Fish and Fish Habitat Report for Nova Scotia: Summary of the threat analysis prepared to support reporting by the Fish and Fish Habitat Protection Program - Maritimes Region

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Table of Contents

List of Figures and Tables v

List of Abbreviations vi

Abstract vii

Résumé viii

1. Introduction 1

2. Overview of Fish and Fish Habitat in Nova Scotia 2

2.1 Watersheds of Nova Scotia 2

2.2 Aquatic Species in Nova Scotia 3

2.2.1 Species at Risk 4

3. Management of Fish and Fish Habitat in Nova Scotia 5

3.1 Regulatory Management 6

3.1.1 Referrals 6

3.1.2 Offsetting and Habitat Banking 8

3.1.3 Compliance 9

3.2 Integrated Planning 9

3.2.1 Restoration 10

3.2.2 Funding programs 11

4. Threats to Fish and Fish Habitat 12

4.1 Previous Fish Habitat Reporting in Nova Scotia 12

4.2 Overview of Threat Analysis Approach 13

4.3 Land Use 14

4.3.1 Land cover disturbance in Nova Scotia 14

4.3.2 Riparian disturbance in Nova Scotia 16

4.3.3 Management actions to address land use in Nova Scotia 18

4.4 Watershed Acidification 19

4.4.1 Impacts of acidification 19

4.4.2 Acidification in Nova Scotia 20

4.4.3 Management actions to address acidification in Nova Scotia 24

4.5 Aquatic Connectivity 24

4.5.1 Impacts of barriers 24

4.5.2 Dams and other water control structures in Nova Scotia 26

4.5.3 Watercourse crossings in Nova Scotia 28

4.5.4 Management actions to improve connectivity in Nova Scotia ... 30
4.6 Aquatic Invasive Species ... 32
4.6.1 Impacts of aquatic invasive species ... 32
4.6.2 Aquatic invasive species in Nova Scotia ... 32
4.6.3 Management actions to address aquatic invasive species in Nova Scotia ... 35
5. Conclusion ... 36
References ... 38
Appendix 1: Data Sets ... 42

List of Figures and Tables

Figure 1. Map of primary watersheds of Nova Scotia 3

Figure 2. Distribution of both species listed under the Species at Risk Act and those assessed as 'at risk' by the Committee on the Status of Endangered Wildlife in Canada............................... 5

Figure 3. Summary of habitat referrals by primary impact in the Maritimes Region (2014-15 to 2020-21) 7

Figure 4. Advice/Response Given and Authorizations Issued – Maritimes Region 8

Figure 5. Map of fish habitat banks in Nova Scotia 9

Figure 6. DFO funding program investments in Nova Scotia 12

Figure 7. Land cover disturbance by watershed across Nova Scotia.......................................16

Figure 8. Riparian zone land cover disturbance by watershed across Nova Scotia 18

Figure 9. Acid rock drainage potential (area (km2) of potentially expose acid rock per watershed area (km2)) in Nova Scotia...22

Figure 10. Watershed buffering capacity (average mg/L of calcium carbonate (CaCO3)) in Nova Scotia..23

Figure 11. Proportion of total stream length behind dams and water controls structures in Nova Scotia..27

Figure 12. Density of watercourse crossings in Nova Scotia (#/km) 29

Figure 13. Passability of assessed culverts in four watersheds of Nova Scotia. Note that these percentages may not be representative of the passability of all culverts in each watershed......30

Figure 14. Spread of smallmouth bass in Nova Scotia from 1940 to 2020...............................34

Figure 15. Spread of chain pickerel in Nova Scotia from 1940 to 2020....................................35

Table 1. Species at risk recovery publications used to identify the distribution of each species 42

Table 2. Nova Scotia distribution of both species listed under the Species at Risk Act and those assessed as 'at risk' by the Committee on the Status of Endangered Wildlife in Canada by primary watershed 43

Table 3. DFO funding contributions by primary watershed of Nova Scotia (includes contribution funds from the Recreational Fisheries Conservation Partnerships Program (2103-2019), the Coastal Restoration Fund (2017-2022), the Habitat Stewardship Program (2018-2022) and the Canada Nature Fund for Aquatic Species at Risk (2019-2022) 46

Table 4. Watershed area and percent disturbance for the overall watershed and riparian zones for the primary watersheds of Nova Scotia...48

Table 5. Acid rock drainage potential and watershed buffering capacity for the primary watershed of Nova Scotia...50

Table 6. Connectivity metrics for the primary watersheds of Nova Scotia 52

Table 7. Decade of first detection of smallmouth bass in the secondary watersheds of Nova Scotia (1940 to 2020)...54

Table 8. Decade of first detection of chain pickerel in the secondary watersheds of Nova Scotia (1940 to 2020)...58

List of Abbreviations

ACAD	Aquatic Connectivity Analytical Database
AIS	aquatic invasive species
AIS-NCP	Aquatic Invasive Species National Core Program
ARD	acid rock drainage
CNFASAR	Canada Nature Fund for Aquatic Species at Risk
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRF	Coastal Restoration Fund
DFO	Fisheries and Oceans Canada
ESA	Ecologically Significant Area
FFHPP	Fish and Fish Habitat Protection Program
FIPEX	Fish Passage Extension
HADD	harmful alteration, disruption, or destruction
IHPP	Indigenous Habitat Participation Program
HSP	Habitat Stewardship Program for Aquatic Species at Risk
NCC	Nature Conservancy of Canada
NHN	national hydrographic network
NRCAN	Natural Resources Canada
NSDFA	Nova Scotia Department of Fisheries and Aquaculture
NSDNRR	Nova Scotia Department of Natural Resources and Renewables
RFCPP	Recreational Fisheries Conservation Partnerships Program
SARA	*Species at Risk Act*
WUA	work, undertaking, or activity

Abstract

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This report compliments the “Habitat Highlights” reporting initiative being undertaken by the Fish and Fish Habitat Protection Program (FFHPP) at Fisheries and Oceans Canada. Fish and fish habitat are subject to a variety of threats from activities occurring in or near water, as well as the impacts of various land use activities. This report presents information on multiple threats to freshwater fish and fish habitat in Nova Scotia: land use, barriers to aquatic connectivity, acidification and aquatic invasive species. These threats were selected for analysis due to the availability of province-wide data sets that could inform a relative threat assessment whereby each threat is mapped using a quantile classification across the 46 primary watersheds of the province. The FFHPP is responsible for the applying the fish and fish habitat protection provisions of the *Fisheries Act* to regulate works, undertakings or activities that could result in harmful impacts to fish and fish habitat. This report outlines the FFHPP’s regulatory and non-regulatory roles in addressing threats to fish and fish habitat. The analysis presented here may support decision-making by the FFHPP, including informing the identification of restoration priorities and possible future identification of Ecologically Significant Areas.

Résumé

MacDonald, J.L., Butler, S.M.M. and Lawler, M.M. 2023. Fish and Fish Habitat Report for Nova Scotia: Summary of the threat analysis prepared to support reporting by the Fish and Fish Habitat Protection Program - Maritimes Region. Can. Tech. Rep. Fish. Aquat. Sci. 3567: viii + 59 p.

Le présent rapport complète l'initiative de production de rapports « Pleins feux sur l'habitat » entreprise par le Programme de protection du poisson et de son habitat (PPPH) de Pêches et Océans Canada. Le poisson et son habitat font face à une variété de menaces découlant d'activités ayant lieu dans l'eau ou à proximité, ainsi qu'aux impacts de diverses activités d'utilisation des terres. Ce rapport présente des renseignements sur de nombreuses menaces pesant sur le poisson d'eau douce et son habitat en Nouvelle-Écosse, notamment l'utilisation des terres, les obstacles à la connectivité de l'habitat aquatique, l'acidification et les espèces aquatiques envahissantes. On a choisi d'analyser ces menaces en raison de la disponibilité d'ensembles de données à l'échelle de la province qui pourraient orienter une évaluation des menaces relatives dans le cadre de laquelle chaque menace serait catégorisée au moyen d'une classification quantile à l'échelle des 46 principaux bassins hydrographiques de la province. Le PPPH est responsable de l'application des dispositions de la *Loi sur les pêches* relatives à la protection du poisson et de son habitat afin de réglementer les travaux, les initiatives ou les activités qui pourraient entraîner des effets néfastes sur le poisson et son habitat. Le rapport décrit les rôles réglementaires et non réglementaires du PPPH concernant la prise de mesures à l'égard des menaces pesant sur le poisson et son habitat. L'analyse présentée dans le rapport pourrait appuyer la prise de décisions par les responsables du PPPH, notamment en orientant la détermination des priorités en matière de remise en état et des possibles zones d'importance écologique futures.

1. Introduction

The Fish and Fish Habitat Protection Program (FFHPP) at Fisheries and Oceans Canada (DFO) helps to conserve and protect fish and fish habitat by applying the fish and fish habitat protection provisions of the *Fisheries Act*, in combination with the relevant provisions of the *Species at Risk Act* (SARA) and the *Aquatic Invasive Species Regulations* to regulate works, undertakings or activities that could result in harmful impacts to fish and fish habitat (DFO 2019a). The purview of the FFHPP includes activities in freshwater, estuarine, marine, or other environments (e.g., riparian) that may impact fish or "fish habitat," defined under ss. 2(1) of the *Fisheries Act* as "water frequented by fish and any other areas on which fish depend directly or indirectly to carry out their life processes, including spawning grounds and nursery, rearing, food supply and migration areas."

The FFHPP reports on its activities in a number of ways, including via an *Annual Report to Parliament* and a new web-based fish and fish habitat reporting series called "Habitat Highlights". This latter product has been developed for a general audience, aiming to generate interest in local habitat issues and showcase how DFO collaborates with provinces and territories, Indigenous organizations and communities, and partners and stakeholders to protect fish and fish habitat beyond its regulatory role. Each individual "Habitat Highlight" showcases how one or more threats to fish and fish habitat is being assessed and managed in a particular geographic area[1]. DFO's Maritimes Region has developed "Habitat Highlights" on the threats of acid deposition, aquatic invasive species, and aquatic connectivity, as well as an overview of Nova Scotia.

This technical report is a supplement to the "Habitat Highlights" for the Maritimes Region[2]. It both provides an examination of the issues featured in the individually published "Highlights" and also serves to tie information related to threat assessment together in a single document, to provide a cohesive narrative for the province of Nova Scotia. Section 2 provides a general overview of fish and fish habitat in Nova Scotia. The threats addressed by this report are not an exhaustive list of all threats acting upon fish and fish habitat; they were selected to provide examples of threats based on the availability of province-wide datasets and to align with broader threat categories identified in the *Fish and Fish Habitat Protection Policy Statement* (DFO 2019a). Information on land use, watershed acidification, aquatic connectivity and aquatic invasive species is provided in Section 4.

This report also outlines DFO's regulatory and non-regulatory role in addressing these threats across the province. Section 3 provides an overview of how the FFHPP-Maritimes Region works closely with the Province of Nova Scotia on shared regulatory initiatives, engages with Indigenous organizations and communities, participates in integrated aquatic ecosystems planning with partners and stakeholders, and administers

[1] https://www.dfo-mpo.gc.ca/ecosystems-ecosystemes/habitat/highlights-faitssaillants-eng.html

[2] FFHPP is divided into administration regions that, in eastern Canada, differ from the overall administrative regions of DFO (https://www.dfo-mpo.gc.ca/about-notre-sujet/organisation-eng.htm). In freshwater environments, the FFHPP-Maritimes Region corresponds to the provincial boundaries for Nova Scotia.

grant and contribution funding for partners to facilitate fish habitat restoration. Further information on these partnerships and examples of projects and initiatives led by partners, with DFO support, are included in Section 4 as well as the region's "Habitat Highlights"[3].

2. Overview of Fish and Fish Habitat in Nova Scotia

2.1 Watersheds of Nova Scotia

The health of fish populations is directly linked to the health of the habitats in which they live. Fish need suitable places to rear, forage, and reproduce, with uninterrupted access between different habitats. Nova Scotia's waterbodies, including lakes, ponds, rivers, streams, wetlands and estuaries, as well as adjacent riparian areas, provide important habitat for fish. Habitat requirements differ among fish taxa and can vary significantly with landscape and waterscape features that have contributed to the life history evolution of these species over time.

Nova Scotia has several thousand kilometers of coastline, thousands of lakes, and hundreds of rivers and wetlands (Province of Nova Scotia 2010). The province is characterized by dense networks of small streams, lakes and bogs which have been influenced by historic glaciation, large areas of impermeable rock and thin soils (Davis and Browne 1998). Unlike other parts of Canada that are dominated by a few large watersheds, Nova Scotia has many smaller watersheds that flow directly into the ocean (Garroway et al. 2012).

Figure 1 shows the 46 primary watersheds in Nova Scotia that are used as the basis for the fish habitat data analysis throughout this report. These primary watersheds drain into four different coastal regions: Atlantic Ocean, Bay of Fundy-Gulf of Maine, Northumberland Strait, and Gulf of St. Lawrence.

[3] https://www.dfo-mpo.gc.ca/ecosystems-ecosystemes/habitat/highlights-faitssaillants-eng.html

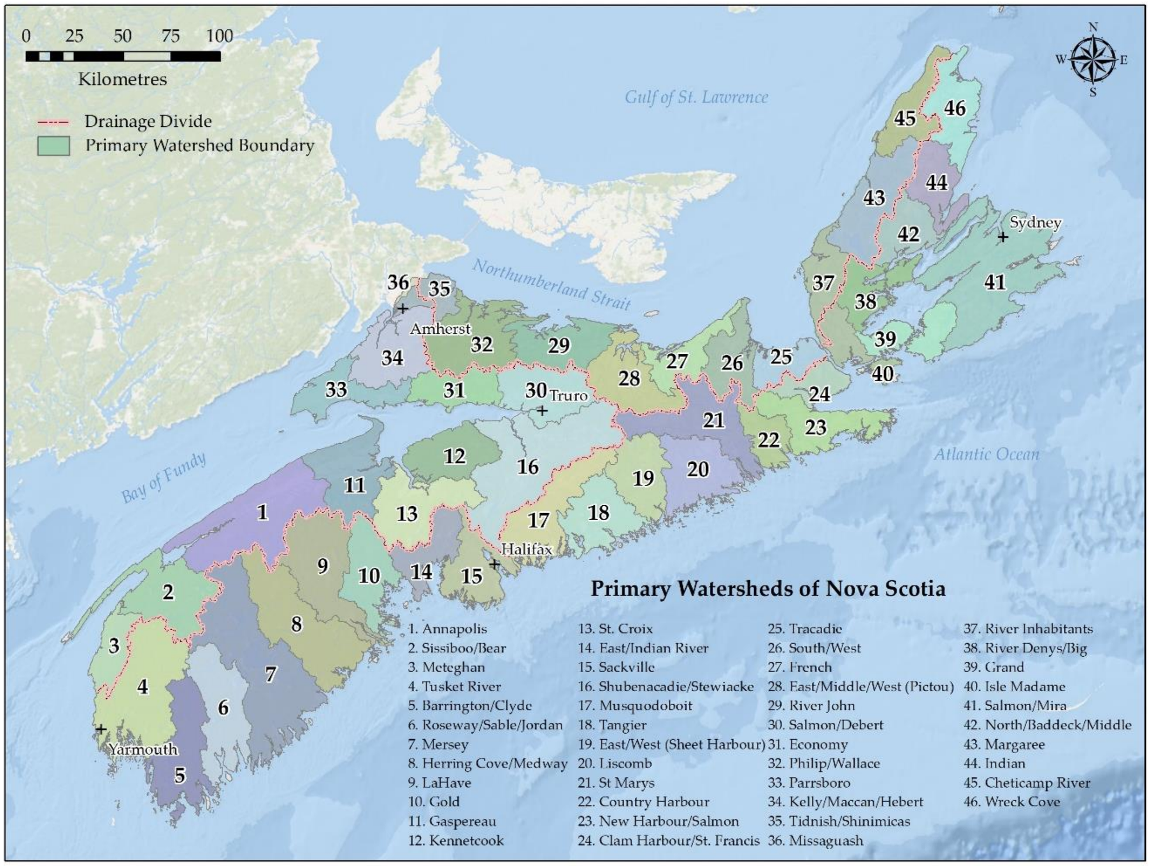

***Figure 1**. Map of primary watersheds of Nova Scotia*[4]

2.2 Aquatic Species in Nova Scotia

There are more than forty different fish species found in Nova Scotia lakes and rivers, including freshwater species, anadromous species (mature at sea and spawn in freshwater) and catadromous species (mature in freshwater and spawn at sea). In general, Nova Scotia has fewer freshwater fish species than are found in western Canada and the species present are heavily influenced by Nova Scotia’s proximity to the ocean (Davis and Browne 1998). Historically, species distribution may have been influenced by the species’ ability to tolerate salt water. Species with the ability to tolerate salt water are generally more widely distributed, as they were able to move from one river system to another via saltwater areas like estuaries (Davis and Browne 1998). In addition, the acidity of a lake or river system is a key factor in the species that are found in that location (Davis and Browne 1998).

[4] Data sources for all base maps contained in this report: General Bathymetric Chart of the Oceans GEBCO_08 Grid, National Oceanic and Atmospheric Administration, National Geographic, Garmin, HERE, Geonames.org, and Esri.

Some of the best known species in Nova Scotia are members of the salmonid family, including Atlantic salmon (*Salmo salar*) and several species of trout such as brook trout (*Salvelinus fontinalis*) and lake trout (*Salvelinus namaycusha*). Other species native to Nova Scotia include freshwater species such as banded killifish (*Fundulus disphanus*), brown bullhead (*Ameiurus nebulosus*), common shiner (*Luxilus cornutus*), white perch (*Morone americana*), and yellow perch (*Perca flavescens*); anadromous species such as American shad (*Alosa sapidissima*), Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus*), alewife (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*), and striped bass (*Morone saxatilis*); and catadromous species such as American eel (*Anguilla rostrata*). Furthermore, several fish species in Nova Scotia have evolved with multiple life history strategies. For example, it is common to find river systems in Nova Scotia with freshwater resident and anadromous ("sea-run") brook trout. While Atlantic whitefish (*Coregonus huntsman*) historically had anadromous and freshwater populations, only the landlocked form exists today, with a recovery goal to reintroduce the species elsewhere to re-establish anadromy (DFO 2018). While each species has unique habitat requirements for each stage in its life cycle, overall, fish require unimpeded access to healthy habitat, appropriate water quality, and adequate physical conditions for spawning and rearing.

2.2.1 Species at Risk

The *Species at Risk Act* (SARA) was proclaimed in 2003 with the purpose to prevent species from becoming extirpated or extinct, to provide for the recovery of extirpated, endangered or threatened species as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened. Species are assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent committee of experts, which assesses the status of a species based on the best available information, including scientific data, local ecological information, and Indigenous traditional knowledge. Once aquatic species are assessed as at risk, the Minister of Fisheries and Oceans is responsible for making a recommendation to the Minister of the Environment and Climate Change on whether or not to list the species under SARA. As part of this process, DFO conducts consultations open to all Canadians to determine potential benefits or impacts of listing a species.

In Nova Scotia, there are four freshwater and/or anadromous species listed under SARA: Atlantic salmon (inner Bay of Fundy population), Atlantic whitefish, yellow lampmussel, and brook floater. In addition, there are several other species found in the province that have been assessed as at risk by COSEWIC and are awaiting a decision regarding listing under SARA, including American eel, Atlantic sturgeon (Maritimes population), Atlantic salmon (Southern Upland and Eastern Cape Breton populations) and striped bass (Bay of Fundy population).

The mapping of species at risk in Nova Scotia made use of available geographic information provided in various species at risk recovery publications for each species (Table 1, Appendix 1). The distribution was informed by the COSEWIC Status Report, Recovery Potential Assessment, Recovery Strategy and/or Management Plan for the respective species and may include both current and historic distribution records. Each of the publications used for this exercise contained maps and/or geographic information (e.g., river names) identifying the presence of a given species. These locations were plotted in the ArcGIS 10.8 environment to determine which Nova Scotia primary watersheds contained the presence of a species at risk. The final map presented in this report depicts the total number of species at risk present for a given watershed, ranging from 1 to 5, and includes both SARA-listed species and COSEWIC assessed species (Figure 2; Table 2, Appendix 1).

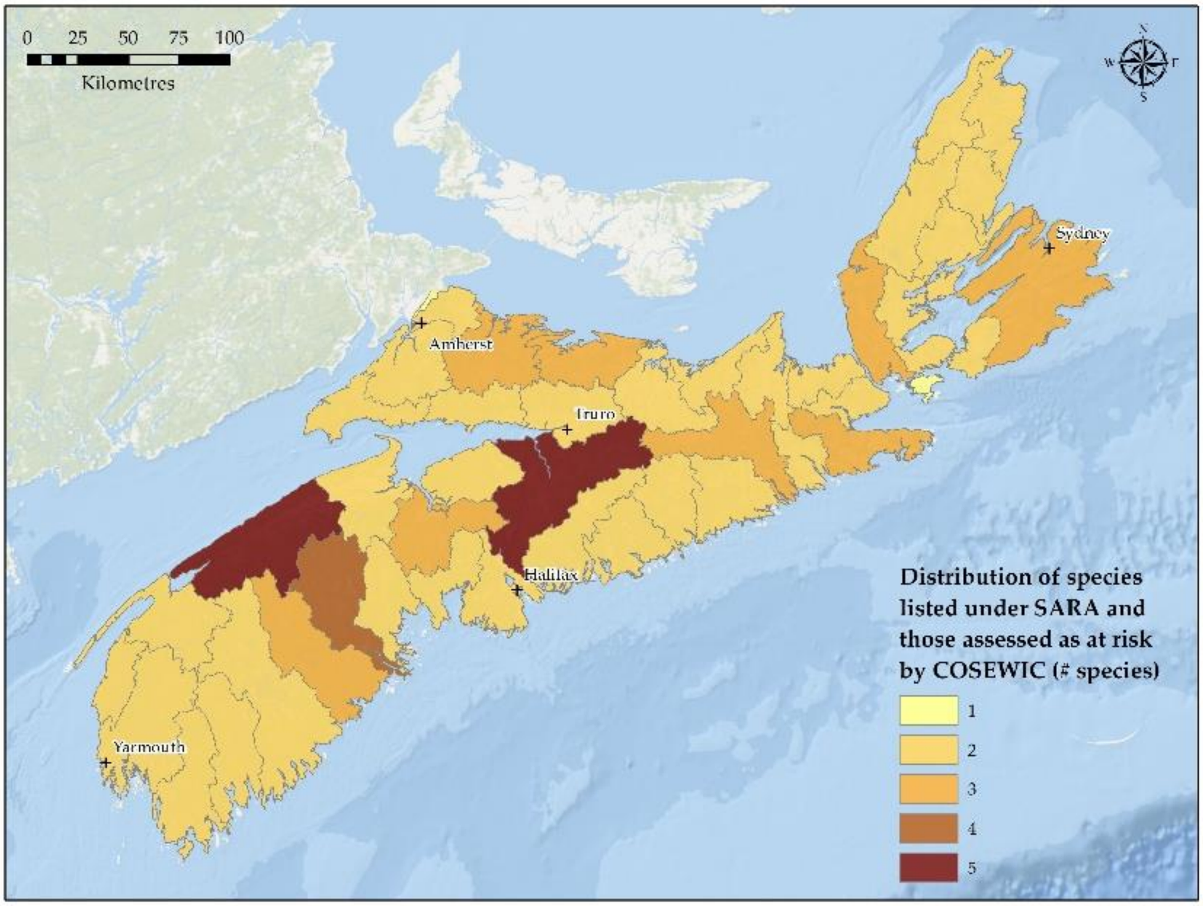

Figure 2. *Distribution of both species listed under the Species at Risk Act and those assessed as 'at risk' by the Committee on the Status of Endangered Wildlife in Canada*

3. Management of Fish and Fish Habitat in Nova Scotia

The following section provides an overview of the management of fish and fish habitat in Nova Scotia, including information on DFO's regulatory and non-regulatory roles. Where there are specific management measures undertaken to address a specific threat to fish habitat, such as aquatic connectivity or aquatic invasive species, these are described in greater detail in later sections of this report.

3.1 Regulatory Management

In DFO's Maritimes Region, the FFHPP and the Province of Nova Scotia both share responsibility for the regulatory oversight of activities that have a potential to impact fish and fish habitat. As a result, the Canada-Nova Scotia Memorandum of Understanding (MOU) on Fish Habitat Management was signed in 2005. The agreement was developed to increase federal-provincial cooperation in protecting and enhancing fish habitat in Nova Scotia. The MOU formalizes procedures for the two levels of government to work together to protect fish habitat in the province in recognition of this shared responsibility.

The Province of Nova Scotia manages Crown lands, water and fisheries, including recreational fisheries, in non-tidal waters. They accomplish this through various legislation, including the *Biodiversity Act*, *Coastal Protection Act*, *Crown Lands Act, Environment Act*, *Forests Act*, and *Water Resources Protection Act*. The Province has also established policies and guidelines that provide for the integration of fish habitat protection and conservation considerations and measures in its decision-making processes.

The Nova Scotia *Environment Act* provides the provincial authority to protect watercourses. Any activity that changes a watercourse, a water resource, or the flow of water therein requires an Approval or Notification in accordance with the *Activities Designation Regulations*. A watercourse alteration is any change made to the bed or bank of a watercourse or to the water flow including culvert and bridge crossings, wharf construction, utility crossings, dams, and removal of materials from the watercourse (Province of Nova Scotia 2015). In most cases, applications submitted for watercourse alterations are shared with DFO for review to ensure there is no contravention of the *Fisheries Act* or SARA.

3.1.1 Referrals

The FFHPP ensures compliance with relevant provisions of the *Fisheries Act* and SARA. These acts provide a legal basis for conserving and protecting fish and fish habitat. The fish and fish habitat protection provisions of the *Fisheries Act* include a prohibition against causing the death of fish, by means other than fishing, and a prohibition against causing the harmful alteration, disruption or destruction (HADD) of fish habitat (DFO 2019a).

Proponents are responsible to plan and implement works, undertaking and activities (WUAs) taking place in or near water in a manner that avoids impacts to fish and fish habitat. When proposed WUAs are unable to avoid the death of fish or the HADD of fish habitat, impacts should be mitigated to the extent possible. If, after applying avoidance and mitigation measures, the WUA will still result in residual impacts, the proponent will need to seek an exception under the *Fisheries Act*, which in most cases would be a Ministerial authorization. Before approving any WUAs that will result in the death of fish and/or the HADD of fish habitat, the Department must consider measures to offset any residual effects after avoidance and mitigation measures are applied (DFO 2019a). "Avoid", "mitigate", and "offset" is a hierarchical approach that is recognized as a best practice in reducing risk to biodiversity – first prevent (avoid), then minimize (mitigate) impacts and then residual impacts should be offset.

Referrals are requests for review or applications for *Fisheries Act* authorizations, submitted to DFO either directly by a proponent or indirectly by a consultant, the Province of Nova Scotia, or other agency concerning proposed WUAs that may affect fish or fish habitat. Figure 3 provides a summary of the referrals received in Maritimes Region by primary impact. While the total number of referrals has increased above 400 per year since the modernization of the *Fisheries Act* in 2019, the proportion of each type of referral has remained relatively constant, with referrals related to infilling being the most common, followed by referrals related to potential impacts to fish passage.

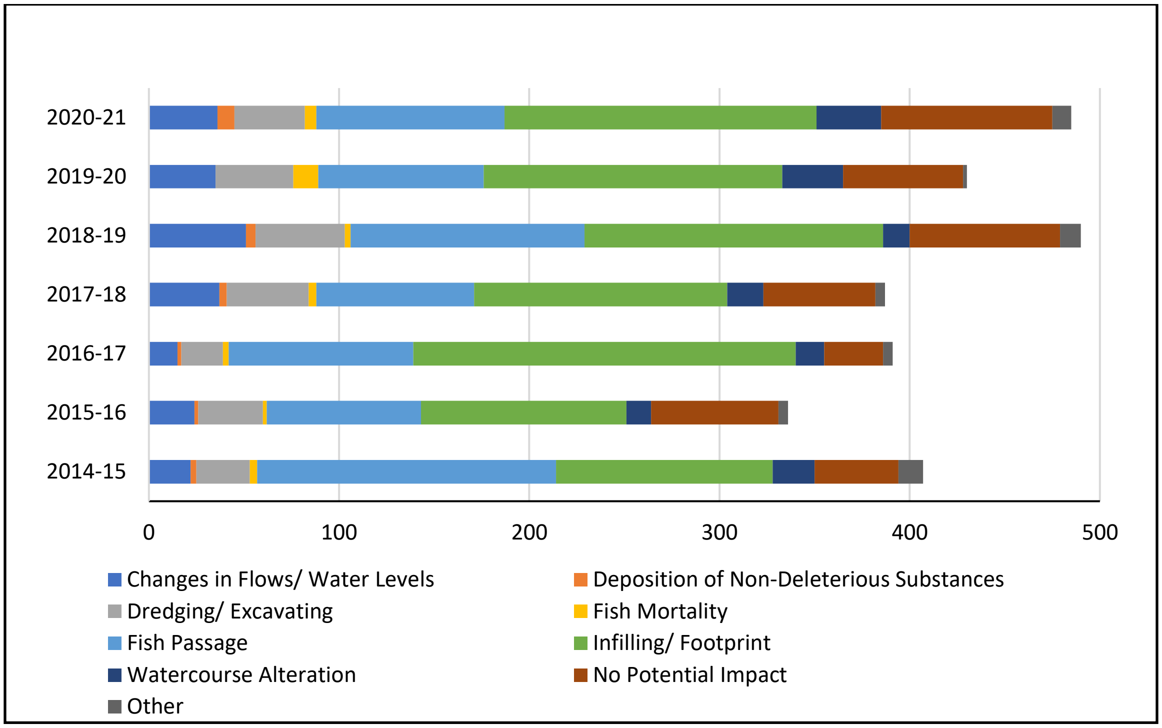

***Figure 3**. Summary of habitat referrals by primary impact received in the Maritimes Region (2014-15 to 2020-21)*

Referrals may result in DFO providing a Letter of Advice to proponents or issuing an authorization or other Ministerial tool under the *Fisheries Act* (Figure 4). DFO also provides written advice to federal agencies, provincial/territorial/other agencies, technical expertise to environmental or impact assessment processes, and provides mitigation measures to permitting agencies.

After appropriate avoidance and mitigation measures were applied, only a small proportion of referrals received in the Maritimes Region resulted in the issuance of an authorization. The residual impacts of these WUAs were required to be offset via a specific habitat offsetting project or through fish habitat banks.

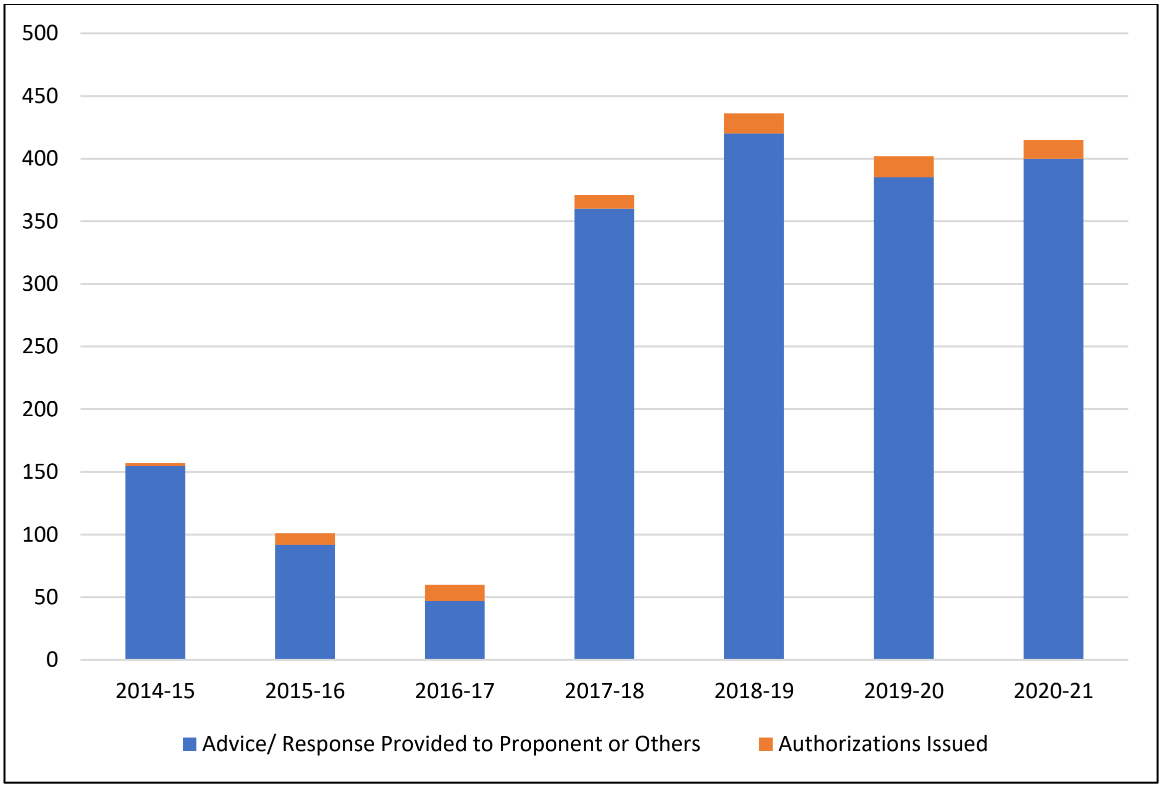

***Figure 4**. Advice/response given and authorizations issued in the Maritimes Region (2014-15 to 2020-21)*

3.1.2 Offsetting and Habitat Banking

Before approving any WUAs that will result in the death of fish and/or the HADD of fish habitat, DFO must consider measures to offset any residual effects after avoidance and mitigation measures are applied. Offsetting measures may include restoring degraded fish habitat or enhancing fish habitat to improve conditions for the production of fish, or creating productive and sustainable fish habitat where none existed before (DFO 2019b). Offset measures are typically applied in two ways: through a specific habitat offsetting project or through fish habitat banks. A fish habitat bank is a formalized approach to offset, in advance, the potential HADD of fish habitat from future authorized WUAs.

In the Maritimes Region, habitat banks have been in place since the early 2000s and over 20 habitat banks have been created to offset authorized projects in marine and freshwater environments (Figure 5). Through these habitat banks, over 1.5 million m^2 of fish habitat has been enhanced, restored or created in Nova Scotia.

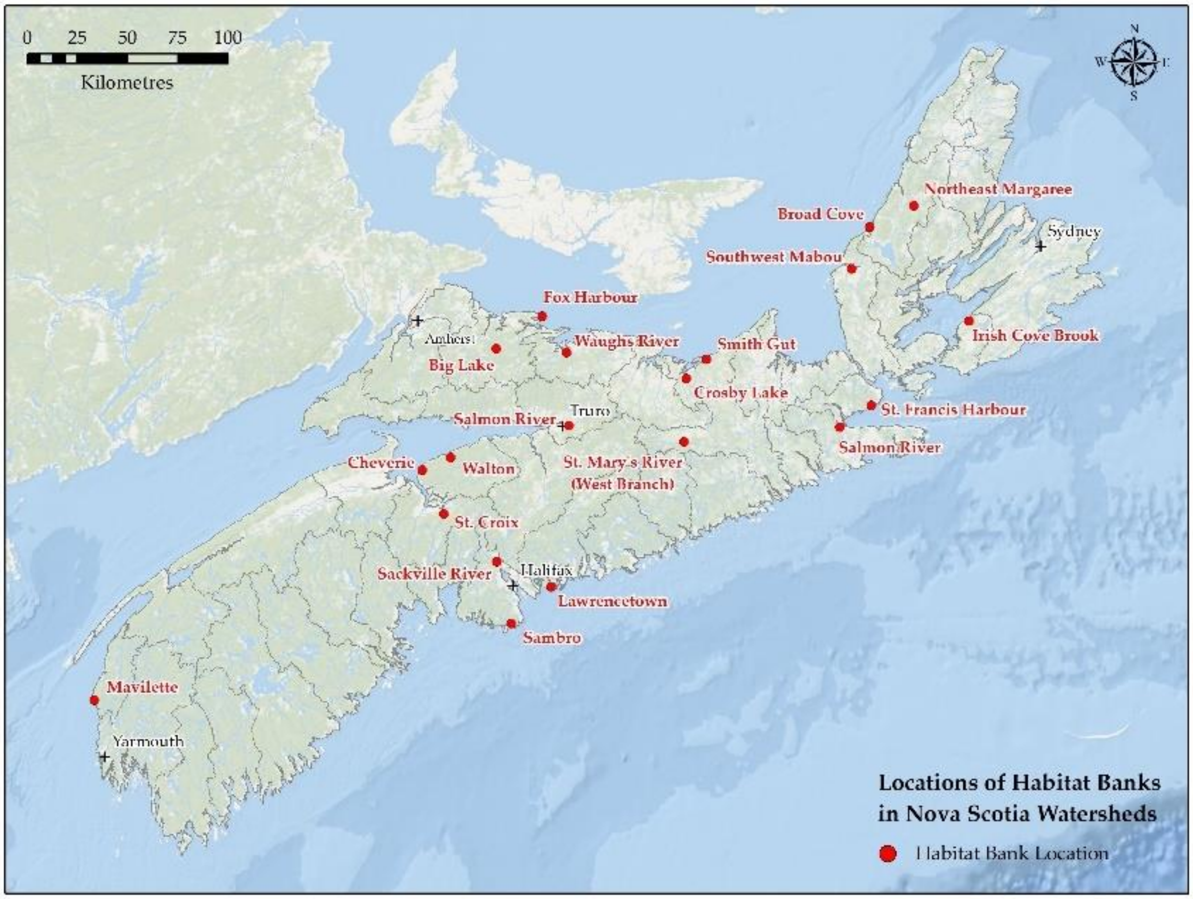

Figure 5. *Map of fish habitat banks in Nova Scotia*

3.1.3 Compliance

DFO's Conservation and Protection Program is responsible for monitoring compliance with legislation and regulations. Fishery officers enforce the fish habitat protection provisions of the *Fisheries Act* through working with FFHPP biologists on sites with authorized WUAs, responding to reports of potential habitat violations from members of the public, conducting habitat patrols, inspections and investigations, working with Crown counsels on prosecutions, and assisting in the education of the public on habitat protection.

3.2 Integrated Planning

The Integrated Planning unit within the FFHPP works collaboratively with provinces and territories, Indigenous groups, partners and stakeholders to enable proactive planning, management and coordination related to fish and fish habitat. Integrated Planning promotes the incorporation of fish and fish habitat conservation, protection, and restoration priorities and objectives into freshwater and coastal planning initiatives, to result in better outcomes through collaboration. This proactive and collaborative planning helps to minimize future impacts to fish and fish habitat; to protect and conserve existing fish and fish habitat including through the identification of sensitive habitats; and to identify ways to improve fish habitat that has been lost through the identification of restoration priorities. Furthermore, the FFHPP works closely with scientists on research that seeks to prioritize knowledge gaps that should be filled to support evidence-based management of freshwater fish habitat and species at risk (Dey et al. 2021; Castañeda et al. 2021).

A relatively new initiative that the Integrated Planning unit is working on is Ecologically Significant Areas (ESAs), a proactive area-based regulatory tool to offer greater conservation and protection for fish and fish habitat that is "sensitive, highly productive, rare, or unique." DFO's national *Framework for Identifying, Establishing, and Managing Ecologically Significant Areas* provides transparency for how the ESA provisions of the *Fisheries Act* (s. 35.2) may be applied across Canada, in collaboration with Indigenous Peoples, provinces and territories, and stakeholders (DFO 2023). ESA case studies are in the early stages of being explored to test components of the national framework and may be considered as future ESA Candidates. Some case studies are being explored in conjunction with external organizations, where conservation and protection objectives for priority fish species and habitats may be used to determine enhanced regulatory measures for these areas in the future.

3.2.1 Restoration

In addition to the FFHPP's regulatory role in conserving and protecting fish and fish habitat, the program also helps to manage the impacts of habitat degradation through restoration. Overall, habitat restoration provides an opportunity to improve the conditions for aquatic ecosystems and reverse, mitigate or adapt to past and ongoing impacts. Fish habitat restoration can address habitat degradation, improve biodiversity, and mitigate climate change impacts. While DFO does not generally carry out restoration work directly, the department supports restoration through funding programs, through participation in processes such as watershed planning and by overseeing habitat offsetting and banking arrangements.

The Department has developed a national *Framework to Identify Fish Habitat Restoration Priorities* that is intended to be an overarching guidance document to provide a consistent yet flexible approach to identify fish habitat restoration priorities. The Framework includes a description of the principles that characterize integrated and effective restoration and identifies considerations regarding how to prioritize restoration actions, opportunities and objectives (DFO 2022a).

Maritimes Region is in the process of developing a *Regional Fish Habitat Restoration Plan* that will identify objectives and priorities for fish habitat restoration in Nova Scotia and will be informed, in part, by an assessment of threats to fish habitat across the province. Establishing priorities for aquatic restoration will help DFO and others select and target restoration opportunities to improve fish habitat.

3.2.2 Funding programs

DFO administers several funding programs that contribute to the conservation, protection and restoration of fish habitat:

- The Recreational Fisheries Conservation Partnerships Program (RFCPP) ran from 2013-2019 with the goal of enhancing the sustainability and ongoing productivity of recreational fisheries. Over this time, more than $3.5 million in funding was provided to partners to restore, rebuild and rehabilitate recreational fisheries habitat across 59 projects in Nova Scotia. These projects contributed to the restoration of over 5,000,000 m^2 of fish habitat in the province.
- The Coastal Restoration Fund (CRF) ran from 2017-2022 with the objective of restoring coastal aquatic habitats. In Nova Scotia, over $8.6 million in funding was provided to six projects that contributed to the restoration of important marine and coastal areas such as saltmarshes, as well as remediating barriers to fish passage at key freshwater and marine points.
- The Aquatic Ecosystems Restoration Fund (AERF) was launched in 2022 to support aquatic restoration projects that will help to address the root causes of impacts to coastal and marine environments. In Nova Scotia, over $13 million in funding has been awarded to six projects that will contribute to the restoration of important marine and coastal areas, such as saltmarshes and eelgrass beds, as well as address habitat degradation and barriers to connectivity.
- The Habitat Stewardship Program for Aquatic Species at Risk (HSP) contributes to the recovery of aquatic species at risk by engaging Canadians in conservation actions. Between 2018-19 and 2023-24, over $1.9 million in funding has been awarded to seventeen freshwater projects in Nova Scotia, including projects to restore fish habitat and remediate barriers to fish passage.
- The Canada Nature Fund for Aquatic Species at Risk (CNFASAR) was established to provide funding to stewardship projects that support the recovery and protection of aquatic species at risk, specifically focused on priority threats, species and places. Between 2019-20 and 2022-23, over $7.3 million in funding was awarded to five freshwater projects in Nova Scotia supporting improvements to fish passage, fish habitat, and water quality.
- The Indigenous Habitat Participation Program (IHPP) launched in 2019 to support opportunities for Indigenous communities to participate in the conservation and protection of fish and fish habitat. Funding is available to support Indigenous peoples participation in consultation related to fish and fish habitat conservation and protection under the *Fisheries Act* or SARA; participation in engagement on the development of fish and fish habitat conservation and protection policies, regulations and programs; and collaborative activities such as planning, protection, monitoring and conservation of fish and fish habitat.

Contribution funding has been invested in watersheds across Nova Scotia, aligning with the different priorities and objectives of the different programs. Mapping of funded restoration projects was completed using the primary watershed scale. While most funded projects have been focused on restoration in a single watershed, a select few projects completed restoration work in multiple primary watersheds. The final map provides a visual depiction of the geographic spread of restoration funding across the different primary watersheds (Figure 6). Maritimes region's "Habitat Highlights" includes StoryMaps that highlight many projects funded through these contribution funding programs.

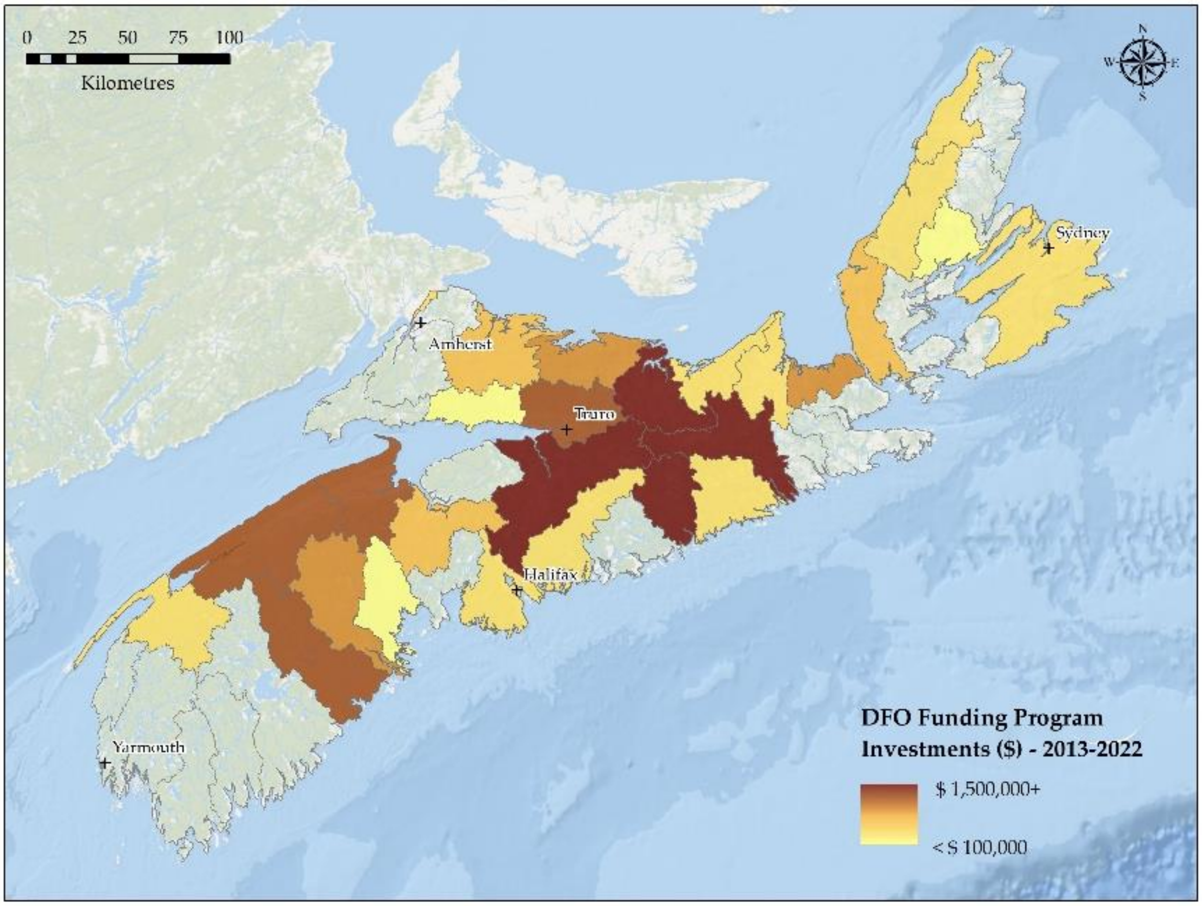

Figure 6. *DFO funding program investments in Nova Scotia including investments made under the RFCPP (2013-2019), CRF (2017-2022), HSP (2018-2022) and CNFASAR (2019-2022).*

4. Threats to Fish and Fish Habitat

4.1 Previous Fish Habitat Reporting in Nova Scotia

Other reporting and assessment initiatives have been completed for freshwater habitats in Nova Scotia. In some cases, different data sets or methodologies have been used to assess similar threats, which may prevent direct comparisons between this report and these other assessments. However, these all provide tools to help habitat managers and the public understand watershed health in Nova Scotia.

The Nova Scotia Watershed Assessment Program was carried out as a collaboration between Dalhousie University and the Province of Nova Scotia. The program aimed to increase knowledge about the state of watersheds in Nova Scotia. Through the program, an assessment of watersheds in Nova Scotia was completed that summarized physical properties, watershed values and key human impacts. Eleven impact indicators were assessed: proportion of watershed with human land use, acidification index, acid rock drainage, stream/road crossings, length of roads within 100m of streams, road density, portion of streams bounded by human land use, portion of stream length behind dams, dam density, surface water usage, and groundwater usage. Watersheds were assigned a relative rank for each of the impact indicators. These ranks were then summed to produce an overall rank for each watershed (NSWAP 2011).

As part of the Nature Conservancy of Canada's (NCC) Freshwater Conservation Blueprint, a Watershed Health Assessment report was completed for the Northern Appalachian-Acadian Region of Canada. The Watershed Health Assessment report developed a watershed stress index to evaluate the relative health of aquatic systems and then identified both conservation and restoration priorities (Millar et al. 2019a). The stressors included within the watershed stress index were: aquatic barrier density, percent area composed of clearcuts, climate velocity, critical load exceedance, percent area composed of cropland, percent area of impervious surface, annual nitrogen leaching, number of non-native fish species, percent area composed of pasture, annual pesticide leaching, annual phosphorus leaching, density of metal point-sources, density of nutrient point-sources, density of organic point-sources, crossing density, unpaved road density, and average temperature change. Watersheds that ranked as low stress on the watershed stress index were assumed to benefit more from conservation, while watersheds that ranked as high stress were assumed to benefit more from restoration activities (Millar et al. 2019a).

4.2 Overview of Threat Analysis Approach

Fish and fish habitat are impacted by multiple threats, both from activities taking place in or near water as well as from broader land use pressures. Information on threats is necessary to support DFO's regulatory and non-regulatory roles with respect to the conservation and protection of fish and fish habitat.

The *Fish and Fish Habitat Protection Policy Statement* identifies six overall categories of threats to fish and fish habitat: habitat degradation, habitat modification, aquatic invasive species, overexploitation of fish, pollution and climate change (DFO 2019a). This report presents information on a subset of these threats in Nova Scotia that were selected to align with the threat categories in the Policy Statement: land use and barriers to aquatic connectivity (habitat degradation and modification); acidification (pollution); and aquatic invasive species. As the purpose of this analysis was to provide an overview of fish habitat threats in Nova Scotia and insight into the relative state of those threats at the primary watershed scale, the analysis focused on using datasets that are consistently collected and reported data across the province, that are publicly available and that can be analyzed at the primary watershed scale. Climate change is not examined in this report but is recommended to be part of any future threat reporting.

The analysis focused on producing a relative assessment of each threat across the primary watersheds of Nova Scotia. For the threats of land use / land cover disturbance, barriers to aquatic connectivity and acidification, a quantile classification map was produced depicting the results of each threat analysis, in which each class contains an equal number of watersheds. For example, the watersheds with the two lowest densities of watercourse crossings fall within the first class, while the watersheds with the two highest densities of watercourse crossings are within the last class. This approach presents how each watershed ranks compared to others but does not provide information on the absolute values nor the differences in values between the ranks. The absolute values for all the threats assessed are included in Appendix 1. Note that the analysis and mapping approach differed for aquatic invasive species; this approach is detailed below.

4.3 Land Use

4.3.1 Land cover disturbance in Nova Scotia

Land-based activities can influence the state of aquatic fish habitat through a variety of factors and processes. While the focus of this report is on habitat degradation and modification within the aquatic environment, an understanding of the general patterns of surrounding land use provides important context to understand the full scope of threats that directly and indirectly impact fish and fish habitat (Collison and Gromack 2022). Identifying land use and land cover patterns at relatively large spatial scales can also help pinpoint locations to target for finer scale analysis (e.g., Murray et al. 2023), depending on research and management objectives.

Land cover disturbance was assessed for Nova Scotia by determining the combined percentage of each primary watershed that was classified as urban development, agriculture or forest loss. Watershed land cover disturbance maps were produced using an adapted methodology from the NCC's Watershed Health Assessment (Millar et al. 2019a). The analysis was completed using various Landsat-derived land cover products (30 m resolution) to identify areas of urban development, agricultural areas, and forest loss:

- Areas classified as urban development were identified using urban land cover extracted from the NRCAN - Canada Centre for Remote Sensing's 2015 Land Cover of Canada[5], and urban impervious surface available from the Global Man-made Impervious Surface (2010) (Brown de Colstoun et al. 2017).
- Agricultural land cover areas were identified using cropland extracted from the NRCAN - Canada Centre for Remote Sensing's 2015 Land Cover of Canada, and pasture / forages extracted from Agriculture and Agri-food Canada's 2021 Annual Crop Inventory[6].
- Areas of forest loss were identified using data available from Global Forest Watch (2021), and included areas identified as gross forest loss for the period of 2011-

[5] https://open.canada.ca/data/en/dataset/4e615eae-b90c-420b-adee-2ca35896caf6

[6] https://open.canada.ca/data/en/dataset/ba2645d5-4458-414d-b196-6303ac06c1c9

2021 (Global Forest Watch 2021). It should be noted that forest loss includes areas impacted by forest harvesting, as well as forest loss due to other processes (e.g., fires, storms). This dataset should also be interpreted as gross forest loss, so areas of forest gain (e.g., regeneration following forest harvesting) are not captured.

To generate the disturbance values at the watershed scale, raster datasets were generated using the aforementioned land cover disturbance datasets within the ArcGIS Desktop environment. A raster dataset is a set of cells or pixels organized into a grid to develop an image. The raster products in a satellite imagery format were created for each disturbance type (urban, agriculture, and forest loss), and for a single composite disturbance dataset capturing all disturbance types. The total and individual disturbance type areas (km^2) were then calculated for each primary watershed and divided by the total watershed area to derive the final watershed disturbance values.

On the final map, darker colours indicate watersheds with a higher amount of disturbance, while lighter colours are indicative of a lower amount of disturbance. The watersheds in central Nova Scotia show the highest levels of disturbance from these combined land uses, while watersheds in southwest Nova Scotia, the eastern shore and Cape Breton are subject to less land use disturbance (Figure 7). The Gaspereau watershed had the highest proportion of watershed disturbance with more than 40% of the watershed classified as disturbed. The most prevalent individual disturbance type varies between watersheds, but generally aligns with historic land use patterns. In the five most heavily disturbed watersheds, agriculture is the greatest contributor to overall watershed disturbance in the Gaspereau, Tidnish/Shinimicas and Annapolis watersheds, while urban areas are the greatest contributor to disturbance in the East/Middle/West (Pictou) and Sackville watersheds (Table 4, Appendix 1).

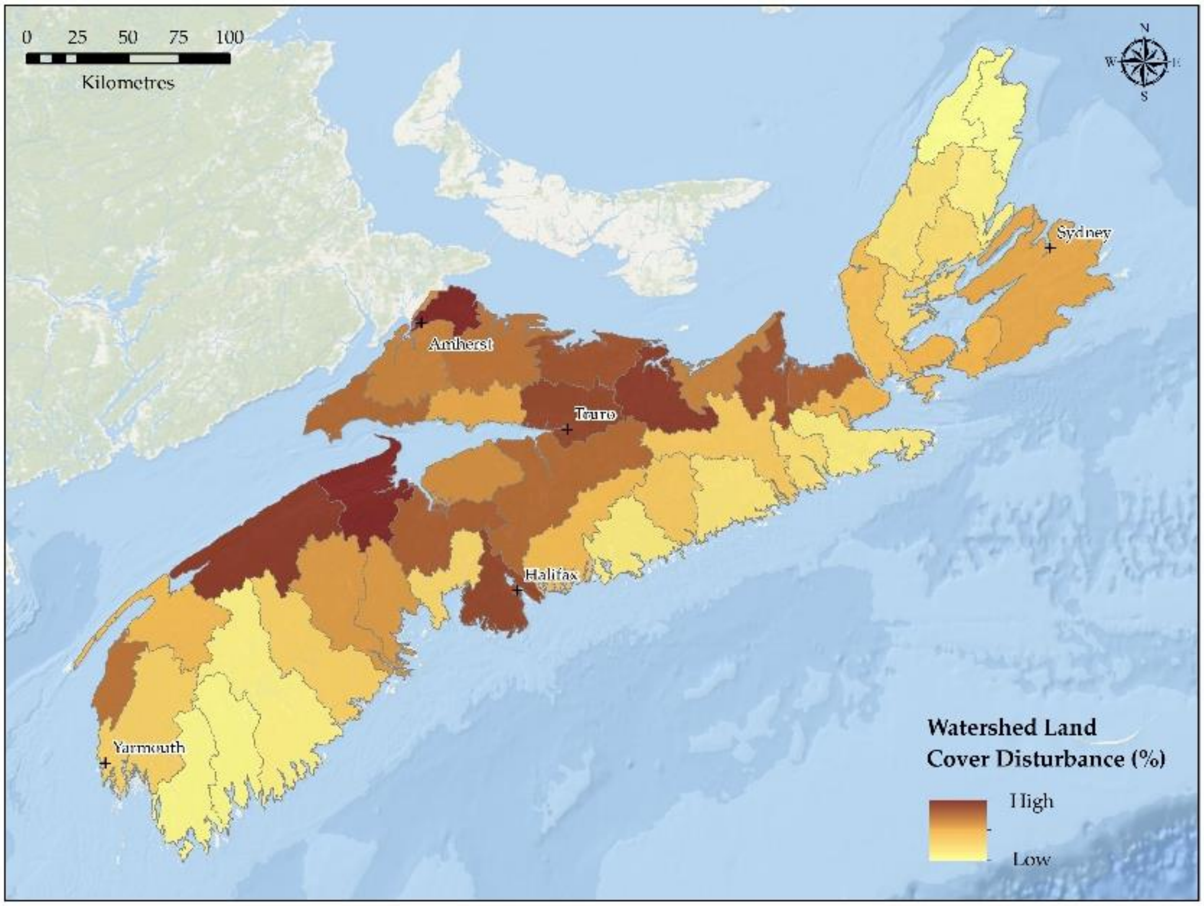

Figure 7*. Land cover disturbance by watershed across Nova Scotia*

4.3.2 Riparian disturbance in Nova Scotia

The riparian zone is the transitional ecosystem between upland and shoreline areas. DFO (2020) has defined 'riparian habitat' as "features outside the aquatic ecosystem, which support the establishment and maintenance of deep and shallow pool features, supply food for migrating and juvenile fish of many species, and influence water temperature."

The quality of aquatic habitat, particularly in freshwater ecosystems, is related to the condition of the adjacent riparian habitat and the types of activities occurring in the riparian zone. There are seven main processes that occur in riparian habitats that support, maintain and protect aquatic ecosystems: erosion, filtration, infiltration, isolation, meandering, shading and subsidization (DFO 2020). Ecologically and biologically diverse, riparian zones often provide an important buffer between the watercourse and adjacent land uses (Province of Nova Scotia 2015). Vegetation along the shoreline helps to slow surface runoff and hold soils in place, preventing erosion and protecting fish from the negative impacts of sedimentation. Roots absorb surface water and pull it into the ground where sediments, nutrients and pollutants can be filtered. Moreover, slowing the flow of runoff can help minimize flooding events following heavy rains or during spring snowmelt. Tree canopies and shoreline vegetation also shade the aquatic habitat, helping to keep water temperatures cooler. In addition, fallen vegetation and coarse woody debris that settles in the water can provide habitat for aquatic species. An important source of foraging inputs for fish, riparian habitats can function to contribute insects and detritus (i.e., leaf litter) to the water (Province of Nova Scotia 2015). These complex and sensitive biophysical processes can all be disturbed by various land uses, which in turn can directly or indirectly impact aquatic ecosystems and the species that depend on them (Collison and Gromack 2022).

The amount of riparian disturbance was assessed for Nova Scotia's primary watersheds by determining the combined percentage of urban development, agriculture or forest loss within a 150 m riparian zone extending outwards from aquatic features. Riparian disturbance was interpreted by narrowing the spatial scope of the land cover disturbance layers discussed in Section 4.3.1. to only include riparian habitat within each watershed. To define the riparian area, a 150 m buffer was applied to all watercourses and waterbodies (1:50,000 Canvec Hydrographic Features[7]). The 150 m buffer was selected to coincide with the 30 m resolution land cover disturbance rasters, which resulted in a 5-pixel spatial footprint surrounding watercourse features. This buffer size was thought to provide a sufficient sample size of pixels to capture the various land cover types for a given location and was determined to be a practical spatial footprint in which to analyze riparian land cover. For future analyses a finer scale raster product (e.g., Murray et al. 2023) and a smaller buffer distance would be recommended.

Land cover disturbance area calculations were replicated for the riparian analysis using both the total composite disturbance and individual disturbance types within the riparian area of each primary watershed. These values were then divided by the total riparian area of each primary watershed to generate the total riparian disturbance values.

The riparian zone disturbance showed similar patterns to the overall watershed land use disturbance, with the watersheds in central Nova Scotia showing the highest levels of riparian disturbance from these combined land uses (Figure 8). The individual disturbance type that contributes the most to the overall riparian disturbance varies across watersheds, with some being almost entirely impacted by one disturbance type while others have similar amounts of disturbance from each land use type. In the five watersheds with the greatest proportion of riparian land cover disturbance, agriculture was the greatest land use type in four (Gaspereau, Tidnish/Shinimicas, Annapolis and Salmon/Debert watersheds) while urban areas were the greatest contributor to overall riparian disturbance in the East/Middle/West (Pictou) watershed (Table 4, Appendix 1).

[7] https://open.canada.ca/data/en/dataset/9d96e8c9-22fe-4ad2-b5e8-94a6991b744b

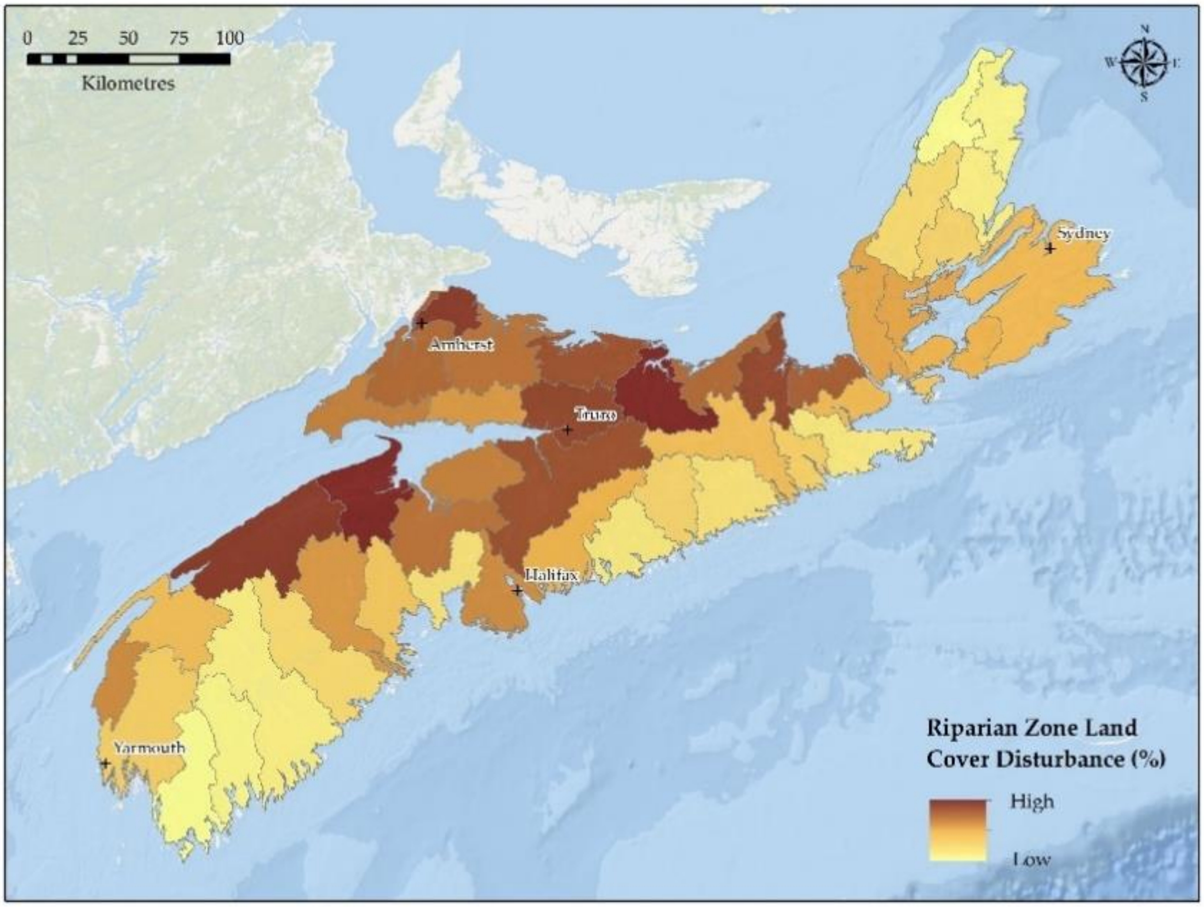

***Figure 8**. Riparian zone land cover disturbance by watershed across Nova Scotia*

4.3.3 Management actions to address land use in Nova Scotia

Regulatory Tools

While knowledge of land use disturbance types across a watershed is valuable to understanding the types of pressures acting on the aquatic environment; the overall management of land use falls outside of DFO's jurisdiction. In the riparian zone, there can be overlapping federal, provincial and municipal jurisdictions (Collison and Gromack 2022). The FFHPP has identified a number of measures for proponents to avoid impacts to fish and fish habitat, including related to maintaining riparian vegetation, carrying out WUAs on land and ensuring proper sediment control (DFO 2022b). If these measures cannot be applied and a project review is required, in some cases, where in-water WUAs have a riparian component, FFHPP may consider those impacts in the review of the proposed activity (Collison and Gromack 2022). Collison and Gromack (2022) provide a more thorough outline of riparian zone management across Canada and specifically in Nova Scotia, as well as proposing a number of recommendations for improved riparian zone management in the province.

Restoration

Restoration techniques, such as vegetation planting, root wads, brush mats or rock riprap, can be used to mitigate the impacts of land use and riparian disturbance on fish habitat. Improving the condition of the streambank has several benefits, including preventing bank erosion, reducing siltation and shading the stream (DFO 2006).

4.4 Watershed Acidification

4.4.1 Impacts of acidification

An essential part of a healthy aquatic ecosystem is clean water. Water quality can be broadly defined in terms of chemical, physical and biological parameters, and is influenced by many factors, including natural and anthropogenic features. Natural features that influence water quality include bedrock composition, watershed size, topography, vegetation and proximity to the ocean. Various land uses also affect water quality, including industrial, agricultural, forestry and urban uses. Substances that affect water quality can enter waterbodies directly (e.g., pollution directly discharged into a lake or river), through surface runoff (e.g., runoff from urban areas may contain nutrients, sediments, animal wastes, petroleum products, and road salts), through groundwater (e.g., contaminants accumulating in soils and then moving to the water table) or through rainfall (e.g., airborne pollutants may become dissolved in rain and deposited through rainfall). Commonly measured parameters for water quality include turbidity, total suspended solids, dissolved oxygen, pH, temperature, dissolved organic carbon, and various potential contaminants (e.g., metals and metalloids).

Water quality is a shared responsibility among multiple federal government departments, provinces and territories, and municipalities. Environment and Climate Change Canada, in partnership with provincial and territorial governments, monitors water quality across Canada (ECCC 2023). A full accounting of water quality is beyond the scope of this report. Rather, this section focuses on a specific threat to fish and fish habitat in Nova Scotia – the buffering capacity of watersheds across the province and the relationship to watershed acidification.

The pH (a relative measure of acidity or alkalinity of a solution, ranging from 1: most acidic, to 14: most alkaline) of water is a limiting factor for many aquatic organisms. Many species can only tolerate a specific pH range for optimal growth and reproduction. For example, streams with a pH of 5.0 or lower will not support many species of fish and other aquatic life (Millar et al. 2019b). The pH of a watercourse is influenced by inputs to the system (e.g., acid deposition, acid drainage, alkaline rock addition), and its buffering capacity (i.e., ability to neutralize acid), a product of underlying geology and overlying landscape features.

Acid deposition, more commonly called “acid rain”, occurs when precipitation (i.e., rain, snow, fog) collects acidic particles and gases, particularly sulphur dioxide and nitrogen oxides. When present in the atmosphere, the residence time of these two gases allows them to travel great distances in air currents, then gradually turn into acids when they come into contact with water (ECCC 2018; USEPA 1980). While sulphur dioxide and nitrogen oxides can come from natural sources, the majority is released into the atmosphere through the burning of fossil fuels to generate electricity, from the emissions of vehicles and heavy equipment, and during manufacturing or other industrial processes (ECCC 2013). In addition to contributing to the acidification of aquatic environments, acid rain can lead to aluminium and other metals being leached from soils into adjacent aquatic areas (Hart et al. 2021).

Various land use activities can contribute to the acidification of surface water, including runoff from mining, quarries, highway construction, and urban development. These types of acid inputs are referred to as acid drainage and are caused by oxidation of sulphur-rich minerals (Davis and Browne 1998).

Buffering capacity is a measure of the ability of a stream or river to neutralize acid inputs (Millar et al. 2019b). The underlying geology of an area, as well as local soil and land cover type, influences the level of negative impact caused by acid inputs in a particular area. Some soil types can buffer acid rain by neutralizing acidity in rainwater as it flows through. However, areas where the soil is thin and/or lacks the ability to neutralize acid in rainwater are particularly vulnerable to acid rain (USEPA 2022).

A critical load is “the amount of acid deposition that a particular region can receive without being adversely affected” (ECCC 2004).

Acidification of freshwater ecosystems impacts aquatic and terrestrial productivity through both the direct impacts of decreasing pH, as well as associated reductions in beneficial nutrients (e.g., calcium and magnesium) and increases in the mobilization of metals, such as aluminum, cadmium and lead (Davis and Browne 1998). Aquatic species have varied tolerance to acidity and dissolved or suspended metals. Generally, the young of most species are more sensitive to fluctuations in pH and metals than adults, and reproduction is a key life history trait that can often be impaired when toxic concentrations are approached. For example, most fish eggs cannot hatch at pH 5 (USEPA 2022). In addition to affecting reproduction, low pH values can result in an overall lowering of species diversity (Davis and Browne 1998). Species that are most sensitive to acidity, including various fish, insect and mollusc species, will be reduced in numbers over time until they are no longer present in the ecosystem. Continued biodiversity loss can have cascading effects on food web dynamics and broader ecosystem functioning (Davis and Browne 1998).

4.4.2 Acidification in Nova Scotia

In the 1970s, scientists began to link ecosystem impacts to acid deposition that was occurring as a result of pollutants traveling long distances from their sources by prevailing winds (ECCC 2018). Nova Scotia was particularly vulnerable to acid rain due to its geographic location in relation to areas of higher industrial emissions. The province was heavily impacted by sulfur deposition, which primarily originated from coal burning in Central Canada and the Northeastern United States. It has been estimated that almost half of all rivers in Nova Scotia were severely affected by acid rain through the 1970s and 1980s (Montgomery et al. 2020).

While many areas across Canada saw a reduction in the acidification of freshwater areas following the reductions in emissions of sulphur and nitrogen oxides in the 1990s (achieved due to emission reduction programs in both Canada and the U.S., and reaffirmed commitments to reduce acid-causing emissions in the ongoing Canada-US Air Quality Agreement), Nova Scotia has not recovered (Province of Nova Scotia et al. 2018). As of 2007, while Atlantic Canada was receiving some of the lowest acid deposition amounts in eastern North America, parts of the region have some of the most acidic surface water on the continent (Clair et al. 2007). This chronic acidification is due to a combination of historic acid deposition, ongoing acid rock drainage, organic acid inputs from abundant wetlands, and poor buffering or acid neutralization capacity due to local bedrock and soils (Clair et al. 2007; Province of Nova Scotia et al. 2018).

Figure 9, which is adapted from the Nova Scotia Watershed Assessment Program (Sterling et al. 2014), shows the level of acid rock drainage potential across the province. This map depicts the amount of acid bearing rock in each primary watershed, normalized by the total area of each watershed. To complete this analysis:

- Areas of high and moderate risk of acid rock drainage (ARD) were extracted from bedrock mapping[8] in southwest Nova Scotia completed by White and Goodwin (2011).
- For the remainder of the primary watersheds not captured by the above work, bedrock geology information from the NS Department of Natural Resources and Renewables (NSDNRR)[9] was used to identify areas that have the Halifax Formation bedrock type. The Halifax Formation is found throughout the southern mainland of Nova Scotia from Yarmouth to Canso and is composed of pyritic slate bedrock. When this slate is exposed to water and oxygen, such as during construction activities, a chemical oxidation process, often aided by bacteria, can occur that releases metal oxides and sulphuric acid, which can then drain into streams and lakes (Davis and Browne 1998; Province of Nova Scotia 2021).
- The areas of high and moderate ARD potential in southwest Nova Scotia were merged with areas of Halifax Formation bedrock type and were intersected with the primary watershed boundaries to calculate the total amount of acid bearing rock falling within each watershed. These total areas were then divided by the total watershed area to generate a normalized area value for each watershed.

The LaHave, Gold, Herring Cove/Medway, Musquodoboit and New Harbour/Salmon watersheds have the highest proportion of acid rock drainage potential in the province with the proportion ranging from 37% to 19% of the total watershed area (Table 5, Appendix 1).

[8] https://novascotia.ca/natr/meb/download/mg/ofm/htm/ofm_2013-002.asp

[9] https://novascotia.ca/natr/meb/download/dp043.asp

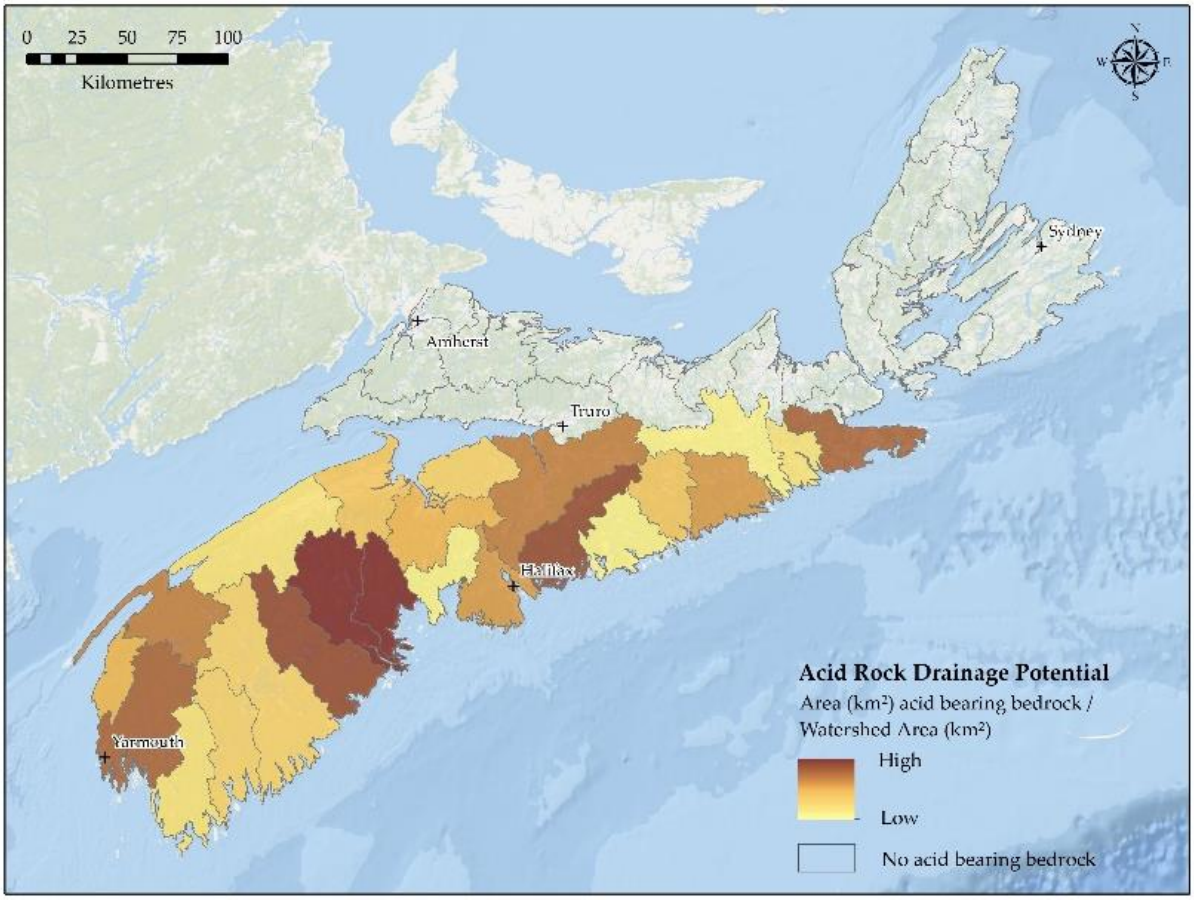

Figure 9*. Acid rock drainage potential (area (km2) of potentially expose acid rock per watershed area (km2)) in Nova Scotia*

A watercourse's buffering capacity is influenced by the soil and bedrock that it passes through. Water that passes through granite or metamorphic-based soils have low levels of conductivity, meaning they are low in dissolved solids. Water passing through these environments pick up few ions, and thus will have little or no capacity to buffer acidic inputs. Alternatively, water flowing through limestone-based soils, with an associated presence of calcium carbonate and magnesium ions, will have a much higher buffering capacity (Millar et al. 2019b). It has been estimated that more than 75% of lakes in Nova Scotia are underlain by granite or metamorphic bedrock (Davis and Browne 1998).

The watershed buffering capacity (i.e., alkalinity) map in Figure 10 was produced using data from the NCC's Stream Classification for the Northern Appalachian–Acadian Region of Canada (Millar et al. 2019b). Using various sources of in-stream field measurements of alkalinity throughout Nova Scotia, the NCC stream classification product made use of a Random Forest statistical package (Liaw and Wiener 2002) with predictor variables to extrapolate the observed alkalinity measurements throughout their study area. A total of 13 predictor variables were used based on various soil characteristics (e.g., soil surface cation exchange capacity, pH, etc.), as the buffering capacity of streams is heavily influenced by the soil and bedrock of the area.

The NCC stream classification product was first converted from a vector format into a raster in ArcGIS Desktop software, in which cell values were based on the buffering capacity values (mg/L of calcium carbonate ($CaCO_3$)) assigned to the stream networks. This step was necessary to account for the length of stream assigned a given buffering capacity value within a watershed. The Spatial Analyst Zonal Statistics tool was then used to calculate the mean average buffering capacity values of all streams for each primary watershed of Nova Scotia.

The map shows that, overall, the watersheds of southwestern Nova Scotia have the lowest buffering capacity. Darker colours indicate watersheds with a lower buffering capacity (Herring Cove/Medway, Roseway/Sable/Jordan, Mersey, Meteghan and Gold), while lighter colours are indicative of streams with a higher buffering capacity (Tidnish/Shinimicas, Missaguash, River John, Gaspereau and Cheticamp).

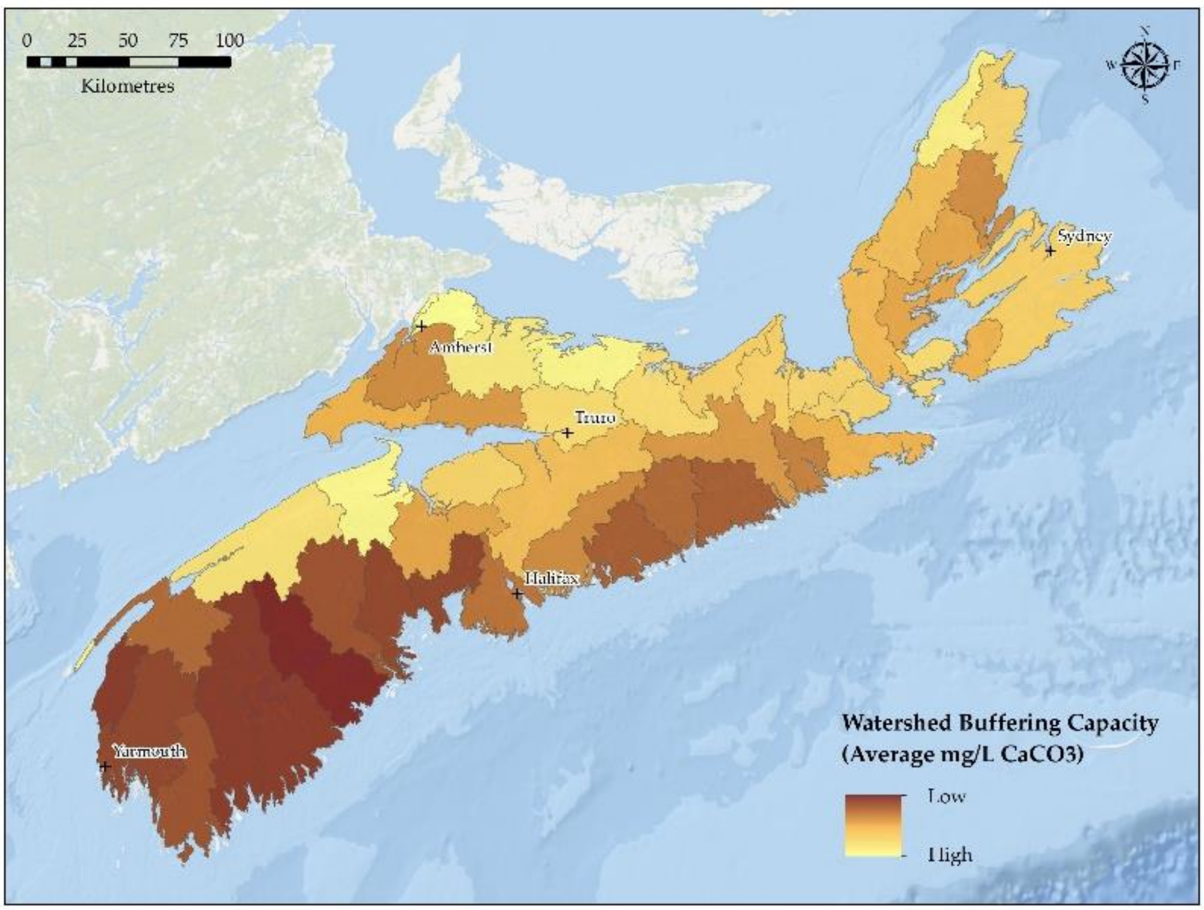

Figure 10. *Watershed buffering capacity (average mg/L of calcium carbonate (CaCO3)) in Nova Scotia*

While this map provides an overall picture of the watersheds that may be most impacted by acidification due to a limited buffering capacity, future assessment and modelling would be improved through the incorporation of more broad scale field surveys of freshwater acidification levels across Nova Scotia.

4.4.3 Management actions to address acidification in Nova Scotia

Regulatory tools

The best approach to managing acid rock drainage is to avoid its development by knowing the location of sulphide-bearing bedrock and avoiding activities that expose or break it up. If disturbance is unavoidable, *The Sulphide Bearing Material Disposal Regulations*, under the Nova Scotia *Environment Act* outline how materials with sulphide content are to be managed.

Restoration

While acid deposition has decreased following the emission reductions achieved in the early 1990s, many areas of Nova Scotia are not showing strong improvements in water quality. It has been predicted that it may take more than 50 years for water quality to recover naturally from the impacts of acid rain (Montgomery et al. 2020; Province of Nova Scotia et al. 2018).

The only long-term mitigation for acidification in freshwater environments is the addition of buffering materials to offset the acidic inputs and improve water quality. 'Liming' is the process by which elements are added to raise the pH of aquatic systems (Province of Nova Scotia et al. 2018). There are different techniques that can be used for liming. Lime dosers are used to add powdered limestone or a slurry limestone mixture directly to streams and rivers. They can treat large quantities of water for a relatively low cost but require ongoing maintenance. An alternate approach is terrestrial or catchment liming, in which powdered limestone is spread on areas of a watershed to increase soil pH and ultimately increase the pH of rivers and streams. This approach can have long lasting benefits although the initial cost of application can be high as the lime is often spread with helicopters.

4.5 Aquatic Connectivity

4.5.1 Impacts of barriers

Freshwater connectivity has been defined as "*the permanent surface hydrologic connections that link lakes, wetlands, and streams*" (Fergus et al. 2017). Habitat connectivity is essential to a healthy aquatic system – when habitat is more connected, fish populations are generally larger, healthier and less susceptible to other stressors like habitat degradation. While structures such as dams, aboiteaux and watercourse crossings provide various benefits, such as hydro-power generation, and are required for connected road and rail networks, they can also contribute to various impacts to freshwater ecosystems. These types of structures can form barriers that disconnect rivers and lakes from riparian wetlands and floodplains. Barriers can disrupt ecological processes that affect the transportation of sediments and nutrients throughout a watershed – they can cause channelization of stream flows, flow constriction, debris accumulation, and riverbed erosion. Overall, barriers can destroy or impair the function of fish habitat and can lead to impacts to fish and other aquatic species.

Over 70% of fish species that use freshwater ecosystems in Atlantic Canada are migratory in nature (Dean et al. 2022). Barriers limit the movement of these species between different freshwater environments, or between freshwater, estuarine, and marine environments to carry out various life cycle processes. If they are unable to migrate, they may fail to reproduce successfully, which can impact overall fish populations. Individual fish health can also be impacted when barriers cause fish to expend more energy than normal to move through barrier structures (DFO 2015).

Large dams are often constructed to generate hydroelectricity (e.g., hydro-power dams). Turbines are powered by the energy of river water flowing over the height of a dam, which generates electricity. Low-head dams are constructed for various purposes, including irrigation, municipal water withdrawal, flood control, low-flow augmentation, recreation, and navigation. Dams without a functional fishway are a physical obstacle to fish passage and can prevent adult fish from swimming upstream to spawn. Juvenile fish can also be killed or injured by dams lacking a fishway, as they swim downstream. In addition to blocking fish passage, dam construction changes the overall hydrology of a system. Dams alter the flow regime of a watercourse, including altering the timing and volume of water flows. The movement of sediment and nutrients within a watercourse can also be affected by dams. These changes in flow regime and sediment movement have impacts beyond the location of a dam – resulting in changes to upstream and downstream habitats and affecting the ability of fish to move through watercourses. Fish may also become entrained through intakes, turbines or spillways or impinged at screens, leading to injury or mortality (DFO 2010).

Watercourse crossings refer to locations where roads, rail lines, or trails cross streams or rivers. Generally, open-bottom structures, such as bridges, are used for large crossings, while culverts are generally used for smaller crossings. Impacts on aquatic habitat are generally associated with improperly designed, installed or functioning watercourse crossings, especially improperly functioning culverts (DFO 2015). For example, improperly designed or functioning culverts may be unable to handle high water flows, leading to flooding in both riparian and terrestrial areas and damage to the watercourse upstream and downstream. Higher water velocity caused by watercourse crossings can also result in the movement of sediment, rock and debris downstream, which can lead to changes in channel morphology (Province of Nova Scotia 2015).

In addition, improperly designed or functioning culverts can impede fish movement. Blocked or ‘perched’ culverts (i.e., a culvert that has the outflow positioned well above the plunge pool), can present a physical barrier to fish passage (Adopt-a-Stream 2019). Debris, such as vegetation, woody debris or unnatural items, can accumulate over time at the inflow of culverts causing a physical barrier to fish passage.

Culverts can impact water levels and the velocity at which water flows. An oversized culvert can result in inadequate water depth for fish to swim through the culvert, while an undersized culvert can result in high water velocities that exceed the swimming ability of some fish (DFO 2015; Province of Nova Scotia 2015). Most fish species native to Nova Scotia can swim for a few minutes before needing to rest; if a culvert is too long, fish will become exhausted before they can swim through it. Therefore, long culverts often require baffles or other features to create resting areas for fish migrating upstream.

4.5.2 Dams and other water control structures in Nova Scotia

More than 600 dams and water control structures exist in Nova Scotia, many of which are contributing to aquatic habitat fragmentation. The majority of these dams are used for water impoundment or storage for hydroelectricity generation, municipal purposes and agricultural uses. Many of the smaller dams are used to impound water for wildlife conservation, such as creating and maintaining wetlands.

The analysis conducted for this report provides an indicator of the amount of upstream habitat that is potentially inaccessible to migrating fish for each primary watershed by assessing the length of stream behind a dam or other water control structure and whether there is upstream fish passage at that structure. The amount of habitat inaccessible to migratory fish species is a factor of both the location of a water control structure within the watershed (i.e., a large dam at the outlet of the main stem of the river is likely to restrict access to a much greater area of fish habitat than a small water control structure on a tributary in the headwaters of the watershed) and whether there is predicted fish passage at the structure.

The location of dams (i.e., water control structures) within each primary watershed were compiled from a variety of sources, including:

- NS water control structure locations, as compiled by the NS Department of Environment and Climate Change, and DFO;
- Hydroelectric system water control structures;
- Salmon presence assessment tool (SPATLAS) barriers to fish passage (dams), developed by DFO; and
- Water control structures operated for wildlife conservation purposes.

Fish passage information was considered for each dam location, based on best available DFO information. Fish passage was determined based on the presence of a fishway, and information available on fish passage for select dam datasets. Assessment on the proper functioning and effectiveness of fishways was not part of this analysis, so it was assumed the presence of a fishway was indicative of a dam having adequate full year-round fish passage for all species. It is important to note that fishways are usually designed for a specific species and may function poorly for non-target species or with water flow ranges that are beyond the operation range of the structure.

Using the Fish Passage Extension (FIPEX) (Oldford et al. 2020) within ArcGIS Desktop software, the total stream length (km) upstream of impassable dams was calculated for each primary watershed. The FIPEX tool made use of a hydrological geometric network (e.g., National Hydro Network) representative of a watershed stream network, in conjunction with the locations of aquatic barriers to calculate various assessments of aquatic connectivity. All dams without fish passage were used for the FIPEX analysis, in which the total and immediate upstream lengths were calculated for each barrier location. The immediate length value corresponds to the length of stream network between a barrier and the next barrier upstream, while the total length refers to the entire stream network length upstream of a barrier, regardless of the presence of other barriers further upstream. To calculate the proportion of stream length upstream of impassable dams at the primary watershed scale, the sum of all immediate upstream length values was calculated for all barriers within a watershed and divided by the total stream length of the entire watershed.

The analysis found that the watersheds with the highest proportion of inaccessible habitat due to dams are in southwest Nova Scotia (Figure 11). In particular, the Mersey, Sissiboo/Bear, and St. Croix watersheds have the highest proportion of total stream length that is inaccessible to migratory fish species, due to dams or other water control structures without upstream fish passage (at 60.5%, 53.9% and 41.5% respectively). The next most impacted watersheds are the Meteghan, Annapolis, and Gold watersheds, where more than 20 per cent of the total stream length is upstream of dams with no upstream fish passage. Conversely, five watersheds either contain no dams or do not contain any dams without fish passage: the Missaguash, Country Harbour, Barrington/Clyde, Liscomb, and River Denys (Table 6). It is important to note that this assessment provides an indicator of the relative amount of accessible habitat for migratory species, but it does not factor in the quality of the habitat.

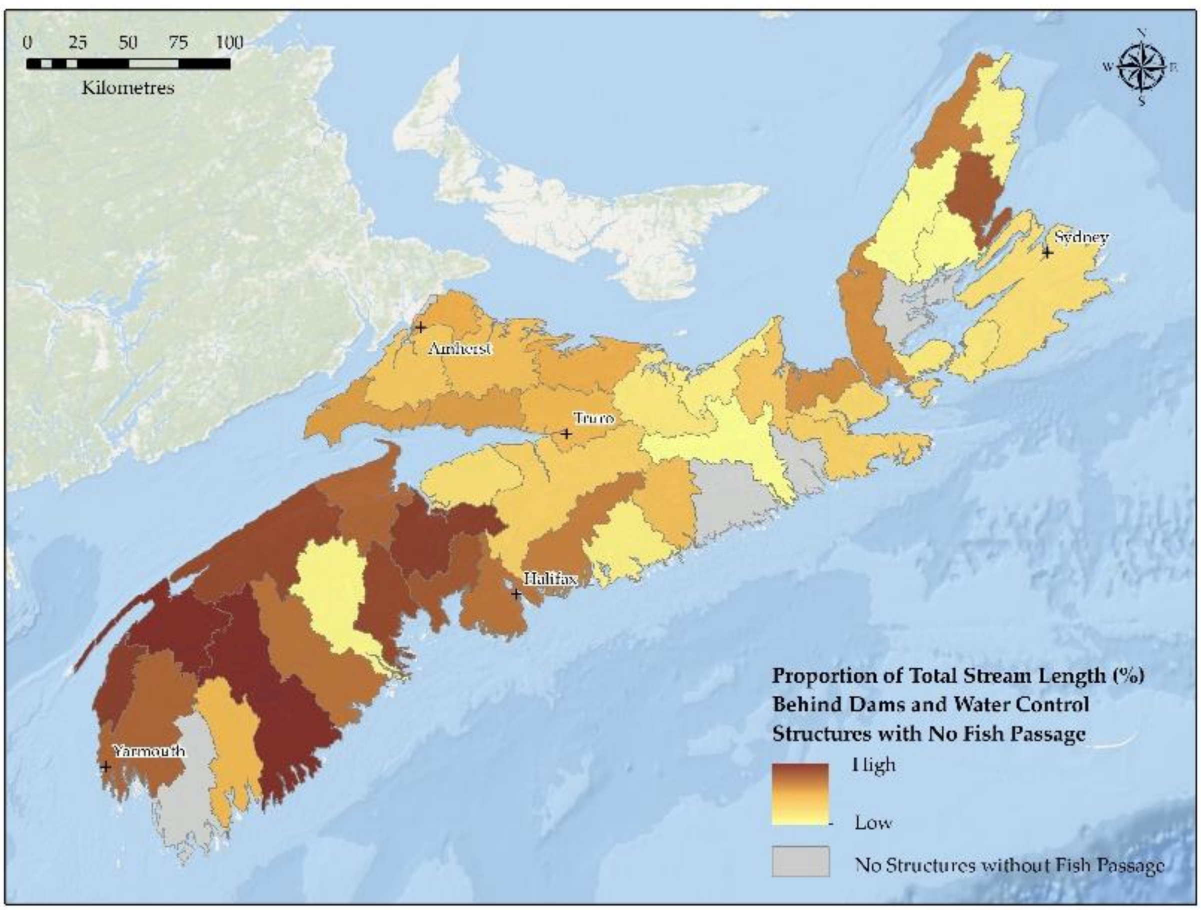

***Figure 11**. Proportion of total stream length behind dams and water controls structures in Nova Scotia*

4.5.3 Watercourse crossings in Nova Scotia

There are more than 30,000 locations in Nova Scotia where roads cross streams or rivers. Culverts are found at the majority of these watercourse crossings. To derive the watercourse crossing density, the total number of crossings was divided by the total stream network length (km) for each primary watershed. The watercourse crossing density map (Figure 12) was produced using the 1:50,000 Canvec National Road Network (NRN)[10] in conjunction with the National Hydrographic Network (NHN)[11]. All road types were overlayed with the NHN stream networks, and the 'intersect' tool in ArcGIS was used to generated point locations of all predicted watercourse crossings. A Spatial Join was then applied which calculated the total number of the watercourse crossing point locations falling within each primary watershed.

The analysis found the highest densities of watercourse crossings in the East/Middle/West - Pictou (0.60 crossings/km), Isle Madame (0.54 crossings/km), Gaspereau (0.53 crossings/km), Meteghan (0.52 crossings/km), Tracadie (0.51 crossings/km), French (0.51 crossings/km), Annapolis (0.49 crossings/km), Sackville (0.49 crossings/km), Gold (0.46 crossings/km), and Parrsboro (0.45 crossings/km) watersheds (Figure 12; Table 6). The watersheds with the lowest density of watercourse crossings were the Missaguash (0.03 crossings/km), Cheticamp River (0.08 crossings/km), Wreck Cove (0.13 crossings/km), Mersey (0.17 crossings/km) and Roseway/Sable/Barrington (0.18 crossings/km).

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10 https://open.canada.ca/data/en/dataset/2dac78ba-8543-48a6-8f07-faeef56f9895

11 https://open.canada.ca/data/en/dataset/a4b190fe-e090-4e6d-881e-b87956c07977

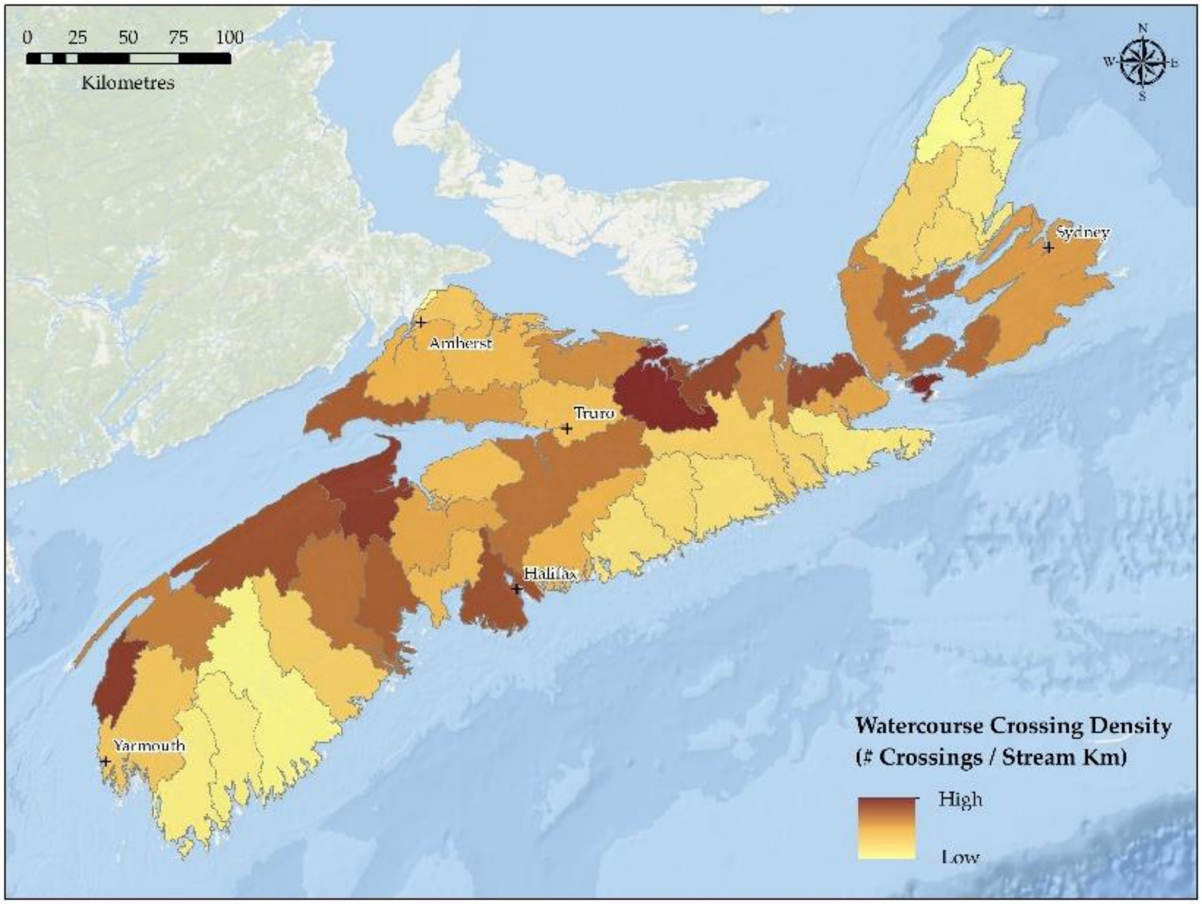

***Figure 12**. Density of watercourse crossings in Nova Scotia (#/km)*

Culverts may vary in terms of their "passability" – that is the ability for fish to move freely through the culvert. In Nova Scotia, the Adopt-a-Stream program has developed tools to help local watershed organizations collect data on a variety of parameters that influence the passability of culverts in the province. One such tool is the Adopt-a-Stream Aquatic Connectivity Analytical Database (ACAD)[12], which allows users to enter information on the culvert (e.g., dimensions, materials, shape, bottom material), how the culvert functions (e.g., backwatering, embedment, outflow drop, slope), and the upstream and downstream characteristics (e.g., elevation, water depth, velocity). The tool can then generate an estimate of the passability of the culvert for five different species: Atlantic salmon, brook trout, American eel, shad and smelt. Passability is characterized by ACAD as: full barrier, partial barrier, potential barrier, passable or data deficient.

The ACAD culvert data was analyzed for the four primary watersheds that had the most culvert assessments entered in the tool: Annapolis, Shubenacadie/Stewiacke, St. Mary's, and LaHave. Across these four watersheds, between 45 and 57 per cent of culverts were classified as barriers (full, partial or potential) to fish passage (Figure 13). While the number of culverts assessed and entered into ACAD is only a portion of the

[12] http://adoptastream.ca/content/aquatic-connectivity-analytical-database

total number of culverts in these respective watersheds, the breakdown in Figure 13 may offer insight into the passability of culverts across Nova Scotia.

It should also be noted that there are a number of factors that can make it challenging to assess the passability of structures – the variability in the shape and size of a structure, seasonal and annual variability in water levels, and swimming performance and biological needs of different fish species (Januchowski-Hartley et al. 2013).

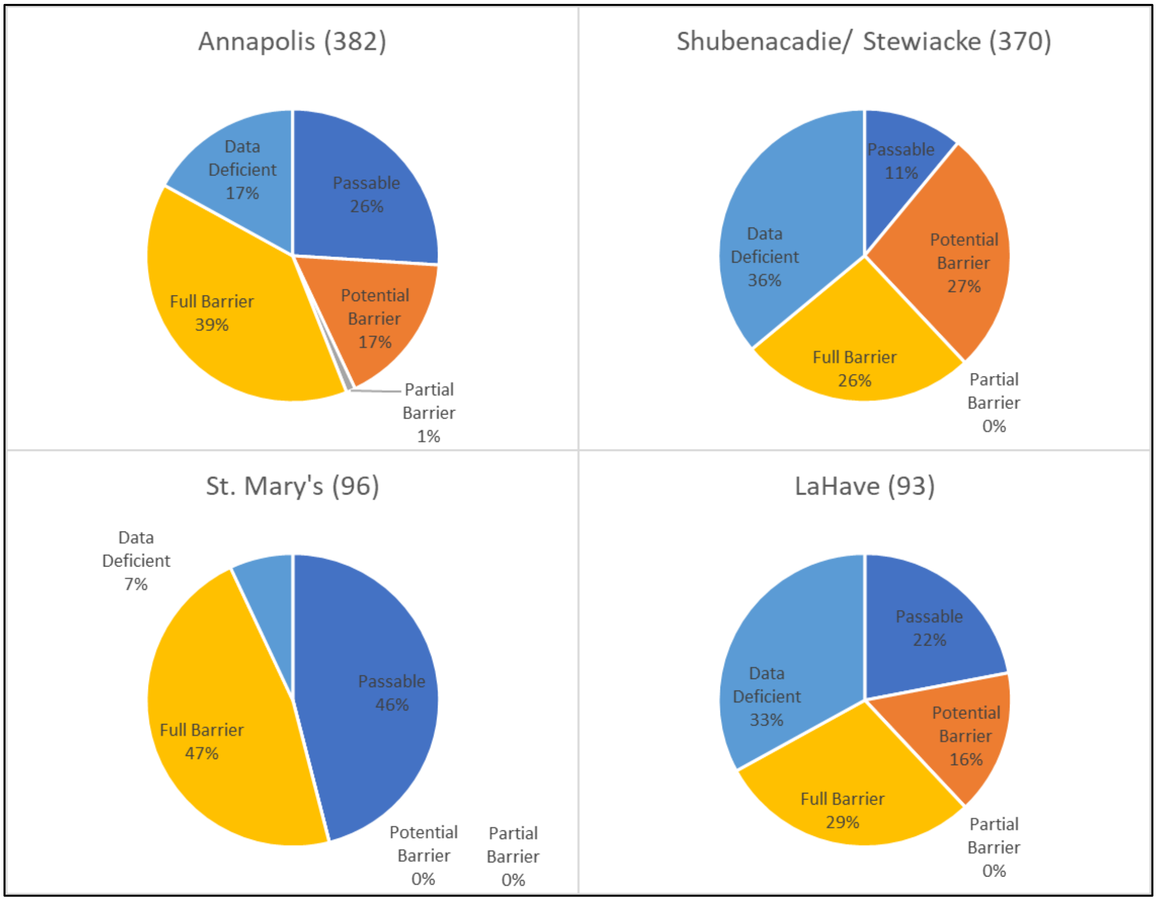

Figure 13. *Passability of assessed culverts in four watersheds of Nova Scotia. Note that these percentages may not be representative of the passability of all culverts in each watershed.*

4.5.4 Management actions to improve connectivity in Nova Scotia

Fish passage issues posed by dams and watercourse crossings can be addressed in a number of ways, ranging from regulatory tools to partnerships with local watershed groups that are remediating culverts to improve passage.

Regulatory tools

WUAs that could impact connectivity and fish passage generally require provincial regulatory oversight. DFO has arrangements with the Province of Nova Scotia to provide a "one window" approach for project reviews and advice under the *Fisheries Act*, SARA and the *Activities Designation Regulations* of the provincial *Environment Act*. The "one window" approach does not negate DFO’s ability, and responsibility in some cases, to use other ministerial tools for the protection of fish and fish habitat.

DFO reviews proposals for: maintenance, refurbishment, and/or replacement of existing dams; proposed new structures; and overall hydro-electric, water impoundment, water-withdrawal or other water management licenses. These projects are reviewed on a case-by-case basis with the goal of improving fish passage and reducing upstream and downstream impacts.

The planning, design, and installation of new culverts and the maintenance of existing culverts must meet the requirements for fish passage under the *Fisheries Act*. In 2002, DFO carried out a random assessment of fifty small culvert installations in Nova Scotia completed between 1996 and 2000 (Langill and Zamora 2002). The assessment found that a significant portion of the culvert installations contributed to habitat fragmentation; fish passage was prevented by perched culverts and/or by culverts with a slope greater than 0.5%. In many cases, habitat fragmentation could have been reduced through redesigning the culvert. The updated Guidelines for the Design of Fish Passage for Culverts in Nova Scotia (DFO 2015) provide detailed criteria for the proper design, installation and maintenance of culverts so that watercourse crossings meet the requirements for fish passage under the *Fisheries Act*. In combination with increased compliance and conformance monitoring and the provision of installer training, these guidelines are helping to ensure that newly installed culverts are allowing fish to move freely through Nova Scotia watersheds.

Restoration

One tool to address the impacts of large migration barriers is to install a fishway to improve connectivity. Fishways may be used around natural (e.g., waterfalls) or anthropogenic (e.g., dams) barriers and must be designed with consideration for specific species (particularly fish swimming capabilities) as well as hydrology. There are several types of fishways, or fish ladders, with designs varying depending on the river flow and the species present.

In cases where an existing culvert is not expected to be replaced in the near future, but is not allowing for fish passage, then remediation may be necessary (DFO 2015). In prioritizing culverts for remediation, there are a number of factors that need to be considered, including the amount and quality of inaccessible upstream habitat, the complexity of the site, the state of the existing culvert, and the presence of aquatic invasive species (AIS) (Adopt-a-Stream 2019).

Remediation and retrofitting techniques include installing an outflow chute, baffles, downstream weirs or fish ladder boxes (Adopt-a-Stream 2019; DFO 2015):

- Outflow chute – devices that can be installed on box or circular culverts where the existing culvert outlet elevation is too high and the culvert is “perched”. Chutes are a temporary solution, providing a narrow notch which guide the fish into the culvert. A chute also back waters the culvert creating water depth.

- Baffle – devices installed on the floor of a box or circular culvert to hold back the flow of water which slows the water velocity. Baffles also create areas where fish can rest.
- Weirs – control structures that can be installed downstream of a culvert to dissipate energy and back water the culvert.
- Fish ladder boxes – devices used where other remediation techniques are not sufficient due to large outflow drops. These operate similarly to a miniature fishway.

While various structures, such as dams and culverts, can impede the movement of native fish and impact their ability to carry out various life processes, these structures can also prevent the movement and spread of AIS. This poses a challenge for determining how to restore habitat connectivity in areas where AIS have been recorded. In watersheds without AIS, it is almost always considered beneficial to fish to restore or improve connectivity throughout a system. However, when AIS are present, decisions must balance the risk of isolating native fish species with the risk of increasing the spread of invasives. The *Decision-Making Framework for Fish Passage Projects in Nova Scotia*, developed collaboratively between the Clean Annapolis River Project and the Adopt-a-Stream program (CARP and NSSA 2020), provides a framework to assess risks and benefits of improving habitat connectivity in areas with AIS.

4.6 Aquatic Invasive Species

4.6.1 Impacts of aquatic invasive species

AIS are “fish, invertebrate or plant species that have been introduced into a new aquatic environment, outside of their natural range” (DFO 2019c). Once an AIS is introduced into an area, their populations can grow quickly, sometimes causing significant negative impacts on native species and their habitats through several mechanisms. They may predate on native species or outcompete them for food and other resources; they may change food webs or introduce diseases or parasites, and they can even alter the habitat itself, making it inhospitable to native species (DFO 2019c; Dextrase and Mandrak 2006).

The impacts of AIS are particularly concerning for species at risk. The introduction, establishment, and spread of AIS is the second highest threat to species at risk in Canada, after habitat loss (Dextrase and Mandrak 2006). In addition to the impacts on native biodiversity and aquatic habitats, AIS can have other socio-economic impacts including economic costs to aquatic industries and harming recreational activity (DFO 2019c).

4.6.2 Aquatic invasive species in Nova Scotia

There are several AIS found in Nova Scotia’s lakes, rivers, coastal, and marine areas. Examples of invasive species found in the marine and coastal areas surrounding Nova Scotia include Asian shore crab (*Hemigrapsus sanguineus*), European green crab (*Carcinus maenas*) and vase tunicate (*Ciona intestinalis*). Smallmouth bass (*Micropterus* *dolomieu*), chain pickerel (*Esox niger*), spinycheek crayfish (*Orconectes limosus*), Chinese mystery snail (*Cipangopaludina chinensis*) and several invasive plant species are examples of the invasive species that pose a threat to the province's freshwater environments.

Smallmouth bass and chain pickerel have the capability to transform freshwater ecosystems by occupying the ecological niche of a top predator (Province of Nova Scotia 2017). Due to the potential severity of impact and availability of data associated with these two species, this report focuses on smallmouth bass and chain pickerel establishment and spread, as well as the management actions taken to mitigate their impacts in Nova Scotia.

Smallmouth bass are primarily found in cool, clear lakes, but they may also be found in slow moving streams with deep pools (LeBlanc 2010). They impact the ecosystem as they consume small-bodied fish or outcompete them for food (Province of Nova Scotia 2017). Smallmouth bass can become a dominant part of the food web (DFO 2009). Smallmouth bass were first introduced into Nova Scotia by the provincial government in the 1940s to develop new recreational fisheries. Since that time, they have spread through many areas of the province through a variety of vectors, including illegal releases, natural dispersal within watersheds, and accidental transfers. While it is considered an invasive species throughout Nova Scotia by the federal government, the Province of Nova Scotia manages a significant recreational sport fishery for smallmouth bass in southern areas of the province, but considers the species invasive in northern regions.

Chain pickerel is a voracious predator and few fish can coexist with the species. The ecological impacts of this invasive species can extend beyond the aquatic environment to include birds and mammals (Province of Nova Scotia 2017). Chain pickerel were introduced into Nova Scotia in the 1940s. Similar to smallmouth bass, chain pickerel have spread through a variety of vectors including further intentional or accidental introductions or through natural dispersal within watersheds (Province of Nova Scotia 2017).[13]

The Nova Scotia Department of Fisheries and Aquaculture (NSDFA) maintains a dataset of AIS detections in the province[14]. If there is a suspected, but unconfirmed presence of AIS or if a report is received from the public, the NSDFA will assess the waterbody. NSDFA uses common angling practices to detect invasive species; visual observations may also be used to confirm presence. If invasive species are captured, their presence is documented and the date of 'confirmation' is recorded in the dataset. It is important to note that the rate of detection is often a function of effort; in other words, years without new detections may not mean that the invasive species are not spreading, but may be due to limited monitoring efforts.

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[13] https://data.novascotia.ca/Environment-and-Energy/1-10-000-Nova-Scotia-Secondary-Watersheds/ynkv-x6rx

[14] https://data.novascotia.ca/Fishing-and-Aquaculture/Nova-Scotia-Freshwater-Fish-Species-Distribution-R/jgyj-d4fh

In order to assess the distribution of smallmouth bass and chain pickerel across Nova Scotia, this report used the NSDFA dataset of AIS detections. Using information on the location and time of individual detections of the species in conjunction with secondary and tertiary watersheds of the province, maps were produced depicting the geographic spread of smallmouth bass and chain pickerel over time (Figures 14 and 15).

The dataset was parsed by date of detection to produce separate *species-decade* datasets based on the species and decade of first recorded occurrence. The *species-decade* locations were joined with watershed polygon boundaries (1:10,000 watershed boundaries – tertiary and secondary from the NS Open Data portal[11]) to identify watersheds containing locations of AIS detections for a given species and decade.

Smallmouth bass has now been recorded in 26 of the province's 46 primary watersheds (Figure 14). The species is spreading both as a result of the free movement of the species between connected waterbodies and deliberate human introductions.

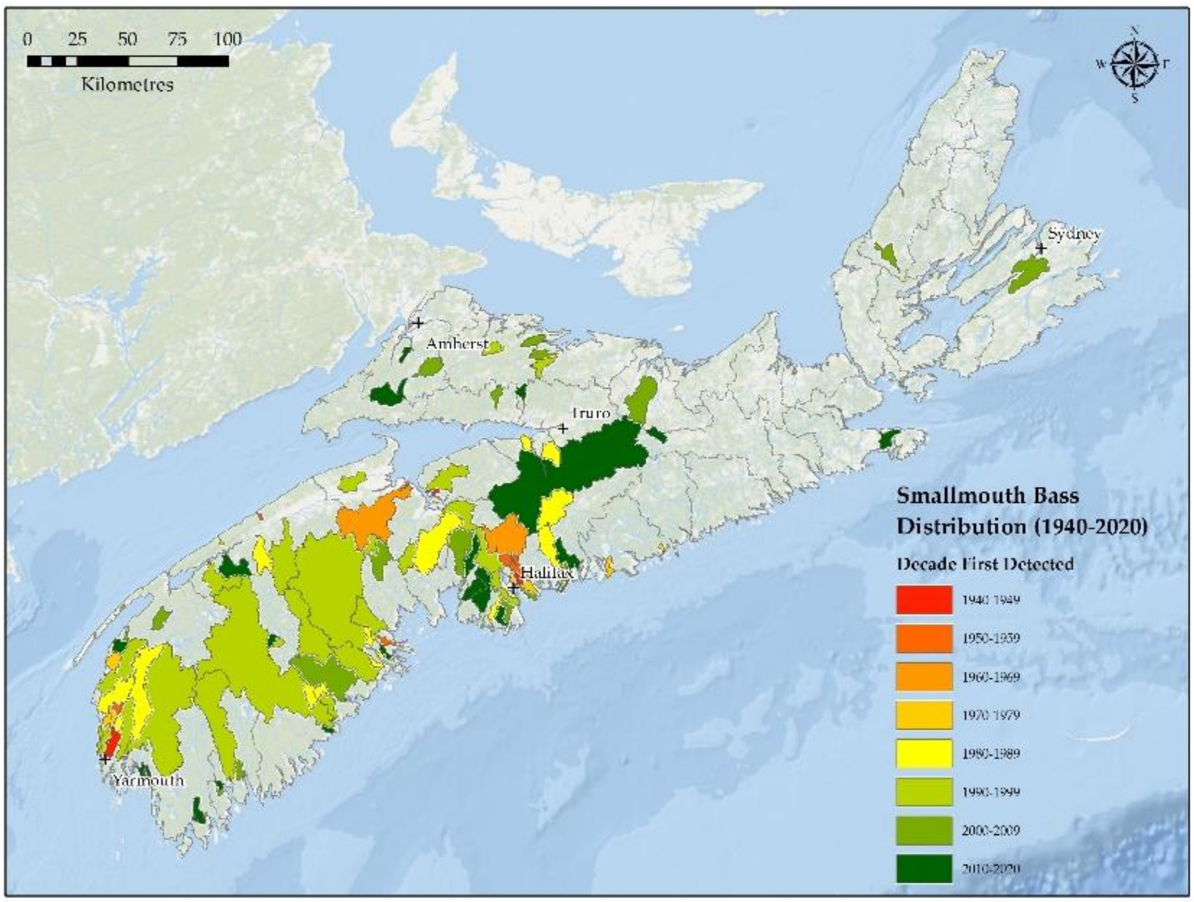

Figure 14*. Spread of smallmouth bass in Nova Scotia from 1940 to 2020*

Chain pickerel has now been recorded in 12 of Nova Scotia's primary watersheds (Figure 15). In some cases, the species is moving freely between connected waterbodies within a watershed. The other main way Chain Pickerel is spreading is via deliberate, illegal introduction by people motivated to increase recreational angling opportunities.

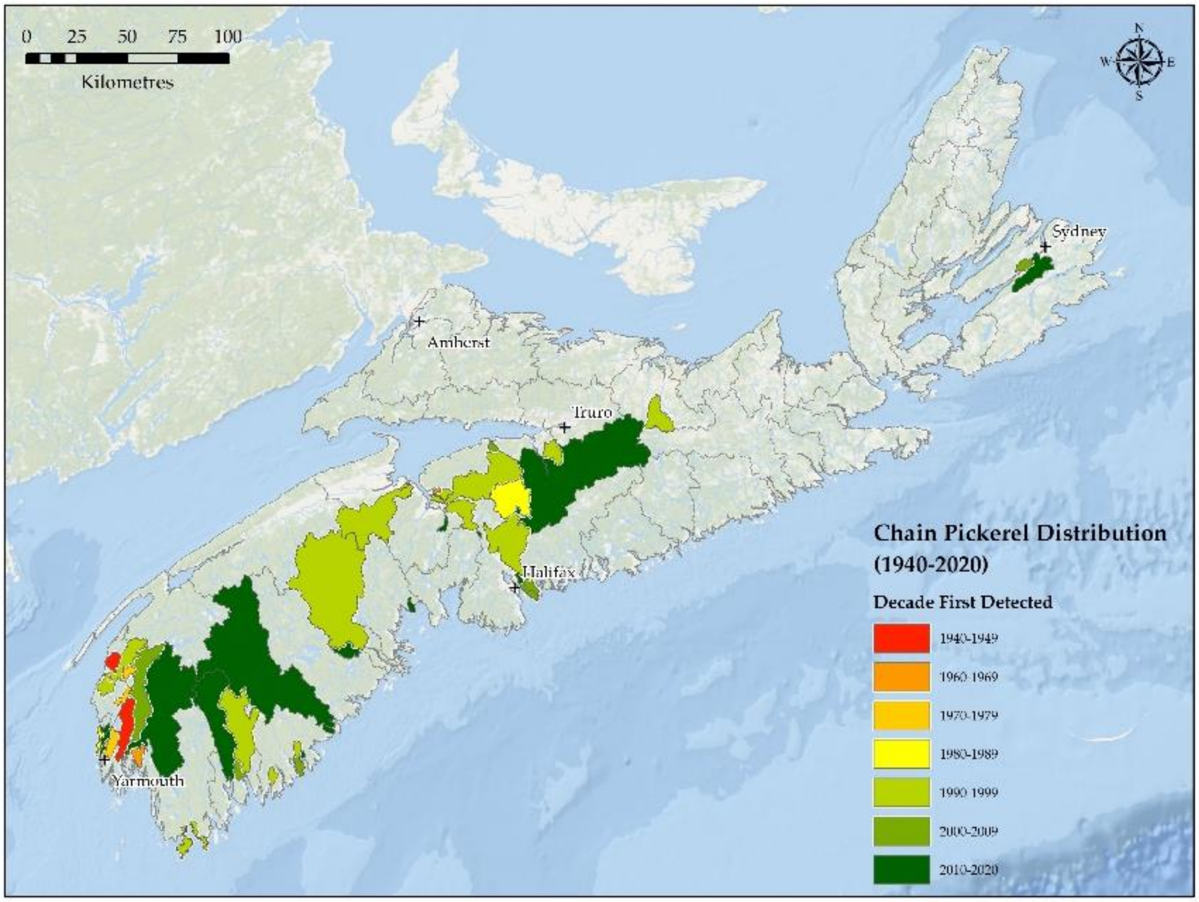

Figure 15. *Spread of chain pickerel in Nova Scotia from 1940 to 2020*

The distribution of these species is probably more widespread than indicated in these maps as fish go through a number of life stages before they are likely to be caught and then reported, meaning they are often present in a location before they are reported. Further, there is limited capacity by the province to investigate every angler report of smallmouth bass or chain pickerel (Province of Nova Scotia 2017).

4.6.3 Management actions to address aquatic invasive species in Nova Scotia

In 2017, DFO established the Aquatic Invasive Species National Core Program (AIS-NCP) to encourage coordination and collaboration between DFO and other jurisdictions with responsibility for AIS management across Canada (DFO 2019c). In Nova Scotia, DFO works closely with the NSDFA to implement the *Aquatic Invasive Species Regulations* as well as the four management pillars (prevention; early detection; response; and control/management). The *Aquatic Invasive Species Regulations* help protect waterbodies across Canada by preventing the spread and introduction of AIS into Canadian waters and managing them once introduced (DFO 2019d). The regulations provide a national framework that enables provincial and federal governments to manage and control AIS.

The *Live Fish Possession Regulations* were established by the province of Nova Scotia under the *Fisheries and Coastal Resources Act* to address the illegal introduction of fish species into provincial waters. These regulations prohibit the unlawful possession of live fish in Nova Scotia.

5. Conclusion

This report has presented an analysis of several indicators of aquatic ecosystem health in relation to broad categories of threats to fish habitat in Nova Scotia. The analysis focused on producing a relative assessment of the selected threats across the primary watersheds of Nova Scotia. The results were depicted using a quantile classification, in which each class contains an equal number of watersheds. This approach presents how each watershed ranks compared to others but does not provide information on the absolute values nor the differences in values between the ranks. The table below summarizes the analysis completed (see Appendix 1 for complete datasets):

Threat	Indicators	Overall Results	
		Most impacted primary watersheds (5)	Least impacted primary watersheds (5)
Land Use	Land cover disturbance (%)	• Gaspereau • Tidnish/Shinimicas • East/Middle/West (Pictou) • Annapolis • Sackville	• Cheticamp River • Wreck Cove • Barrington/Clyde • Roseway/Sable/Jordan • Mersey
	Riparian land cover disturbance (%)	• Gaspereau • East/Middle/West (Pictou) • Tidnish/Shinimicas • Annapolis • Salmon/Debert	• Cheticamp River • Barrington/Clyde • Wreck Cove • Roseway/Sable/Jordan • Mersey
Acidification	Acid rock drainage potential (area (km^2) of potentially exposed acid rock per watershed area (km^2))	• LaHave • Gold • Herring Cove/Medway • Musquodoboit • New Harbour/Salmon	• 23 watersheds are outside the assessment area
	Watershed buffering capacity (average mg/L of calcium carbonate)	• Herring Cove/Medway • Roseway/Sable/Jordan • Mersey • Meteghan • Gold	• Tidnish/Shinimicas • Missaguash • River John • Gaspereau • Cheticamp
Connectivity	Proportion of total stream length behind dams and water control structures without fish passage	• Mersey • Sissiboo/Bear • St. Croix • Meteghan • Annapolis	• Missaguash • Country Harbour • Barrington/Clyde • Liscomb • River Denys
	Density of watercourse crossings (#/km)	• East/Middle/West (Pictou) • Isle Madame • Gaspereau • Meteghan • Tracadie and French (tie)	• Missaguash • Cheticamp River • Wreck Cove • Mersey • Roseway/Sable/Barrington

The analysis conducted here shows some common patterns across the province. For example, the relative assessment of watercourse crossing density shows a similar pattern to that of watershed land cover disturbance (Figures 12 and 7); in other words, generally, the primary watersheds with the greatest relative density of watercourse crossings aligns with the watersheds subject to the greatest level of land cover disturbance.

The analysis also highlights several watersheds in which multiple threats are impacting fish and fish habitat. For example, the Gaspereau watershed has the highest relative level of watershed and riparian disturbance; ranks highly relative to other primary watersheds for the density of watercourse crossings and the proportion of total stream length behind dams and water control structures without fish passage; and both smallmouth bass and chain pickerel are present in the watershed. However, acidification is of lesser concern in this area. Conversely, both the Gold and LaHave watersheds have high relative levels of acidification impacts (as assessed by the two indicators used in this report: acid rock drainage potential and buffering capacity); rank relatively highly compared to other primary watersheds for the density of watercourse crossing; and both smallmouth bass and chain pickerel are present. However, the watershed and riparian disturbance indicators were both in the middle range relative to other primary watersheds.

This report provides insights into the historical and existing pressures that are impacting fish habitat in Nova Scotia. It is important that management actions and decisions take into consideration how multiple threats in a watershed may accumulate and/or interact (Craig et al. 2017). Recommendations for future work include expanding the analysis to consider additional threats to fish and fish habitat and their impacts on Nova Scotia watersheds, such as water withdrawal and climate change, as well as exploring the use of thresholds in assessing each threat.

The information in this report may be used in future proactive planning and prioritization initiatives by the FFHPP-Maritimes, as well as other DFO programs and those of partners. The results may help to inform the identification of restoration priorities to be included in DFO's Fish Habitat Restoration Plan for Nova Scotia and/or the future identification of Ecologically Significant Areas, both of which are advancing through engagement with the Province, Indigenous groups, partners and stakeholders.

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Appendix 1: Data Sets

***Table 1**. Species at risk recovery publications used to identify the distribution of each species*

Species	Population	SARA Status	COSEWIC Status	Data Source
American Eel			Threatened	COSEWIC assessment and status report on the American Eel *Anguilla rostrata* in Canada, 2012
Atlantic Salmon	Eastern Cape Breton		Endangered	Recovery Potential Assessment for Eastern Cape Breton Atlantic Salmon, 2013
Atlantic Salmon	Gaspe-Southern Gulf of St. Lawrence		Special Concern	COSEWIC Assessment and Status Report on the Atlantic Salmon (*Salmo salar*), 2010
Atlantic Salmon	Inner Bay of Fundy	Endangered	Endangered	Recovery Strategy for the Atlantic salmon (*Salmo salar*), inner Bay of Fundy populations, 2010
Atlantic Salmon	Southern Upland		Endangered	Recovery Potential Assessment for Southern Upland Atlantic Salmon, 2013
Atlantic Sturgeon			Threatened	COSEWIC Status Report on the Atlantic Sturgeon *Acipenser oxyrinchus* in Canada, 2011
Atlantic Whitefish		Endangered	Endangered	Recovery Strategy for the Atlantic Whitefish (*Coregonus huntsmani*) in Canada, 2018
Brook Floater		Special Concern	Special Concern	Management Plan for the Brook Floater (*Alasmidonta varicosa*) in Canada, 2018
Striped Bass	Bay of Fundy		Endangered	COSEWIC Assessment and Status Report on the Striped Bass *Morone saxatilis* in Canada, 2012
Yellow Lampmussel		Special Concern	Special Concern	Management Plan for the Yellow Lampmussel (*Lampsilis cariosa*) in Canada, 2010

***Table 2**. Nova Scotia distribution of both species listed under the Species at Risk Act and those assessed as 'at risk' by the Committee on the Status of Endangered Wildlife in Canada by primary watershed*

Watershed	**Species at Risk**									
	American Eel	Atlantic Salmon (Eastern Cape Breton)	Atlantic Salmon (Gaspe-Southern Gulf of St. Lawrence)	Atlantic Salmon (inner Bay of Fundy)	Atlantic Salmon (Southern Upland)	Atlantic Sturgeon	Atlantic Whitefish	Brook Floater	Striped Bass (Bay of Fundy)	Yellow Lamp-mussel
Annapolis	X				X	X		X	X	
Barrington / Clyde	X				X					
Cheticamp River	X		X							
Clam Harbour / St. Francis	X				X					
Country Harbour	X				X					
East / Indian River	X				X					
East / Middle / West (Pictou)	X		X							
East / West (Sheet Harbour)	X				X					
Economy	X			X						
French	X		X							
Gaspereau	X			X						
Gold	X				X					
Grand	X	X								
Herring Cove / Medway	X				X		X			
Indian	X	X								
Isle Madame	X									
Kelly / Maccan / Hebert	X			X						
Kennetcook	X			X						

Watershed	Species at Risk									
	American Eel	Atlantic Salmon (Eastern Cape Breton)	Atlantic Salmon (Gaspe-Southern Gulf of St. Lawrence)	Atlantic Salmon (inner Bay of Fundy)	Atlantic Salmon (Southern Upland)	Atlantic Sturgeon	Atlantic Whitefish	Brook Floater	Striped Bass (Bay of Fundy)	Yellow Lamp-mussel
LaHave	X				X	X		X		
Liscomb	X				X					
Margaree	X		X							
Mersey	X				X					
Meteghan	X				X					
Missaguash	X									
Musquodoboit	X				X					
New Harbour / Salmon	X				X			X		
North / Baddeck / Middle	X	X								
Parrsboro	X			X						
Philip / Wallace	X		X					X		
River Denys / Big	X	X								
River Inhabitants	X	X	X							
River John	X		X					X		
Roseway / Sable / Jordan	X				X					
Sackville	X				X					
Salmon / Debert	X			X						
Salmon / Mira	X	X								X
Shubenacadie / Stewiacke	X			X		X		X	X	
Sissiboo / Bear	X				X					
South / West	X		X							

Watershed	Species at Risk									
	American Eel	Atlantic Salmon (Eastern Cape Breton)	Atlantic Salmon (Gaspe-Southern Gulf of St. Lawrence)	Atlantic Salmon (inner Bay of Fundy)	Atlantic Salmon (Southern Upland)	Atlantic Sturgeon	Atlantic Whitefish	Brook Floater	Striped Bass (Bay of Fundy)	Yellow Lamp-mussel
St. Croix	X			X		X				
St. Mary’s	X				X			X		
Tangier	X				X					
Tidnish / Shinimicas	X		X							
Tracadie	X		X							
Tusket River	X				X					
Wreck Cove	X	X								

***Table 3**. DFO funding contributions by primary watershed of Nova Scotia (includes contribution funds from the Recreational Fisheries Conservation Partnerships Program (2103-2019), the Coastal Restoration Fund (2017-2022), the Habitat Stewardship Program (2018-2022) and the Canada Nature Fund for Aquatic Species at Risk (2019-2022)*

Watershed	Total Contribution ($) Amount (2013-2022)	Total # Funded Projects (2013-2022)
Annapolis	$1,058,715	7
Barrington / Clyde		
Cheticamp River	$247,500	4
Clam Harbour / St. Francis		
Country Harbour		
East / Indian River		
East / Middle / West (Pictou)	$2,116,134	5
East / West (Sheet Harbour)	$1,771,944	3
Economy	$60,520	2
French	$461,435	4
Gaspereau	$1,070,244	7
Gold	$25,000	2
Grand		
Herring Cove / Medway	$1,266,245	8
Indian		
Isle Madame		
Kelly / Maccan / Hebert		
Kennetcook		
LaHave	$815,984	9
Liscomb	$364,561	1
Margaree	$433,144	3
Mersey		
Meteghan		
Missaguash	$490,895	2
Musquodoboit	$364,561	1
New Harbour / Salmon		
North / Baddeck / Middle	$58,300	2
Parrsboro		
Philip / Wallace	$577,064	1
River Denys / Big		
River Inhabitants	$539,998	5
River John	$821,553	2
Roseway / Sable / Jordan		
Sackville	$217,918	8

Salmon / Debert	$1,330,810	3
Salmon / Mira	$331,012	8
Shubenacadie / Stewiacke	$1,977,963	16
Sissiboo / Bear	$147,180	3
South / West	$370,572	5
St. Croix	$577,064	1
St. Mary’s	$1,911,811	7
Tangier		
Tidnish / Shinimicas		
Tracadie	$882,225	4
Tusket River		
Wreck Cove		

***Table 4**. Watershed area and percent disturbance for the overall watershed and riparian zones for the primary watersheds of Nova Scotia*

Watershed	Watershed Area (km^2)	Watershed Disturbance (%)				Riparian Disturbance – 150m Buffer (%)			
		Total	Urban	Forest Loss	Agriculture	Total	Urban	Forest Loss	Agriculture
Annapolis	2,272.60	28.86	8.59	6.07	14.21	30.43	7.82	3.47	19.15
Barrington / Clyde	1,424.45	6.19	5.06	0.91	0.21	3.69	2.92	0.55	0.22
Cheticamp River	803.63	3.02	2.20	0.38	0.44	2.56	2.00	0.27	0.29
Clam Harbour / St. Francis	526.00	17.84	6.96	9.79	1.09	14.81	6.79	7.03	0.99
Country Harbour	572.56	12.81	5.16	7.15	0.50	11.47	5.41	5.63	0.43
East / Indian River	777.64	14.55	10.68	3.66	0.21	9.66	7.40	2.20	0.06
East / Middle / West (Pictou)	1,189.49	29.52	13.45	6.25	9.82	30.64	15.72	4.07	10.85
East / West (Sheet Harbour)	1,002.47	15.43	5.18	10.25	0.00	11.19	3.55	7.64	0.00
Economy	779.83	19.19	6.25	7.25	5.69	17.25	6.36	5.32	5.57
French	748.13	23.08	10.10	7.23	5.75	23.84	12.17	5.48	6.19
Gaspereau	1,323.67	41.27	10.53	4.78	25.96	41.14	9.90	3.03	28.21
Gold	1,067.99	19.83	10.97	5.77	3.09	13.92	9.36	2.44	2.12
Grand	769.95	17.89	9.89	6.29	1.71	15.37	9.09	4.28	2.01
Herring Cove / Medway	2,026.39	15.37	7.70	5.84	1.83	10.19	6.67	2.42	1.10
Indian	845.82	9.30	4.69	4.49	0.12	5.83	4.18	1.43	0.22
Isle Madame	115.25	17.32	13.24	1.64	2.43	13.53	10.31	1.30	1.92
Kelly / Maccan / Hebert	1,285.69	24.20	7.38	9.43	7.39	23.49	7.20	6.09	10.20
Kennetcook	1,014.20	20.81	5.37	7.48	7.96	20.02	5.29	5.96	8.77
LaHave	1,685.77	20.03	8.59	7.27	4.17	15.66	8.78	3.97	2.91
Liscomb	1,198.75	12.05	4.55	7.50	0.00	8.03	3.05	4.99	0.00
Margaree	1,370.93	11.47	5.23	4.01	2.24	9.72	5.46	1.66	2.60

Mersey	2,992.85	8.17	4.54	3.47	0.16	4.73	3.51	1.16	0.06
Meteghan	620.30	24.24	8.76	6.82	8.67	18.36	7.86	3.69	6.81
Missaguash	41.14	21.53	1.46	1.16	18.91	24.40	0.37	1.12	22.91
Musquodoboit	1,389.42	17.65	9.27	4.36	4.03	14.93	7.31	2.62	5.00
New Harbour / Salmon	1,075.00	9.59	4.69	4.80	0.10	6.85	3.93	2.85	0.07
North / Baddeck / Middle	766.56	14.50	5.64	5.96	2.90	11.23	4.43	2.98	3.81
Parrsboro	859.60	24.57	8.60	12.01	3.97	21.96	7.34	9.63	4.99
Philip / Wallace	1,488.56	24.35	6.83	8.26	9.26	23.18	7.98	5.88	9.32
River Denys / Big	785.21	14.59	9.10	3.14	2.34	15.38	10.36	2.29	2.73
River Inhabitants	1,196.28	17.26	9.40	3.84	4.02	15.51	9.03	2.76	3.72
River John	1,090.92	26.75	6.82	5.60	14.33	26.09	7.87	3.60	14.61
Roseway / Sable / Jordan	1,431.48	6.32	4.51	1.75	0.06	4.31	3.35	0.94	0.02
Sackville	972.38	28.62	26.49	2.06	0.08	19.20	17.73	1.39	0.07
Salmon / Debert	1,173.90	27.10	11.46	7.03	8.61	29.55	11.63	5.30	12.63
Salmon / Mira	2,881.88	18.56	11.37	5.08	2.11	14.64	9.15	3.83	1.66
Shubenacadie / Stewiacke	2,706.36	25.14	10.27	6.08	8.79	25.31	10.73	4.24	10.33
Sissiboo / Bear	1,444.26	17.70	7.63	6.64	3.42	14.34	6.96	4.08	3.31
South / West	894.08	25.74	8.51	7.51	9.72	26.54	9.83	5.26	11.46
St. Croix	1,345.58	25.69	8.49	8.73	8.48	23.34	8.11	4.79	10.43
St. Mary’s	1,533.74	16.08	6.14	8.90	1.04	14.19	6.56	5.99	1.64
Tangier	1,091.98	10.53	5.33	5.18	0.02	6.10	3.51	2.59	0.00
Tidnish / Shinimicas	483.87	30.09	6.84	7.23	16.01	30.45	6.29	4.39	19.77
Tracadie	589.74	25.19	10.18	7.46	7.55	25.08	11.18	5.90	7.99
Tusket River	2,165.13	15.30	7.09	3.52	4.69	11.46	5.26	1.84	4.36
Wreck Cove	1,037.05	4.06	2.93	0.73	0.40	4.28	3.28	0.62	0.38

***Table 5**. Acid rock drainage potential and watershed buffering capacity for the primary watershed of Nova Scotia*

Watershed	Acid Rock Drainage Potential (area (km^2) of potentially exposed acid rock / watershed area (km^2))	Buffering Capacity (mg/L $CaCO_3$)
Annapolis	0.047	16.27
Barrington / Clyde	0.057	4.58
Cheticamp River	0	19.02
Clam Harbour / St. Francis	0	14.18
Country Harbour	0.045	8.19
East / Indian River	0.035	4.34
East / Middle / West (Pictou)	0	15.09
East / West (Sheet Harbour)	0.083	5.63
Economy	0	9.73
French	0	14.14
Gaspereau	0.097	22.40
Gold	0.290	4.30
Grand	0	12.57
Herring Cove / Medway	0.277	3.09
Indian	0	9.01
Isle Madame	0	15.10
Kelly / Maccan / Hebert	0	9.33
Kennetcook	0.069	14.87
LaHave	0.372	4.95
Liscomb	0.139	5.41
Margaree	0	12.29
Mersey	0.078	3.21
Meteghan	0.116	3.59
Missaguash	0	34.55
Musquodoboit	0.201	9.09
New Harbour / Salmon	0.192	10.30
North / Baddeck / Middle	0	9.99
Parrsboro	0	10.87
Philip / Wallace	0	17.30
River Denys / Big	0	10.22
River Inhabitants	0	11.66
River John	0	23.93
Roseway / Sable / Jordan	0.058	3.16
Sackville	0.124	6.07

Salmon / Debert	0	15.87
Salmon / Mira	0	14.15
Shubenacadie / Stewiacke	0.144	13.64
Sissiboo / Bear	0.154	6.17
South / West	0	14.14
St. Croix	0.098	9.84
St. Mary’s	0.022	9.56
Tangier	0.042	5.22
Tidnish / Shinimicas	0	35.16
Tracadie	0	14.18
Tusket River	0.168	4.35
Wreck Cove	0	14.22

***Table 6**. Connectivity metrics for the primary watersheds of Nova Scotia*

Watershed	Proportion of Stream Length Upstream of Dams with No Upstream Fish Passage	Stream Crossing Density (# crossings / stream km)
Annapolis	27.07	0.49
Barrington / Clyde	-	0.20
Cheticamp River	6.39	0.08
Clam Harbour / St. Francis	2.82	0.40
Country Harbour	-	0.30
East / Indian River	17.51	0.38
East / Middle / West (Pictou)	0.86	0.60
East / West (Sheet Harbour)	3.93	0.24
Economy	5.02	0.42
French	0.49	0.51
Gaspereau	16.39	0.53
Gold	20.95	0.46
Grand	0.65	0.44
Herring Cove / Medway	8.93	0.31
Indian	17.51	0.22
Isle Madame	2.47	0.54
Kelly / Maccan / Hebert	3.24	0.38
Kennetcook	2.31	0.35
LaHave	0.29	0.43
Liscomb	-	0.24
Margaree	0.11	0.25
Mersey	60.50	0.17
Meteghan	28.41	0.52
Missaguash	-	0.03
Musquodoboit	6.91	0.39
New Harbour / Salmon	3.08	0.22
North / Baddeck / Middle	0.08	0.25
Parrsboro	5.10	0.45
Philip / Wallace	3.78	0.37
River Denys / Big	-	0.44
River Inhabitants	5.86	0.42
River John	4.76	0.42
Roseway / Sable / Jordan	4.07	0.18
Sackville	10.01	0.49
Salmon / Debert	4.06	0.36
Salmon / Mira	2.34	0.41

Shubenacadie / Stewiacke	3.07	0.42
Sissiboo / Bear	53.93	0.42
South / West	3.40	0.42
St. Croix	41.54	0.39
St. Mary's	0.13	0.32
Tangier	0.32	0.22
Tidnish / Shinimicas	4.21	0.34
Tracadie	6.36	0.51
Tusket River	11.58	0.33
Wreck Cove	0.18	0.13

***Table 7**. Decade of first detection of smallmouth bass in the secondary watersheds of Nova Scotia (1940 to 2020)*

Decade	Primary Watershed	Secondary Watershed
1940-1949	Kennetcook	Kennetcook River
1940-1949	Sackville	Dartmouth Lakes
1940-1949	Tusket River	Ohio Millstream Brook
1950-1959	Annapolis	Shore Direct 1DC-SD29
1950-1959	Gold	Shore Direct 1EG-SD12
1950-1959	Meteghan	Salmon R. (Dig Co)
1950-1959	Shubenacadie / Stewiacke	Shubenacadie River
1950-1959	Tusket River	Ohio Millstream Brook.
1960-1969	Gaspereau	Gaspereau / Black River
1960-1969	Sackville	Dartmouth Lakes
1960-1969	Shubenacadie / Stewiacke	Shubenacadie River
1970-1979	Gaspereau	Gaspereau / Black R.
1970-1979	Meteghan	Salmon River (Digby County)
1970-1979	Meteghan	Shore Direct 1DA-SD6
1970-1979	Sackville	Cow Bay R.
1970-1979	Sackville	Shore Direct 1EJ-SD3
1970-1979	Shubenacadie / Stewiacke	Shubenacadie River
1970-1979	Tangier	Shore Direct 1EL-SD15
1970-1979	Tangier	Shore Direct 1EL-SD4
1970-1979	Tusket River	Cedar Lake (Un-named River)
1980-1989	Annapolis	Annapolis River
1980-1989	Gaspereau	Gaspereau / Black River
1980-1989	Herring Cove / Medway	Medway River
1980-1989	LaHave	Marsh Brook.
1980-1989	LaHave	Shore Direct 1EF-SD2
1980-1989	LaHave	Shore Direct 1EF-SD8
1980-1989	Mersey	Mersey River
1980-1989	Meteghan / Tusket River	Salmon River (Digby County)
1980-1989	Musquodoboit	Porters Lake
1980-1989	Sackville	Partridge River
1980-1989	Shubenacadie / Stewiacke	Shore Direct 1DG-SD3
1980-1989	Shubenacadie / Stewiacke	Shubenacadie River
1980-1989	St. Croix	St. Croix River
1980-1989	Tusket River	Cedar Lake (Un-Named River)

1980-1989	Tusket River	Tusket River
1990-1999	Annapolis	Annapolis River
1990-1999	Annapolis	Lequille River
1990-1999	Annapolis	Shore Direct 1DC-SD54
1990-1999	Gaspereau	Cornwallis River
1990-1999	Gold	Gold River
1990-1999	Gold	Mushamush River
1990-1999	Herring Cove / Medway	Herring Cove Brook
1990-1999	Herring Cove / Medway	Medway River
1990-1999	Herring Cove / Medway	Petite Riviere
1990-1999	Kennetcook	Cogmagun River
1990-1999	LaHave	LaHave River
1990-1999	LaHave	Marsh Brook
1990-1999	Mersey	Mersey River
1990-1999	Meteghan	Meteghan River
1990-1999	Meteghan / Tusket River	Salmon River (Digby County)
1990-1999	Philip / Wallace	Pugwash River
1990-1999	River John	French River
1990-1999	Roseway / Sable / Jordan	Roseway River
1990-1999	Sackville	Cow Bay River
1990-1999	Sackville	Kearney Run
1990-1999	Sackville	McIntosh Run
1990-1999	Sackville	Sackville River
1990-1999	Shubenacadie / Stewiacke	Shubenacadie River
1990-1999	Sissiboo / Bear	Shore Direct 1DB-SD21
1990-1999	St. Croix	Avon River
1990-1999	St. Croix	St. Croix River
1990-1999	Tusket River	Annis River
1990-1999	Tusket River	Cedar Lake (Un-Named River)
1990-1999	Tusket River	Shore Direct 1EA-SD14
1990-1999	Tusket River	Shore Direct 1EA-SD15
1990-1999	Tusket River	Tusket River
2000-2009	Annapolis	Annapolis River
2000-2009	Annapolis	Lequille River
2000-2009	East / Indian River	Indian River (Halifax County)
2000-2009	East / Middle / West (Pictou)	Middle River Pictou
2000-2009	Economy	Portapique River
2000-2009	Gold	Gold River

2000-2009	Gold	Mushamush River
2000-2009	Gold	Shore Direct 1EG-SD12
2000-2009	Herring Cove / Medway	Medway River
2000-2009	Herring Cove / Medway	Petite Riviere
2000-2009	Kelly / Maccan / Hebert	Maccan River
2000-2009	LaHave	LaHave River
2000-2009	LaHave	Marsh Brook.
2000-2009	Margaree	Margaree River
2000-2009	Mersey	Mersey River
2000-2009	Meteghan / Tusket River	Salmon River (Digby County)
2000-2009	Musquodoboit	Shore Direct 1EK-SD3
2000-2009	River John	Dewar River
2000-2009	River John	French River
2000-2009	Roseway / Sable / Jordan	Roseway River
2000-2009	Roseway / Sable / Jordan	Shore Direct 1EC-SD20
2000-2009	Roseway / Sable / Jordan	Shore Direct 1EC-SD6
2000-2009	Sackville	Dartmouth Lakes
2000-2009	Sackville	Kearney Run
2000-2009	Sackville	McIntosh Run
2000-2009	Sackville	Nine Mile River
2000-2009	Sackville	Pennant River
2000-2009	Sackville	Sackville River
2000-2009	Sackville	Shore Direct 1EJ-SD2
2000-2009	Salmon / Mira	Sydney River
2000-2009	Shubenacadie / Stewiacke	Shubenacadie River
2000-2009	Sissiboo / Bear	Shore Direct 1DB-SD2
2000-2009	Sissiboo / Bear	Sissiboo River
2000-2009	St. Croix	Avon River
2000-2009	St. Croix	St. Croix River
2000-2009	Tusket River	Annis River
2000-2009	Tusket River	Tusket River
2010-2020	Annapolis	Annapolis River
2010-2020	Barrington / Clyde	Clyde River
2010-2020	East / Indian River	Indian River (Halifax County)
2010-2020	East / Indian River	Northeast River
2010-2020	Gold	Gold River
2010-2020	Gold	Shore Direct 1EG-SD16
2010-2020	Herring Cove / Medway	Herring Cove Brook

2010-2020	Herring Cove / Medway	Medway River
2010-2020	Herring Cove / Medway	Petite Riviere
2010-2020	Kelly / Maccan / Hebert	Maccan River
2010-2020	Kelly / Maccan / Hebert	River Hebert
2010-2020	LaHave	LaHave River
2010-2020	Mersey	Mersey River
2010-2020	Mersey	Shore Direct 1ED-SD4
2010-2020	Meteghan	Shore Direct 1DA-SD8
2010-2020	Meteghan / Tusket River	Salmon River (Digby County)
2010-2020	Musquodoboit	Chezzetcook River
2010-2020	New Harbour / Salmon	Shore Direct 1EQ-SD17
2010-2020	Roseway / Sable / Jordan	Roseway River
2010-2020	Roseway / Sable / Jordan	Shore Direct 1EC-SD19
2010-2020	Sackville	Cow Bay River
2010-2020	Sackville	Nine Mile River
2010-2020	Sackville	Partridge River
2010-2020	Sackville	Pennant River
2010-2020	Sackville	Sackville River
2010-2020	Sackville	Shore Direct 1EJ-SD3
2010-2020	Sackville	Woodens River
2010-2020	Salmon / Debert	Folly River
2010-2020	Shubenacadie / Stewiacke	Shubenacadie River
2010-2020	Sissiboo / Bear	Sissiboo River
2010-2020	St. Mary’s	St. Mary's River
2010-2020	Tusket River	Annis River
2010-2020	Tusket River	Shore Direct 1EA-SD2
2010-2020	Tusket River	Shore Direct 1EA-SD3
2010-2020	Tusket River	Tusket River
2010-2020	Tusket River	Shore Direct 1EA-SD14

Table 8. *Decade of first detection of chain pickerel in the secondary watersheds of Nova Scotia (1940 to 2020)*

Decade	Primary Watershed	Secondary Watershed
1940-1949	Meteghan	Shore Direct 1DA-SD6
1940-1949	Tusket River	Annis River
1960-1969	Kennetcook	Kennetcook River
1960-1969	Meteghan	Shore Direct 1DA-SD6
1960-1969	Tusket River	Ste Anne du Ruisseau
1970-1979	Meteghan	Meteghan River
1970-1979	Meteghan / Tusket River	Salmon River (Digby County)
1970-1979	Tusket River	Annis River
1970-1979	Tusket River	Ohio Millstream Brook
1980-1989	Shubenacadie / Stewiacke	Shubenacadie River
1980-1989	Tusket River	Annis River
1980-1989	Tusket River	Shore Direct 1EA-SD15
1990-1999	Barrington / Clyde	Shore Direct 1EB-SD7
1990-1999	Barrington / Clyde	Shore Direct 1EB-SD9
1990-1999	East / Middle / West (Pictou)	East River Pictou
1990-1999	Gaspereau	Gaspereau / Black River
1990-1999	Kennetcook	Kennetcook River
1990-1999	LaHave	LaHave River
1990-1999	Mersey	Shore Direct 1ED-SD14
1990-1999	Mersey	Shore Direct 1ED-SD25
1990-1999	Meteghan	Meteghan River
1990-1999	Meteghan	Shore Direct 1DA-SD6
1990-1999	Roseway / Sable / Jordan	Jordan River
1990-1999	Shubenacadie / Stewiacke	Shubenacadie River
1990-1999	St. Croix	St. Croix River
2000-2009	East / Middle / West (Pictou)	East River Pictou
2000-2009	Gaspereau	Gaspereau / Black River
2000-2009	Kennetcook	Kennetcook River
2000-2009	Kennetcook	Noel River
2000-2009	LaHave	LaHave River
2000-2009	Mersey	Shore Direct 1ED-SD15
2000-2009	Meteghan	Meteghan River
2000-2009	Meteghan / Tusket River	Salmon River (Digby County)
2000-2009	Roseway / Sable / Jordan	Shore Direct 1EC-SD6

2000-2009	Sackville	Cow Bay River
2000-2009	Sackville	Shore Direct 1EJ-SD2
2000-2009	Salmon / Mira	Sydney River
2000-2009	Shubenacadie / Stewiacke	Shubenacadie River
2000-2009	St. Croix	St. Croix River
2000-2009	Tusket River	Annis River
2000-2009	Tusket River	Tusket River
2010-2019	East / Middle / West (Pictou)	East River Pictou
2010-2019	Gaspereau	Gaspereau / Black River
2010-2019	Gold	Shore Direct 1EG-SD2
2010-2019	Herring Cove / Medway	Petite Riviere
2010-2019	LaHave	LaHave River
2010-2019	Mersey	Mersey River
2010-2019	Mersey	Shore Direct 1ED-SD12
2010-2019	Mersey	Shore Direct 1ED-SD4
2010-2019	Meteghan	Meteghan River
2010-2019	Roseway / Sable / Jordan	Jordan River
2010-2019	Roseway / Sable / Jordan	Roseway River
2010-2019	Sackville	Cow Bay River
2010-2019	Sackville	Dartmouth Lakes
2010-2019	Sackville	Sackville River
2010-2019	Salmon / Mira	Sydney River
2010-2019	Shubenacadie / Stewiacke	Shubenacadie River
2010-2019	St. Croix	St. Croix River
2010-2019	Tusket River	Annis River
2010-2019	Tusket River	Cedar Lake (Un-named River)
2010-2019	Tusket River	Shore Direct 1EA-SD14
2010-2019	Tusket River	Tusket River