux
Agriculture
Streamside Livestock Grazing
Mining
Other Resource Extraction Activities
Work in or near Water
Habitat Restoration
Fisheries

The remaining activities were analyzed following the SAR Risk Framework, which considered likelihood of occurrence, level of impact, causal certainty, threat risk, threat occurrence, threat frequency, and threat extent (DFO, 2014a). The threat risk is a product of likelihood of occurrence and level of impact, as stated in the SAR Risk Framework (DFO, 2014a). Detailed methods for each category can be found in **Table 2**.

Table 2: Methodology for Striped Bass Threats Assessment based on the SAR Framework (DFO, 2014a)

Threat Evaluation Criteria	Methods
Likelihood of Occurrence	**DFO (2014a) definition:** "The probability of a specific threat occurring for a given population over 10 years or 3 generations, whichever is shorter." **Categories:** Known or very likely to occur (known), likely to occur (likely), unlikely, remote, unknown The generation time for the BoF Striped Bass population is estimated to be 4 years (DFO, 2014b), making the time for 3 generations 12 years. Thus, a 10-year time period was used for analysis of future threats. Likelihood of occurrence was determined based on evidence from the review of literature around Striped Bass in the region.
Level of Impact	**DFO (2014a) definition:** "The magnitude of the impact caused by a given threat, and the level to which it affects the survival or recovery of the population." **Categories:** Extreme, high, medium, low, unknown There have been no population abundance estimates for the Shubenacadie Striped Bass population in the last 20 years (DFO, 2014b). For the categorization of the Level of Impact, backing literature and evidence is used to quantify how a threat will impact the survival or recovery of the Shubenacadie population. The precautionary approach is used in the absence of supporting literature. The small spatial extent of the ESA candidate site, and the fact that there is only one spawning population, is considered when estimating the level of impact.
Causal Certainty	**DFO (2014a) definition:** "The strength of evidence linking the threat to the survival and recovery of the population. Evidence can be scientific, traditional ecological knowledge or local knowledge." **Categories:** Very high, high, medium, low, very low For this risk assessment, the categories are defined by the quality of the evidence linking a threat to population decline or hinderance of population recovery or survival. The definitions for each category listed in the SAR were modified slightly to fit the threats assessment. Very high: Studies on BoF Striped Bass population to give very strong evidence of a causal link. High: Studies on other Striped Bass populations that can be used to support a causal link.

	Medium: Studies for Striped Bass are limited; multiple studies on similar species to use as evidence. Low: Few studies for Striped Bass; few studies for other fish species. Very low: No studies on BoF Striped Bass and no studies on other species.
Threat Risk	**DFO (2014a) definition:** "The product of Likelihood of Occurrence and Level of Impact" **Categories:** Low, medium, high, unknown This evaluation criteria follows a standard formula as provided in the SAR Risk Framework and is illustrated in **Table 3**.
Population-Level Threat Occurrence	**DFO (2014a) definition:** "The timing of the occurrence of the threat and describes whether a threat is historical, current and/or anticipatory for a given population. Any combination of Population-Level Threat Occurrence categories is possible." **Categories:** Historical, current, anticipatory, potential The categorization will follow as outlines in DFO (2014a). A combination of categories can be applied for a single threat. The "potential" category was added and considered separate from the "anticipatory" category. This was done to distinguish between anticipatory threats, where there is a strong indication that plans are in place for a specific activity within the next 10 years, and potential threats, where there is little indication that an activity will happen but there is still a possibility.
Population-Level Threat Frequency	**DFO (2014a) definition:** "The temporal extent of a given threat over the next 10 years or 3 generations, whichever is shorter." **Categories:** Single, recurrent, continuous Methodology as outlined in DFO (2014a).
Population-Level Threat Extent	**DFO (2014a) definition:** "The proportion of the population affected by a given threat." **Categories:** Extensive, broad, narrow, restricted There have been no population abundance estimates for the Shubenacadie Striped Bass population in the last 20 years (DFO, 2014b). For the categorization of the population-level threat extent, the proportion of the population that is expected to be affected is used, as outlined in DFO (2014a). Given the small spatial extent of the ESA candidate and that there is only one spawning population, the threats are likely to be extensive in many cases. The precautionary approach is used in the absence of supporting literature.

Table 3: Threat Risk Matrix as outlined in the SAR Risk Framework (DFO, 2014a)

		Level of Impact				
		Low	**Medium**	**High**	**Extreme**	**Unknown**
Likelihood of Occurrence	**Known**	Low	Medium	High	High	Unknown
	Likely	Low	Medium	High	High	Unknown
	Unlikely	Low	Medium	Medium	Medium	Unknown
	Remote	Low	Low	Low	Low	Unknown
	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

The SAR risk framework evaluates these parameters using a quantitative method based on the population of the species (DFO, 2014a). Since there are no current estimates of the population size for the BoF Striped Bass, adjustments and assumptions had to be made when completing the risk analysis. Several tools and sources were used to inform the categorization of the evaluation parameters including spatial data, reports on other species or populations of Striped Bass, and development reports from different industries in the area. The precautionary approach was applied in cases where limited information was available.

When evaluating future activities, the temporal extent of potential future threats is the shorter of the next 10 years, or 3 generations (DFO, 2014a). The generation time for the BoF Striped Bass population is estimated to be 4 years (DFO, 2014b), making the time for 3 generations 12 years. Thus, a 10-year time period was used for analysis of future threats. The Threat Occurrence parameter was also modified to include "potential" as one of the categories. This was done to distinguish between anticipatory threats, where there is a good indication that plans are in place for a specific activity within the next 10 years, and potential threats, where there is little indication that an activity will happen but it there is still a possibility.

CHAPTER 4 RESULTS

4.1 ESA Ecological Criteria

The ecological criteria for establishing an ESA are rare or unique, sensitive, and highly productive. An area can meet any one of these criteria to be considered for ESA designation (DFO, 2022a). At least one of these criteria need to be met to qualify for an ESA designation; meeting more than one of these criteria would make a site a stronger ESA candidate (DFO, 2022a). This case study compared against these criteria using the ESA criteria definitions in the Draft ESA Framework, as seen in **Table 4**.

Table 4: ESA Ecological Criteria Definitions (DFO, 2022a)

ESA Ecological Criteria Definition as per (DFO, 2022a)	Application to Stewiacke River Case Study
Sensitive: An area containing fish and/or fish habitat that is easily and adversely affected by human activity or natural events: • where recovery of the fish species and/or habitat is only achieved after a prolonged period with or without human intervention (e.g., low resilience or recoverability); • that includes one or more endangered, threatened, special concern/vulnerable fish species or species in decline, or habitat(s) that are important to these species; and/or, • that has special importance for a life stage of a priority fish species.	BoF Striped Bass has been assessed as “endangered” by COSEWIC (COSEWIC, 2012). Additionally, with the spawning habitat being limiting for the BoF population, if anything changes the habitat to make it unsuitable for spawning, the Striped Bass BoF DU could be in jeopardy. Thus, the case study is sensitive.

Highly Productive: An area, relative to other areas in the region, that contains higher/greater: • aggregations and/or abundance of fish species, populations, communities, habitats, structural features, or ecological processes used for some important function in their life history; • aquatic biological or genetic diversity; and/or, • ecosystem functioning that supports regional priority fish species.	The Striped Bass spawning habitat can be considered highly productive, as it is the only supporting habitat for the BoF population. The Shubenacadie Striped Bass population are successfully reproducing every year and support recreational and FSC fisheries in the region, as discussed in Section **2.6.4.1**. Thus, the case study is highly productive.
Rare or Unique: An area that: • has unique or rare fish species, populations or communities; • has unique, rare, or distinct fish habitats or ecosystems, especially limiting habitats for regional priority species; • has unique or unusual features (e.g., geomorphological, oceanographic, or hydrological) that support fish species, populations or communities; • has a relatively higher degree of naturalness and supports regional priority species; and/or • is unique for other ecological reasons that supports one or more fish populations (e.g., a habitat feature important for a life cycle stage located in a critical area).	Both Striped Bass and their spawning habitat in the Stewiacke River are rare and unique. • Species – the Shubenacadie River population is the only confirmed population within the BoF DU that is successfully reproducing each year (COSEWIC, 2012; DFO, 2014b). The Shubenacadie population has several traits that make them unique from other Striped Bass populations, as discussed in Section **2.3**Error! Reference source not found. • Habitat – the spawning ground in the Stewiacke River is the only remaining spawning habitat that is being used annually by the population. This habitat is the limiting habitat for the Shubenacadie population (DFO, 2014b).

4.2 Other Prioritization Considerations

As laid out in the Draft ESA Framework, the Prioritization Considerations are used to help select site candidates (DFO, 2022a). Ideal ESA candidates are those that meet several of the considerations listed in **Table 5**, along with a description of if and how the prioritization considerations are met.

Table 5: Prioritization Considerations for Stewiacke ESA Case Study (DFO, 2022a)

Prioritization Considerations as per (DFO, 2022a)	**Met by ESA Case Study (Y/N)**	**Rationale**
Meet multiple ESA ecological criteria	Y	This area meets all three ESA ecological criteria (Section **4.1**).
Contain habitat for multiple aquatic species of ecological importance	N	While there is presence of other species within the case study boundary, these species are not using the spawning area for critical life functions (DFO, 2022b).
Contain limiting habitats, especially for species at risk and other regionally important species	Y	This area is a limiting habitat as the only known spawning area for BOF Striped Bass (Section **2.3**).
Is highly natural relative to other areas	N	Much of the land within the case study boundary has been converted to other land uses, including urban and agriculture (Sections **2.6.2.1** and **2.6.2.2**). Within 100 m of the Striped Bass spawning site, approximately 13% is forested (**Figure 5**). Thus, there is little intact forest riparian habitat left, and the area is not considered to be highly natural.
Support climate change resiliency	Unknown	The proposed regulations do not target specific climate change impacts to Striped Bass, as this is an indirect pressure that is complex to analyze (Section **2.6.5.2**). Thus, it is unknown if this case study meets this consideration.
Is a priority area of conservation for Indigenous Peoples	Anticipated	The Striped Bass ESA is important for Mi'kmaq in the region (Section **2.3**). Engagement with Mi'kmaq groups is needed to confirm support.
Is supported by multiple stakeholder groups	Anticipated	While engagement on this particular case study has not started, engagement for the National ESA Framework with stakeholder groups and others indicates that there is general interest in ESAs in Nova Scotia (A.

		Gromack, personal communications, 2022). Engagement for this case study with all groups is needed to confirm support.
Has foreseeable pressures on the CPOs	Y	Results from the risk assessment determined that there are foreseeable pressures on the CPOs that could be mitigated through an ESA designation and associated regulations (Section **4.3**). These pressures include passage barriers, deleterious substances, streamside livestock grazing, and work in or near water.
Has had partner or stakeholder investment in restoration	N	While there has been DFO funded work by ENGOs and Mi'kmaq groups in the Stewiacke River Watershed, these initiatives did not target Striped Bass or their spawning habitat (NSSA, 2020).
Is well studied relative to other areas and/or well recognized by communities for ecological importance	Unknown	This consideration is relative in terms of other case studies being considered for ESA designation (A. Gromack, personal communications, August 2022). This would likely be considered on a case-by-case basis during the ESA designation process. Thus, it is unknown if this case study meets this consideration.
Has opportunities for partnering in ESA management activities	Y	The Stewiacke River ESA case study presents an opportunity for co-management with Mi'kmaq (Section **2.4**). While exploring co-management opportunities go beyond the scope of this report and require engagement with Mi'kmaq groups, this is identified as future work for advancing of the case study.
Contribute to other conservation initiatives or targets including marine conservation targets, freshwater targets, and terrestrial targets	Unknown	Canada is currently committed to protecting 25% of lands and oceans by the year 2025, and 30% by the year 2030 (ECCC, 2022). It is currently not known whether ESAs will contribute towards these conservation targets. However, this would likely be decided on a case-by-case basis during the ESA designation process (DFO, 2022a). Thus, it is unknown if this case study meets this consideration.

4.3 Risk Assessment

The risk assessment was completed for the activities identified in **Table 1**. The results of the risk assessment are summarized in **Table 6**. Detailed descriptions of the selection of the parameters for each activity can be found in **Table 7** through **Table 15**.

Table 6: Risk Assessment Results Summary

Activity	Likelihood of Occurrence	Level of Impact	Causal Certainty	Threat Risk	Threat Occurrence	Threat Frequency	Threat Extent
Fish Passage Barriers	Remote	Extreme	High	Low	Potential	Continuous	Extensive
Dykes and Aboiteaux	Known	Unknown	Very low	Unknown	Current	Continuous	Broad
Agriculture	Known	Low	Low	Low	Current	Recurrent	Extensive
Streamside Livestock Grazing	Likely	Low	Medium	Low	Current	Recurrent	Broad
Mining	Unknown	High	Medium	Unknown	Potential	Recurrent	Extensive
Other Resource Extraction Activities	Unknown	High	Medium	Unknown	Potential	Recurrent	Broad
Work in or near Water	Likely	Medium	Medium	Medium	Potential	Recurrent	Broad
Habitat Restoration	Unlikely	Unknown	Medium	Unknown	Potential	Single	Broad
Directed Fisheries	Known	High	High	High	Current	Recurrent	Broad

Table 7: Fish Passage Barriers – Description of Risk Assessment Parameters

Likelihood of Occurrence: Remote
There is little indication that this threat is currently happening, or will happen, within the next 10 years.
Level of Impact: Extreme
Barriers to fish passage that interrupt access to spawning habitat may result in severe population decline, given that the Stewiacke River is the only known remaining spawning ground for the BoF population. Barriers to fish passage have resulted in the severe decline of Striped Bass in the Saint John and Annapolis Rivers after the

construction of the Mactaquac Dam and Annapolis Causeway, respectively (COSEWIC, 2012; DFO, 2014b; Smith, 2018).
Causal Certainty: High
The other two populations in the BoF DU, in the Saint John River and the Annapolis River, have been unable to spawn due to the construction of fish passage barriers (DFO, 2014b). Thus, there is strong evidence that barriers to fish passage can have extreme effects on spawning success and survival of the population.
Threat Occurrence: Potential
There are currently no barriers to fish passage in the main migration corridor connecting Cobequid Bay to the spawning area and overwintering area in Grand Lake (**Figure 3; Figure 7**). Barriers to fish passage are not expected for the next 10 years.
Threat Frequency: Continuous
Barriers to fish passage would result in a continuous impact to fish migration should they be built by cutting off access to habitats.
Threat Extent: Extensive
Given that there is only one spawning habitat remaining for the BoF population, it is assumed that barriers to fish passage would impact close to 100% of the population.

Table 8: Dykes and Aboiteaux – Description of Risk Assessment Parameters

Likelihood of Occurrence: Known
Dykes and aboiteaux were built by the Acadians and have been rebuilt and maintained in the 1950s (Section **2.6.1.1)**. The dykes and aboiteaux are known to be present around the spawning area and are expected to remain for at least the next 10 years.
Level of Impact: Unknown
The impacts of the historical dykes and aboiteaux on Striped Bass spawning is unknown. It has been hypothesized by DFO that the dykes have had impacts on sediment accrual and resulted in Striped Bass egg strandings (Section **2.6.5.2**).
Causal Certainty: Very low
No studies were found surrounding the impacts of dykes and aboiteaux on Striped Bass spawning habitat. Given that the impacts on Striped Bass spawning is unknown, this has been identified as knowledge/data gap for future consideration.
Threat Occurrence: Current
Given the presence of dykes and aboiteaux in close proximity to the Striped Bass spawning habitat, the threat occurrence is current.
Threat Frequency: Continuous

Effects of dykes and aboiteaux on Striped Bass and their spawning habitat has been continuous since their construction.
Threat Extent: Broad
Given the small spatial extent of the spawning habitat and the presence of dykes and aboiteaux, it is assumed that the threat would have impacts to a large portion of the spawning population and eggs. Thus, the threat extent is broad.

Table 9: Agriculture – Description of Risk Assessment Parameters

Likelihood of Occurrence: Known
Spatial data shows agriculture in the land surrounding the spawning area (**Figure 5**). The practices discussed in Section **2.6.2.2** are commonplace in agriculture and thus, it is assumed that they are taking place.
Level of Impact: Low
Given that the Striped Bass population is successfully using the spawning area annually, it is assumed that the surrounding agriculture is having a low impact on spawning success. The ranking for this parameter assumes that agricultural practices around use of fertilizers will remain consistent over the next 10 years.
Causal Certainty: Low
Stormwater runoff can carry sediments from nearby agricultural sites and discharge excess nutrients and chemicals into the watercourse, which may lead to eutrophication and decreased water quality (DFO, 2010). Eutrophication can result in lower dissolved oxygen (DO) concentrations. Eggs require a DO concentration of >5mg/L (DFO, 2014b).
Threat Occurrence: Current
Is it assumed that current agricultural activities will continue for the next 10 years. Given that there is little natural stand left in the area (**Figure 5**), expansion of agriculture within the case study boundary is not expected in the next 10 years.
Threat Frequency: Recurrent
The use of chemicals and heavy machinery on agricultural lands is continuous. However, impacts to the Striped Bass spawning habitat are likely closely tied to storm and flood events (Section **2.6.2.2**), which are recurrent in nature. High flow events would result in runoff from agricultural lands that carry excess nutrients into the water.
Threat Extent: Extensive
Given the large area that is agricultural land use surrounding the spawning area, and the small spatial area of the spawning site, it is assumed that the threat would impact close to 100% of the population.

Table 10: Streamside Livestock Grazing – Description of Risk Assessment Parameters

Likelihood of Occurrence: Likely
Given that the spawning area is surrounded by agricultural lands, it is assumed that streamside livestock grazing is likely happening in the vicinity of the spawning area. Verification on the type of agriculture that is occurring near the spawning area would be needed to confirm the occurrence of streamside livestock grazing.
Level of Impact: Low
Given that Striped Bass are still successfully spawning annually in the Stewiacke River, it is assumed that the impact from streamside livestock grazing is low.
Causal Certainty: Medium
Given the literature to support the impacts of streamside livestock grazing on fish eggs (DFO, 2010), the causal certainty is considered to be medium.
Threat Occurrence: Current
With the presence of agricultural lands adjacent to the spawning area, it is assumed that streamside livestock grazing is currently happening.
Threat Frequency: Recurrent
It is assumed that streamside livestock grazing would be recurring over the span of 10 years.
Threat Extent: Broad
Given the small spatial extent of the spawning area, the impacts of streamside livestock grazing, including trampling and water quality impacts, would be broad.

Table 11: Mining – Description of Risk Assessment Parameters

Likelihood of Occurrence: Unknown
There are current exploratory licences for mining in the Stewiacke and Shubenacadie Rivers, and within the Striped Bass spawning area (**Figure 6**). However, it is unknown whether these exploratory mining licences will lead to the establishment of mining projects within the case study boundary.
Level of Impact: Medium-Extreme
Mining activities in the Stewiacke and Shubenacadie Rivers could have a medium to extreme level of impact on Striped Bass and their ability to spawn. This level of impact would mainly depend on the location of the mining leases. Downstream mining leases may have a medium impact on Striped Bass, with impacts mainly being related to pollutants, chemicals, and extra sediment impacting habitat quality. Potential mining projects located directly in the spawning area could cause direct and extensive damage to the spawning habitat.

Causal Certainty: Medium
While no studies were found linking the impacts of mining to the BoF Striped Bass population, there is evidence of mining activities causing harm to other fish species (Section **2.6.2.3**).
Threat Occurrence: Potential
Given that no set plans were found for full scale mining operations to be developed in the region within the next 10 years, the threat occurrence is potential.
Threat Frequency: Recurrent
Should the development of mining operations occur, it is assumed that mining activities would be recurrent.
Threat Extent: Extensive
Given the small spatial extent of the Striped Bass spawning habitat, any mining activities in the region would likely impact a significant portion of the spawning population and be considered extensive.

Table 12: Other Resource Extraction Activities – Description of Risk Assessment Parameters

Likelihood of Occurrence: Unknown
The likelihood of other resource extraction activities, including projects such as natural gas projects, in unknown.
Level of Impact: Medium-Extreme
The level of impact from resource extraction activities ranges from medium to extreme, depending on the nature and location of the project.
Causal Certainty: Medium
There are many studies explaining the impacts that reduced water quality from resource extraction projects can have on fish spawning (Section **2.6.2.3**). As such, the causal certainty is medium.
Threat Occurrence: Potential
No plans for resource extraction projects within the case study boundary in the next 10 years were found. Thus, the threat occurrence is potential.
Threat Frequency: Recurrent
Should any resource extraction projects be developed in the area, the threat frequency would be considered recurrent.
Threat Extent: Broad
Given the small area of the spawning habitat, impacts to Striped Bass spawning as a result of water quality changes would be considered broad.

Table 13: Work in or near water – Description of Risk Assessment Parameters

Likelihood of Occurrence: Likely
Work in or near water is a broad category that can include use of heavy machinery, near water, to more intense projects such as infilling or dredging. Given that there is infrastructure requiring maintenance, such as a bridge and culverts, near the spawning area, it is likely that work in or near water will occur in the next 10 years.
Level of Impact: Low-High
The level of impact from work in or near water can range from low to high, depending on the nature of the work, the proximity to the spawning area, and the preventative measures used to prevent damages to fish habitat.
Causal Certainty: Medium
Work in or near water is likely to have direct impacts on fish habitat. While no studies pertaining specifically to Striped Bass and work in or near water were found, the general impacts on fish habitat are well documented (Section **2.6.3.1**).
Threat Occurrence: Anticipatory
It is assumed that structures located near the spawning area will require maintenance within the next 10 years. Thus, the threat occurrence is anticipatory.
Threat Frequency: Recurrent
Work in or near water could happen multiple times within the next 10 years. Thus, the threat frequency is recurrent.
Threat Extent: Broad
Given the small spatial extent of the spawning habitat, it is assumed that the threat extent would be broad.

Table 14: Habitat Restoration – Description of Risk Assessment Parameters

Likelihood of Occurrence: Unlikely
There has been work throughout the BoF to restore tidal wetland habitat and protect dykelands from climate change impacts. However, the case study is not currently a priority site for habitat restoration (Section **2.6.3.2**). Thus, the likelihood of occurrence within the next 10 years is unlikely.
Level of Impact: Unknown
The level of impact from work in or near water associated with habitat restoration can range from low to high, depending on the nature of the work, the proximity to the spawning area, and the preventative measures used to prevent damages to fish habitat. However, it is unknown if habitat restoration may also have positive impacts to Striped Bass by provided additional habitat (Section **2.6.3.2**).

Causal Certainty: Medium
Habitat restoration would likely involve work in or near water, which would have impacts to spawning habitat for the duration of construction activities. While no studies pertaining specifically to Striped Bass and work in or near water were found, the general impacts on fish habitat are well documented (Section **2.6.3.1**).
Threat Occurrence: Potential
There are currently no anticipated plans for restoring tidal wetland habitat within the case study boundary, as the case study is not currently a priority site for habitat restoration (Section **2.6.3.2**). Thus, the threat occurrence in potential.
Threat Frequency: Single
Habitat restoration would have direct impacts to habitat once, during the construction phase. Thus, the threat frequency is single.
Threat Extent: Narrow
Given the small spatial extent of the spawning habitat, it is assumed that the threat extent would be broad.

Table 15: Directed Fisheries – Description of Risk Assessment Parameters

Likelihood of Occurrence: Known
Directed recreational and FSC Striped Bass fisheries are present in the region. Given the economic, social, and cultural significance of these fisheries, it is expected that targeted fishing for Striped Bass will continue into the next 10 years.
Level of Impact: High
While there are currently no population estimates or catch rates for directed fisheries, the level of impact to Striped Bass is expected to be high, as stated in the 2014 RPA (DFO, 2014b).
Causal Certainty: High
The 2014 Striped Bass RPA lists directed fisheries as the main threat to the BoF Striped Bass (DFO, 2014b). Thus, the causal certainty for this activity is high.
Threat Occurrence: Current
Directed recreational and FSC fisheries is a current human activity that impacts BoF Striped Bass.
Threat Frequency: Recurrent
The threat frequency of fishing activities on Striped Bass is recurrent.
Threat Extent: Broad

Considering that the BoF population is mainly supported by the Shubenacadie spawning population, the threat extent is considered to be broad.

4.4 Conservation and Protection Objectives

CPOs are written for an ESA to protect habitat from risks and conserve the ecosystem functioning of the ESA. These CPOs should be evidence-based and be linked to the conservation priorities of the ESA (DFO, 2022a). The literature review and risk assessment helped to identify the conditions needed for Striped Bass spawning and associated migration. CPOs were formulated based on the ecological criteria discussed above (Section **4.1**). The CPOs identified below are preliminary. Should DFO continue work on this case study for ESA designation, CPOs and ESA regulations would be developed and finalized in consultation with partners, Indigenous groups, stakeholders, academics, and others (DFO, 2022a).

CPO 1 – Conserve, protect and, where appropriate, restore Striped Bass spawning habitat to an optimum state that allows the species to carry out their key life processes (i.e., spawning and associated migration).

Sub-objective 1 – Maintain and/or increase the population of Striped Bass present in the ESA

Sub-objective 2 – Maintain and/or improve physical and chemical water characteristics required for Striped Bass spawning

- Water flow velocity 30.5-500 cm/s (Andrews, Dadswell, et al., 2019)
- Temperature 13ºC-24ºC (DFO, 2014b)
- Dissolved Oxygen >5mg/L (DFO, 2014b)

- Salinity ≤1 ppt (DFO, 2014b)

Sub-objective 3 – Maintain and/or improve connectivity within the Striped Bass migration corridor for fish passage.

4.5 Regulatory Considerations

The regulations of an ESA are put in place to protect from the human activities that threaten fish and fish habitat. For this case study, the risk assessment was used to inform the human activities that may result in pressures to Striped Bass and their spawning habitat and are thus incompatible with a possible ESA designation (DFO, 2022a). Possible regulations for this case study are outlined in **Table 16**. These regulatory considerations are preliminary; should the case study continue to designation, engagement with partners would be needed to further develop and establish the regulations (DFO, 2022a).

The activities regulated in the ESA will fall into the categories of prohibited, in which the activity is not authorized, or prescribed, where the impacts of the activity need to be mitigated to occur withing the ESA. Prescribed activities would require authorization from DFO in order to take place (DFO, 2022a). It is important to note that proposed regulations will not target specific industries. Instead, they are written to regulate the activities that may impact fish and fish habitat. For example, if a CPO were written to maintain or improve water quality in the ESA, mining activities involving the deposit of deleterious substances may be prohibited.

Table 16: ESA Regulatory Considerations. Asterisk (*) refers regulations that apply to migration corridor only.

Activity	Prohibited	Prescribed	Rationale/Description
New Deposit of Deleterious Substances	X		New work that involves the deposit of deleterious substances into the watercourse will be prohibited. Current activities that discharge deleterious substances into the watercourse (i.e., agriculture) must establish a monitoring plan within 2 years of ESA designation.
Use of Heavy Equipment in/near Water		X	Use of heavy equipment in/near the spawning area may take place outside of Striped Bass spawning and larval seasons. Regulatory conditions to avoid/mitigate sedimentation and erosion would be established. Restoration activities involving use of heavy equipment in/near water will have a streamlined authorization process and will be done in consistency with the restoration management plan.
Water Extraction/Diversion		X	Water extraction activities must be authorized by DFO. Water extraction shall not impact the overall flow regime of the watercourse in a way that impacts Striped Bass eggs. Water extraction shall not occur during spawning and after.
Streamside Livestock Grazing	X		Streamside livestock grazing results in water quality issues that can affect the area year-round. Requirement for fencing to be added along the stream to ensure that cattle do not enter the water.
Infilling	X		Infilling work in the ESA will be prohibited as it may alter the spawning habitat significantly and impede spawning.
*New Water Control Structures	X		Construction of new water control structures that impede fish passage shall not occur within the ESA and the migration corridor as it may result in no access to the spawning habitat by Striped Bass.
*Watercourse Crossings		X	New crossings must be open bottomed and be designed in a way that does not restrict fish passage. Construction of new watercourse crossings shall not take place during Striped Bass migration and spawning.

CHAPTER 5 ANALYSIS AND DISCUSSION

5.1 Proposed ESA Boundary

The risk assessment used a small boundary, which included the spawning area and a 30m buffer surrounding the spawning area, to identify the human activities which had the greatest impacts to Striped Bass. The risk assessment also considered the migration corridor for connectivity impacts only. The literature recommends that protection of watercourses be expanded to a catchment basis and include larger areas of land to protect from the impacts that land-based activities can have on water ecology (Abell et al., 2007; Acreman et al., 2020; Moilanen et al., 2008). In this case, the small case study boundary is unable to protect against cumulative effects from upstream activities, such as forestry. However, the number of human activities in this region and the amount of development that has already taken place may make a larger boundary unrealistic in terms of socioeconomic impacts. The selection of the case study boundary aimed to balance the protection of ecological features with the socioeconomic impacts that could be associated with am ESA designation.

In terms of ecological function, using an ESA to protect connectivity within the migration corridor would guarantee access to the spawning habitat. This consideration is critical for survival of Striped Bass, as the spawning habitat in the Stewiacke River is the only remaining habitat that is used annually by BoF Striped Bass (Acreman et al., 2020; Bower et al., 2015). The maintenance of habitats that support spawning and early life stages is critical for species survival (DFO, 2021). Thus, ensuring connectivity between important habitats needed for spawning and a critical first step in the protection of this important species. Continued work on this case study would likely aim to assess the threats in the greater Stewiacke and Shubenacadie watersheds to determine if expansion of the boundary is necessary.

5.2 Opportunities

This case study is complex in terms of the number of human uses in the area. The complexities of this case study present both opportunities and challenges should ESA designation go forward. Collaboration with Mi'kmaq groups in the region is one of the main opportunities for this case study (Section **2.4**). Co-management frameworks between DFO and Mi'kmaq groups in the region could be explored. Other partnerships could include education and outreach partnerships for the ESA. Any such partnerships with Mi'kmaq groups should be explored through meaningful engagement and consultation with Mi'kmaq groups (Papadopoulos, 2021; Rayne et al., 2020). Integration of Mi'kmaq Ecological Knowledge and a two-eyed seeing approach is important for growing healthy partnerships for management and make advancements towards reconciliation (Papadopoulos, 2021).

The case study also presents an opportunity for tidal wetland marsh habitat restoration. While it is unknown whether these types of projects may occur in this area, the case study presents an opportunity to restore tidal wetland habitat and then use ESA regulations to protect the restored habitat (Nova Scotia Department of Agriculture, 2022). Doing so would have implications for the ESA boundary to ensure that restored habitat is then protected by ESA regulations. Restoration of tidal wetland habitat could also present an opportunity for future studies around saltmarsh use by Striped Bass.

5.3 Challenges

The complexities of this case study bring with it several challenges, many of which were beyond the scope for this report. However, identifying challenges can help in determining next steps and making recommendations if ESA designation for this area is pursued. First, there are boundary implications for cumulative effects. The small boundary around the Striped Bass spawning area means that activities happening outside cannot be regulated. This means that upstream activities may impact Striped Bass and their spawning habitat, resulting in cumulative effects that regulations do not protect against (Abell et al., 2007; Impact Assessment Agency of Canada, 2018). With this, broadening the boundary is also a challenge due to the many activities going on in the region. There are several current human uses that would need to be brought to compliance should ESA designation go forward. Managing these activities, and the socioeconomic implications that come with it, is a challenge. Meaningful engagement with stakeholders in the region would be a first step to ensure that all perspectives are heard (Papadopoulos, 2021).

Additionally, this ESA case study does not align with the naturalness criteria. With the many human uses in the region and the lack of forest riparian habitat, the area is not considered highly natural (**Table 5**). The challenge with this is resource allocation, especially when comparing to other potential ESA candidates that may be more natural and meet more of the prioritization considerations. Efforts may be better suited in highly natural areas that may have a greater conservation value.

Finally, the RPA identified fishing as the biggest threat to Striped Bass (DFO, 2014b). The intent of ESA policy is to regulate human activities other than fishing, and thus fishing was not included in the draft regulations. Given that fishing is currently the biggest threat to Striped Bass, excluding fishing from regulations may then be ineffective at protecting against the biggest threat, and thus may be ineffective overall. An ESA could be used to bring awareness to the species and area, and possibly promote the need for additional fisheries management measures, if necessary. Public backlash and impacts to recreational and FSC fishers may arise if fishing regulations are put in place (Papadopoulos, 2021).

5.4 Next Steps

The work done for this case study to date, and compiled in this report, has been used to gather background information on Striped Bass and the habitat needs for spawning. Through compiling of background information, completing the threats assessment, and proposing possible regulations for an ESA, data and knowledge gaps and room for future work emerged. These gaps in knowledge are used to inform next steps for the case study and make recommendations for continued work. There were several data gaps that were identified throughout, which present opportunities for next steps, future work, and research.

Should DFO pursue this case study further, engagement and collaboration with several parties is needed to cover data gaps and collaborate with rights holders and stakeholders in the region. First, engagement with Mi'kmaq groups is an important next step into understanding their possible support for the Stewiacke River ESA. Gathering perspectives from Mi'kmaq groups in the region is important and proper consultation is critical to make advancements in the establishment of an ESA (DFO, 2022a). Also, with fisheries being the biggest current threat to Striped Bass, it is important to understand the aspects of fishing that are having the most impact. Post release mortality, bycatch, and direct mortality may all be having an impact on Striped Bass (DFO, 2014b). An analysis into fisheries management is needed to better understand and possibly manage fisheries impacts on Striped Bass (Section **2.6.4.1**). Collaboration with experts in this field will give a better insight on whether enhanced regulation or management of fishing within the area is needed for the continued survival and success of Striped Bass.

Finally, there are several areas where filling knowledge gaps would help to inform progress on the case study. First, a cumulative effects analysis was not considered and was beyond the scope of work for the writing of this report. Consideration of cumulative effects is a challenge with the small ESA boundary, as threats outside of the boundary would not be regulated by an ESA but may still have impacts to Striped Bass (Abell et al., 2007). To better understand if and how other stressors may impact Striped Bass spawning, a cumulative effects analysis is needed, along with a reassessment of the ESA boundary. A cumulative effects analysis should also consider climate change in the region and how climate change will impact the ability to support Striped Bass spawning. Additionally, assessing the impacts to Striped Bass from possible salt marsh restoration would help to understand what benefits, if any, would be to Striped Bass from restoring salt marsh habitat. Filling knowledge around the historical impacts that dykes have had on Striped Bass eggs would help to further inform if restoration of tidal wetland habitats should be pursued in this region (Section **2.6.3.2**). Finally, this report only included fish passage issues in the analysis of the migration corridor. However, the human uses around the migration corridor and in Grand Lake, and their impacts to Striped Bass, are less understood. It is recommended that a threats analysis along a migration corridor is conducted to better understand if additional regulations are needed in this area.

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

The results from the risk assessment were beneficial for identifying the overarching threats to Striped Bass and their spawning habitat. Understanding these threats is important for informing management decisions; the proposed regulations aim to eliminate and/or reduce the threats to Striped Bass, both current and into the future. It is important to note that the threat from many human activities is still unknown (**Table 6**). However, the lack of information should not limit management decisions for the protection of Striped Bass. Using the precautionary principle is critical for proactively protecting the species and the limiting spawning habitat (Abell et al., 2007). Alternatively, the do-nothing approach may allow for current and future activities to expand and develop. While Striped Bass are currently successful in spawning annually, development in the area may put the Shubenacadie population at risk. Further cumulative effects and climate change impacts may exacerbate the impacts from local human activities (Impact Assessment Agency of Canada, 2018). Thus, proactively protecting this important species is important to ensure their survival.

While this report explores concludes that an ESA is justified, it is important to note that further investigation is necessary to fully evaluate the feasibility and use of an ESA. It is necessary to better understand the types of activities that could impact the conditions necessary for Striped Bass egg survival (the tide and the river coinciding and creating salinity and suspension conditions necessary for egg survival) and how effects from climate change may impact these conditions. This would help to deepen understanding of how the habitat dynamics may change and impact Striped Bass. From a sociocultural perspective, Striped Bass is an important species to protect, given its regional importance (Section **2.4**). However, there are challenges with this case study that may hinder progress. Given that the case study does not meet all the prioritization considerations (Section **4.2**), understanding the public support for this case study may help make a stronger case for this area. Engagement is needed with stakeholders and rightsholders to understand their perspectives of the work done to date, and if they support an ESA designation for the region (DFO, 2022a; Papadopoulos, 2021). In particular, collaborations with Mi'kmaq in the region should be explored at all stages of the process (Papadopoulos, 2021). Additionally, the boundary for the ESA should be revised after consultation with various groups should this site be pursued as an ESA candidate. Possible expansion of the boundary may be needed after assessing threats in the migration corridor and cumulative effects.

Finally, an analysis on other management tools should be conducted to understand what other legislative and regulatory tools, both federal and provincial, could be used to achieve the CPOs. This should include the exploration of fisheries regulation options (Section **2.6.4.1**) and current *Fisheries Act* legislation that could be applied to strengthen protections for Striped Bass. As well, land-based management options should be reviewed, considering that many land-based activities can impact downstream habitat (Section **2.6.2.1**). Land-based management tools could also be used in conjunction with an ESA designation to provide stronger overall protections in the region (Acreman et al., 2020).

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APPENDIX A FIGURES

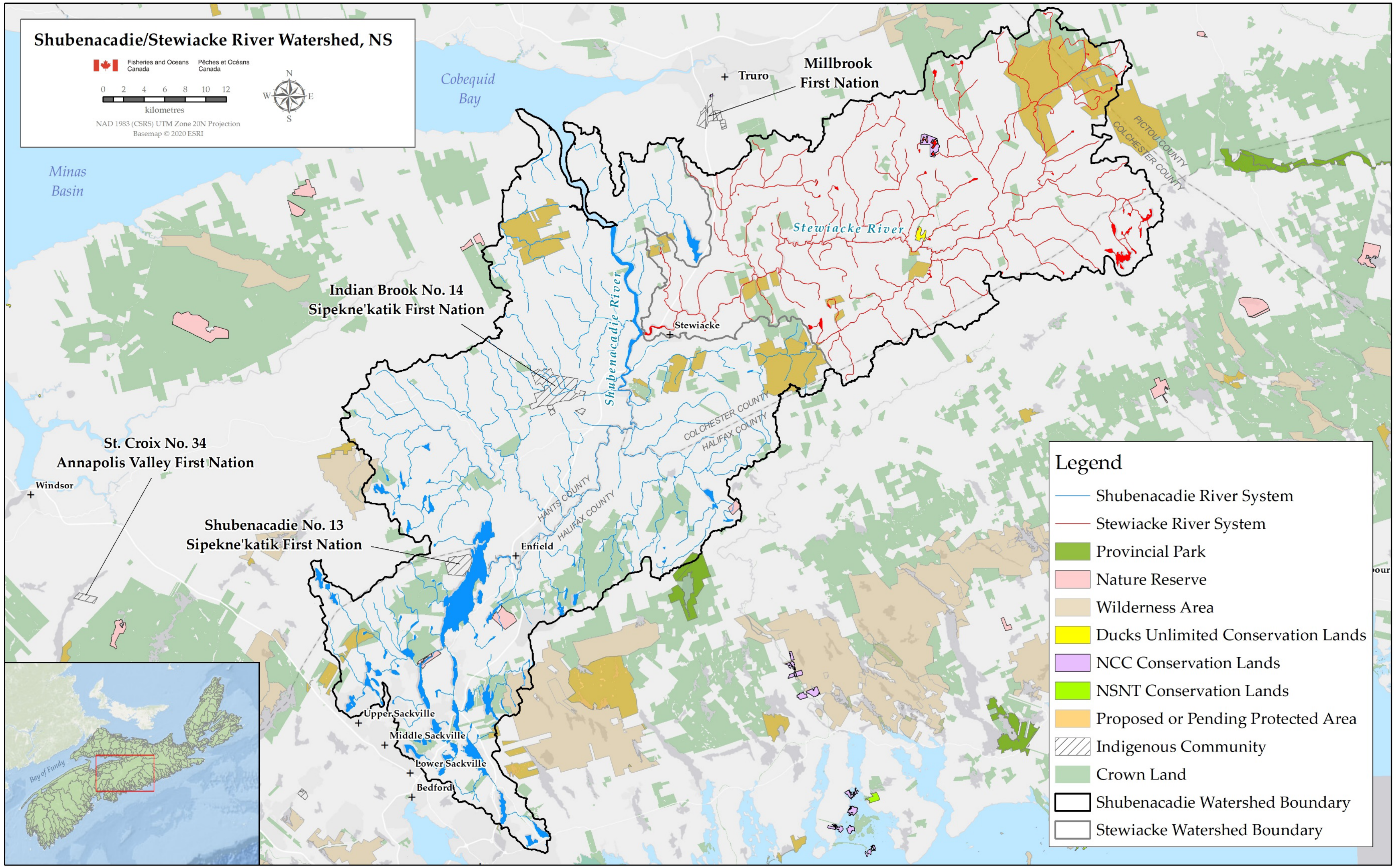

Figure 1: Overview of the Shubenacadie/Stewiacke Watershed, NS (DFO, 2022b; reproduced with permission, Sean Butler 2022)

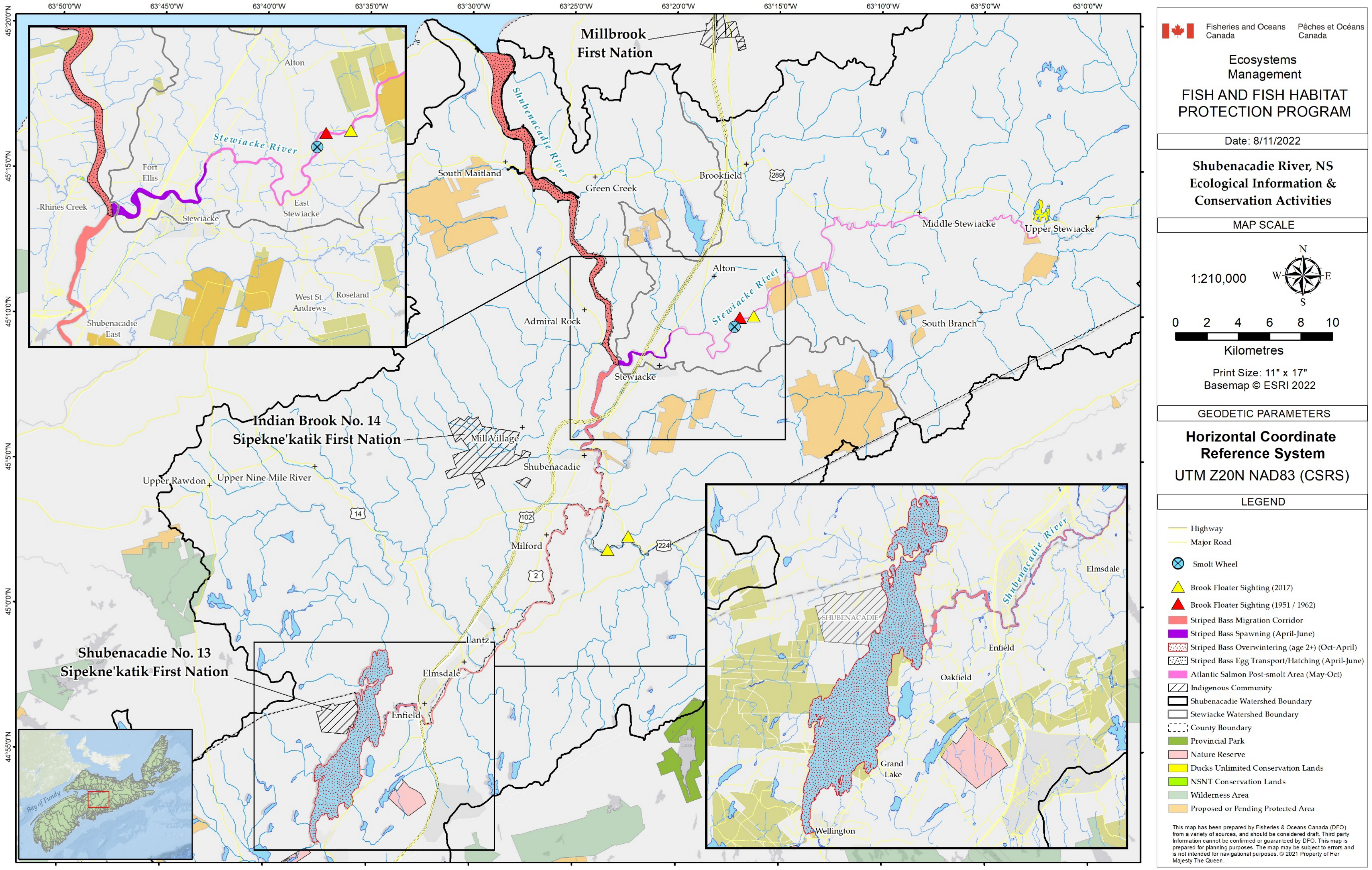

Figure 2: Shubenacadie River, NS – Striped Bass Important Habitat Areas (DFO, 2022b; reproduced with permission, Sean Butler 2022)

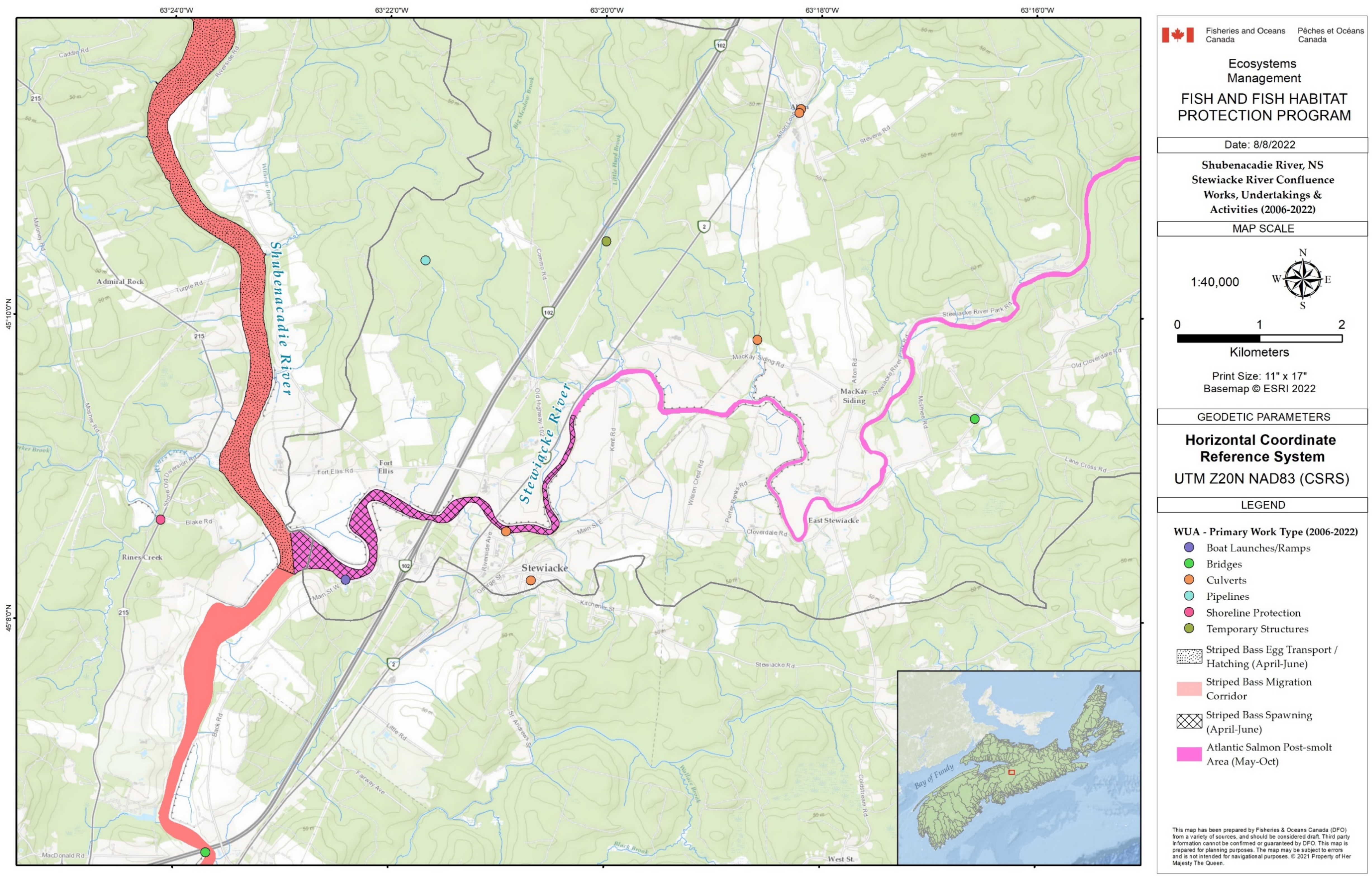

Figure 3: Stewiacke River Confluence – Works, Undertakings & Activities (2006-2022) (DFO, 2022b; reproduced with permission, Sean Butler 2022)

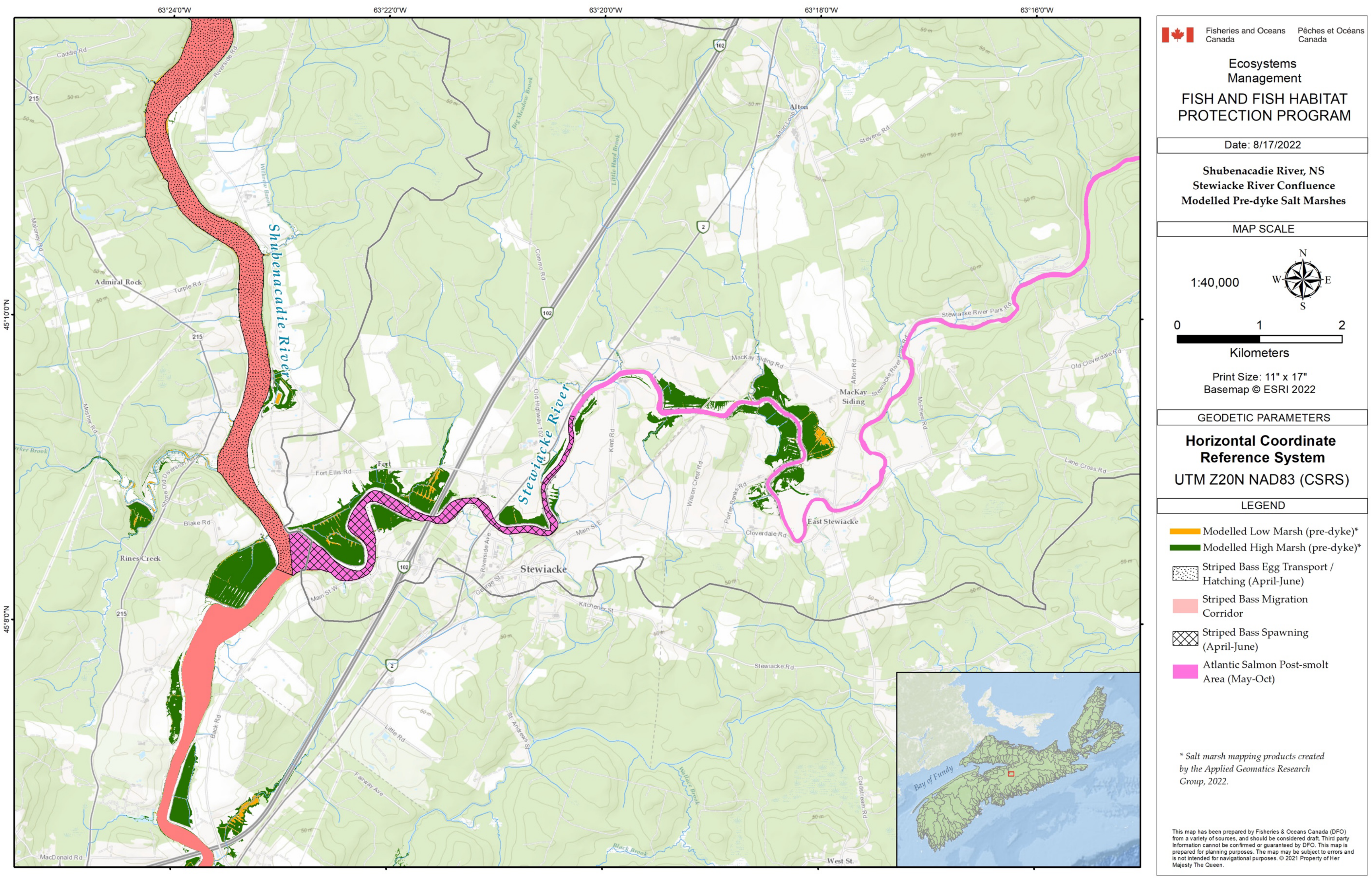

Figure 4: Stewiacke River Confluence – Modelled Pre-dyke Salt Marshes (DFO, 2022b; reproduced with permission, Sean Butler 2022)

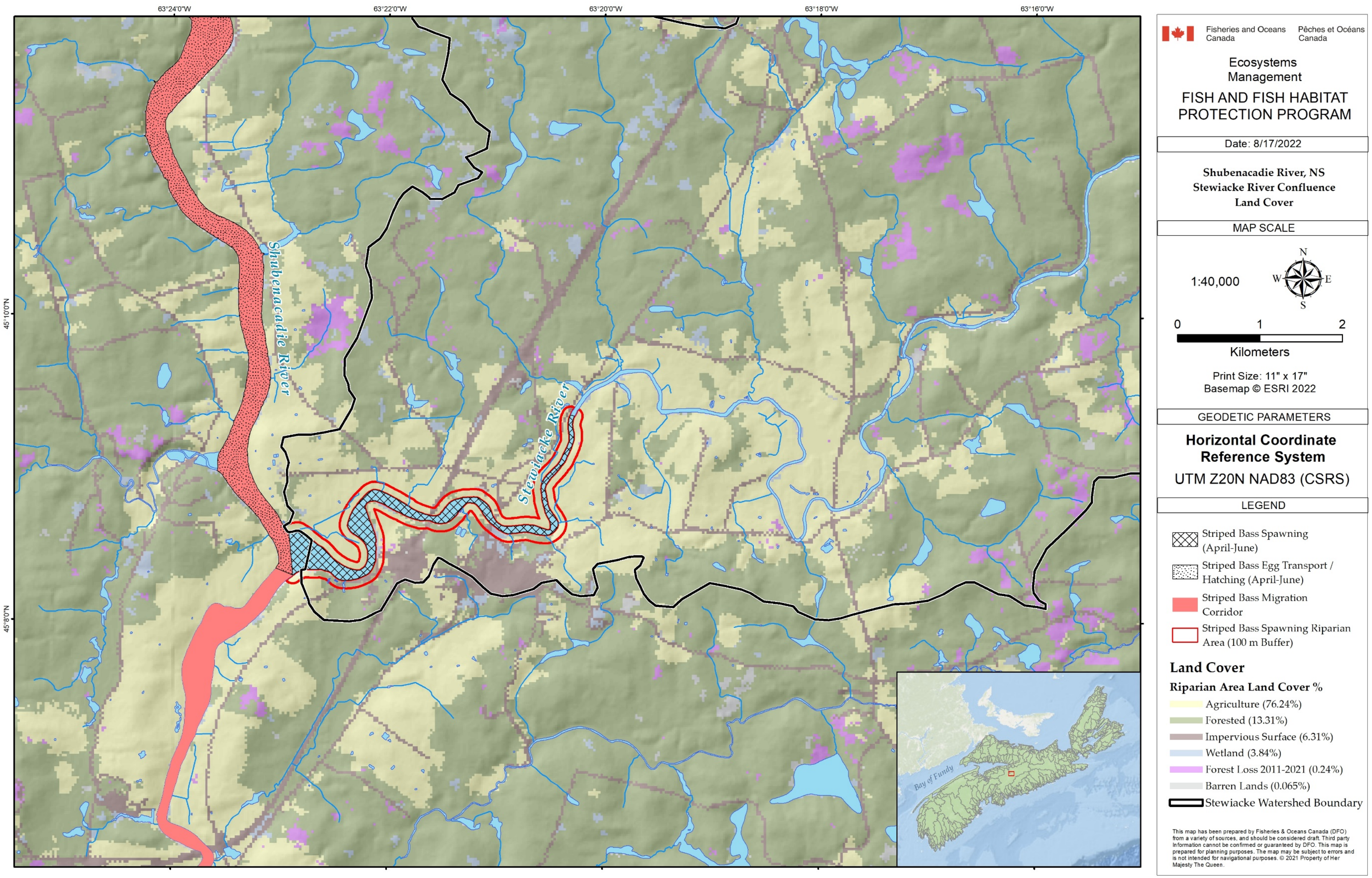

Figure 5: Stewiacke River Confluence – Land Cover (DFO, 2022b; reproduced with permission, Sean Butler 2022)

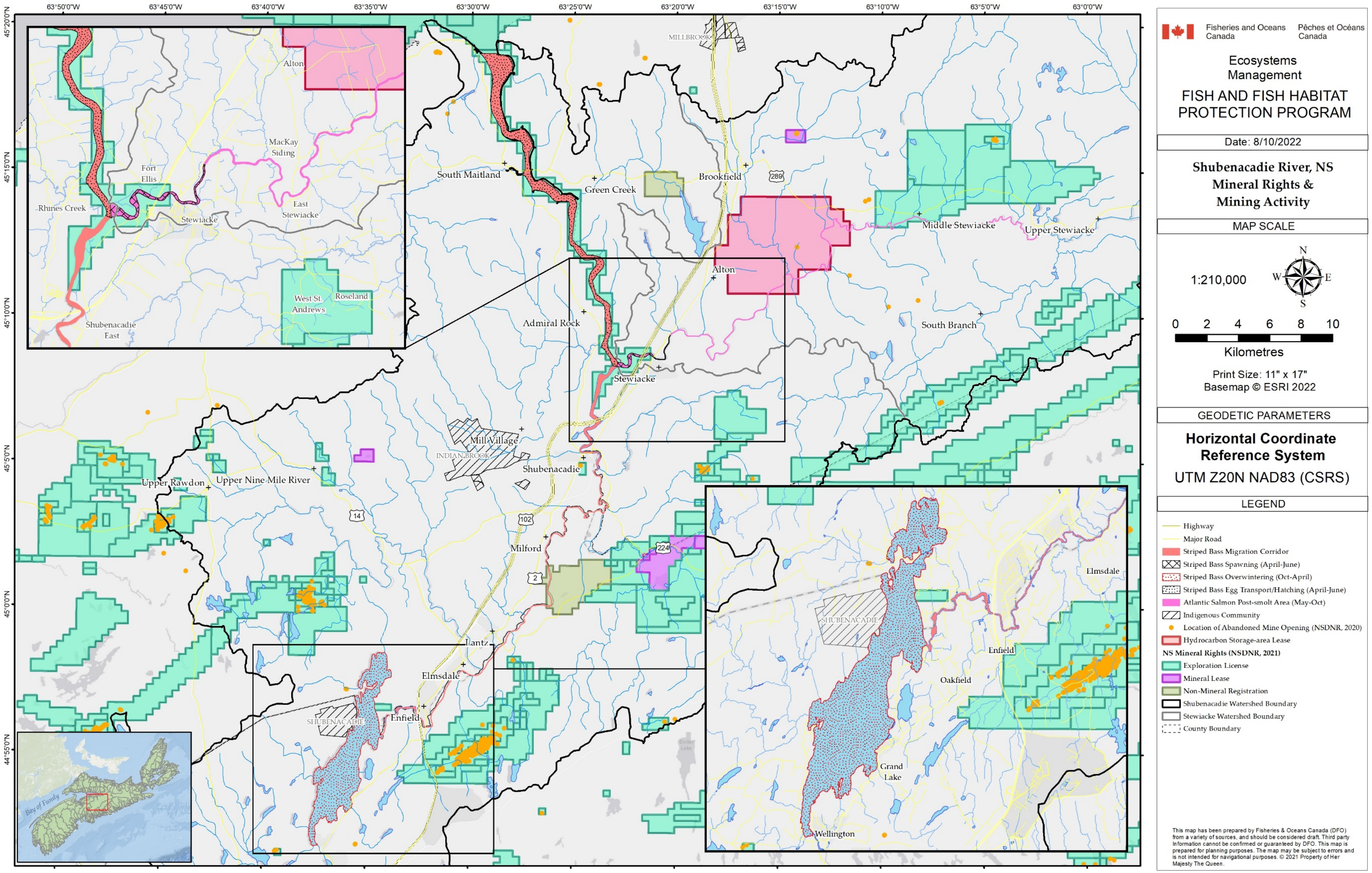

Figure 6: Shubenacadie River, NS – Mineral Rights & Mining Activity (DFO, 2022b; reproduced with permission, Sean Butler 2022)

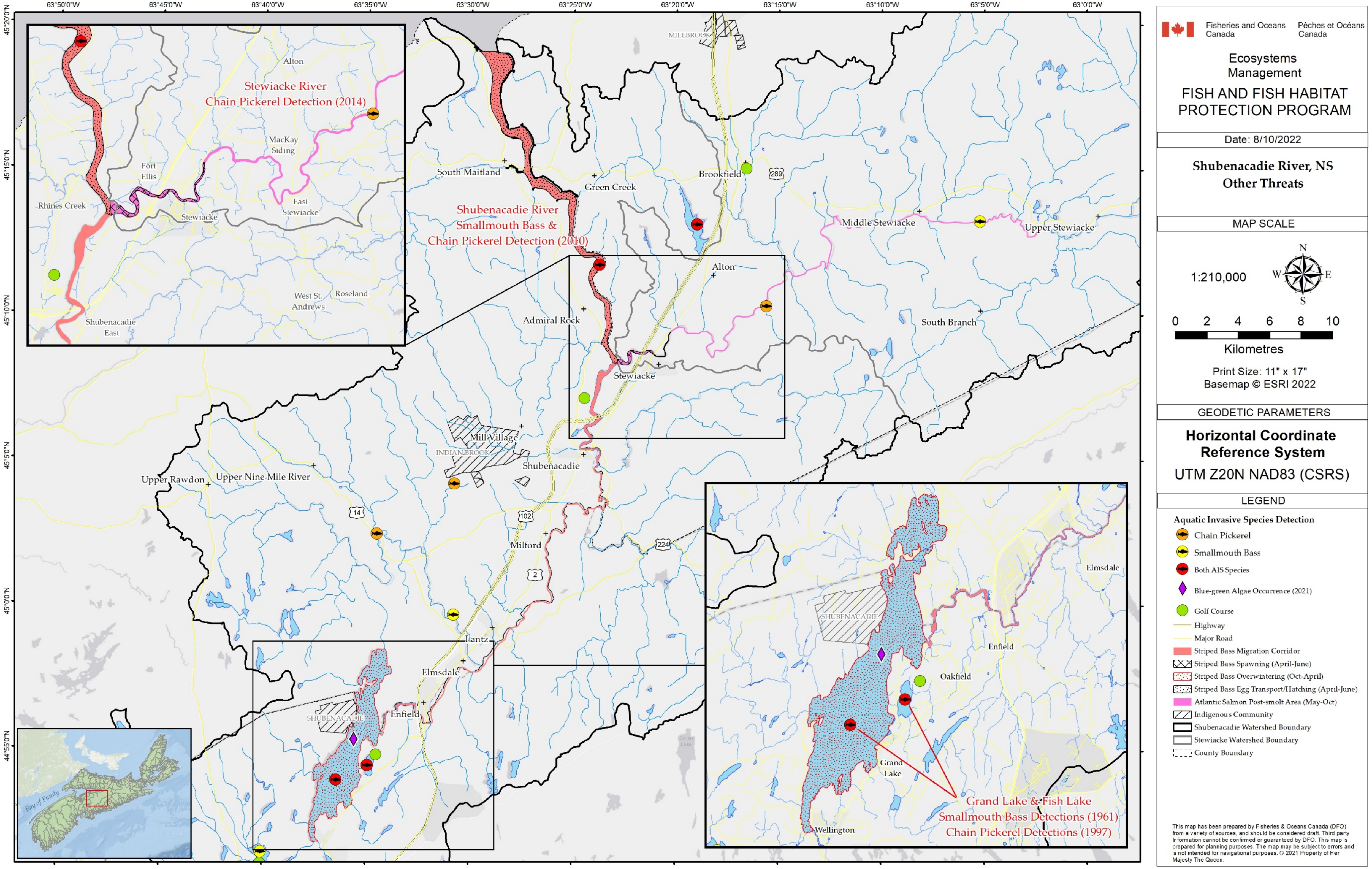

Figure 7: Shubenacadie River, NS – Other Threats (DFO, 2022b; reproduced with permission, Sean Butler 2022)

APPENDIX B PERMISSION FOR USE OF FIGURES

Subject: FW: Permission for using figures in GP Report
Date: Friday, November 18, 2022 at 1:54:23 PM Atlantic Standard Time
From: Gromack, Aimee
To: Samanta Martinez Membreno
CC: Lawler, Madeline
Attachments: RE: Maps.eml

Hi Sam,

Please see below regarding permission to use the maps. Attached is the original email from Sean for your reference and Madeline's (she is covering for Sean while he is on extended parental leave).

Hopefully we hear back from Tim Webster soon.

I'll get your report to you soon, hopefully today but if not, this weekend.

Cheers,

Aimee

From: Samanta Martinez Membreno <samanta.martinez@dal.ca>
Sent: Wednesday, November 16, 2022 10:32 AM
To: Butler, Sean <Sean.Butler@dfo-mpo.gc.ca>; Gromack, Aimee <Aimee.Gromack@dfo-mpo.gc.ca>
Subject: Permission for using figures in GP Report

Hi both,

Hope you are doing well! I am currently in the final stages of writing my graduate project report, and I want to include Sean's figures in my report. I also want to include an email with your permission to use the figures in the Appendix. Below is a table of the figures that I have included (and they are also saved here). Regarding the saltmarsh figure, I included the one without the dyke and aboiteaux locations, since that one was marked for internal use only. Please let me know if this is okay!

Title	Permission to Use
Overview of the Shubenacadie/Stewiacke Watershed, NS	Yes
Striped Bass Important Habitat Areas	Yes
Works, Undertakings & Activities (2006-2022)	Yes
Bedrock Geology	Yes
Modelled Pre-dyke Salt Marshes	TBD – see email to Tim Webster
Land Cover	Yes
Other Threats	Yes
Mineral Rights & Mining Activity	Yes

Subject: RE: salt marsh modelling - permission to use
Date: Friday, November 18, 2022 at 2:55:31 PM Atlantic Standard Time
From: Allard,Karel (ECCC)
To: Webster,Timothy, Gromack, Aimee
CC: Lawler, Madeline, Butler, Sean, Samanta Martinez Membreno, Theriault,Marie-Helene (ECCC)

CAUTION: The Sender of this email is not from within Dalhousie.

Hi all,

Yes, I am certainly supportive as this aligns with the intent of our collective efforts.

Please keep me and Marie-Hélène Thériault posted as results are generated that are based on these products. The Inner Bay of Fundy initiative team would constitute a receptive audience for such communication.

All the best,

Karel

Karel Allard, PhD

Protected Areas Coordinator, Protected Areas / Canadian Wildlife Service
Environment and Climate Change Canada / Government of Canada
Karel.Allard@ec.gc.ca / Cell: 506-364-5944

Coordonnateur des aires protégées, Aires protégées / Service canadien de la faune
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Karel.Allard@ec.gc.ca / Tél. cell : 506-364-5944

From: Webster,Timothy <Timothy.Webster@nscc.ca>
Sent: 18 novembre 2022 14:47
To: Gromack,Aimee (DFO/MPO) <aimee.gromack@dfo-mpo.gc.ca>; Allard,Karel (ECCC) <Karel.Allard@ec.gc.ca>
Cc: Lawler, Madeline <Madeline.Lawler@dfo-mpo.gc.ca>; Butler, Sean <Sean.Butler@dfo-mpo.gc.ca>; Samanta Martinez Membreno <samanta.martinez@dal.ca>
Subject: Re: salt marsh modelling - permission to use

Hello

Thanks for the interest in those data. I have no problem with it being used for grad research. I have included Karel as well but I expect he is in agreement also.

Regards Tim

Get Outlook for iOS

From: Gromack, Aimee <Aimee.Gromack@dfo-mpo.gc.ca>

Sent: Friday, November 18, 2022 1:48:38 PM
To: Webster,Timothy <Timothy.Webster@nscc.ca>
Cc: Lawler, Madeline <Madeline.Lawler@dfo-mpo.gc.ca>; Butler, Sean <Sean.Butler@dfo-mpo.gc.ca>; Samanta Martinez Membreno <samanta.martinez@dal.ca>
Subject: salt marsh modelling - permission to use

> **CAUTION**: This message was sent from **outside the organization**. Please **do not click links or open attachments** unless you recognize the source of this email and know the content is safe.

Hi Tim,

You provided Sean Butler with your data showing predicted salt marsh, pre and post dyke (we love this data set!). **Can this data be used in a student grad project (see attached figure)?** Our student, Samanta Martinez, was working as an intern when Sean originally received the data from you and would like to use it in her grad project titled "Determining effectiveness of Ecologically Significant Areas for protecting Striped Bass (Morone saxatilis) spawning habitat in the Stewiacke River, NS". In Sam's report, she mentions the need to look at the role that salt marsh restoration could play in supporting striped bass spawning and her report refers to and describes the attached map.

Please let us know if you are ok with her using the data. Sam or I can give you more information about the grad project if you like, just let us know. She needs to know really soon, **by November 24** if possible.

Sean is on parental leave for an extended period and Madeline is covering for him – cc'ing her so she is looped in.

Best regards,

Aimee Gromack BSc, MMM
(she/her | elle/elle)
Senior Biologist, Integrated Planning

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