# Managing the Groundfish Industry on Sensitive Benthic Areas of Interest for Marine Protected Area Network Establishment in the Scotian Shelf Bioregion

By

Delaney B. Ewing

Submitted in partial fulfillment of the requirements
for the degree of Master of Marine Management

at

Dalhousie University
Halifax, Nova Scotia

December 2020



(905) 259-1555 | delaneyewing@dal.ca

## Table of Contents

**Ewing, D**. (2020). Managing the Groundfish Industry on Sensitive Benthic Areas of Interest for Marine Protected Area Network Establishment in the Scotian Shelf Bioregion [Graduate Project]. Halifax, NS: Dalhousie University.

## Abstract

Increases to the number and extent of Marine Protected Areas (MPAs) in recent decades is been critical for the conservation of coastal and marine environments. Canada has met its original target of conserving 10% of their oceans by 2020 and are intending to increase their commitments to conserving 30% of their ocean by 2030. This includes designating sites aimed at protecting coral and sponge species whose habitat-building capabilities may support entire ecosystems. These coral and sponge reefs may be at risk of smothering and physical disturbance from nearby fisheries operations, yet the socioeconomic necessity of the fishing industry must be considered in MPA development. Stakeholder identification and prioritization analyses were used to determine that those operating within the groundfish industry were likely to be significantly affected by benthic MPA designation on Canada's Scotian Shelf as a result of decreased fishing territory that could correlate into reduced quotas and increased costs of travelling to and from fishing grounds. A Marxan analysis with conservation targets ranging between 15-50% for sensitive benthic areas (SBAs) on the Scotian Shelf was performed to determine the optimal locations for an MPA network that minimally affected groundfish operators. The conservation targets were set against the locations of known groundfish industry operations. The 15% and 25% scenarios resulted in the best output of Areas of Interest for MPA designation because there was minimal overlap between SBAs and fisheries. Maintaining opportunities for Canada's coastal industries while conserving unique marine features is key for developing a sustainable economy.

*Keywords*: marine protected area; Nova Scotia; sensitive benthic areas; coral; groundfish; commercial fishing

## List of Abbreviations

**AOI** – Area of Interest

**BLM** – Boundary Length Modifier

**CAPP** – Canadian Association of Petroleum Producers

**CBD** – United Nations Convention on Biological Diversity

**CCPFH** – Canadian Council of Professional Fish Harvesters

**DFO** – Fisheries and Oceans Canada

**ECCC** – Department of Environment and Climate Change Canada

**ENGO** – Environmental Non-Government Organization

**FSC** – Food, Social, Ceremonial

**MPA** – Marine Protected Area

**NMCA** – National Marine Conservation Area

**NOAA -** National Oceanic and Atmospheric Administration

**OECM** – Other Effect Area-Based Conservation Measure

**PCA** – Parks Canada Agency

**KDE** – Kernel Density Estimation

**SBA** – Sensitive Benthic Area

**TAC** – Total Allowable Catch

**UN** – United Nations

## List of Figures

## List of Tables

# Chapter 1. Introduction

## *1.1 Management Problem and Rationale*

Canada's coastline is the longest globally, stretching across three oceans and measuring over 243,042 km (Statistics Canada, 2016). The nation's exclusive economic zone extends 200 nautical miles beyond the coast and contains rich biodiversity and unique ecosystems which may be endemic to Canada. To protect these ecosystems and the services they provide, as well as meet their domestic and international conservation commitments, Canada aims to increase its extent of marine protected areas (MPAs) (DFO, 2020f). Canada's MPAs provide a nature-based solution for addressing climate change via the conservation of marine ecosystems, habitats, and species (DFO, 2020f). They also contribute to the preservation of Canadian culture while providing economic opportunities for coastal communities (DFO, 2020f).

Canada's portion of the Atlantic Ocean contains the Maritime provinces of New Brunswick, Prince Edward Island, Newfoundland and Labrador, and Nova Scotia. Three bioregions – defined as a high-level spatial unit based on oceanographic and bathymetric similarities that are critical for defining habitats and their species (DFO, 2009a) – have been identified within Canada's Atlantic. These are the Gulf of St. Lawrence, the Newfoundland and Labrador Shelves, and the Scotian Shelf (DFO, 2018c).

The Scotian Shelf bioregion is one of 13 bioregions in Canada and includes the Shelf, the Bay of Fundy, and the Canadian portion of the Gulf of Maine (DFO, 2009a). It is classified by inshore, midshore, and offshore areas. The inshore is comprised of waters less than 100 m deep, or less than 25 km from offshore Nova Scotia, and located between Cape North and Cape Sable Island (Bundy et al., 2014). The midshore is a region straddling the inshore and offshore (Bundy et al., 2014). Finally, the offshore is an area farther out to sea, including the edges of the continental shelf, and is located approximately 370 km from the shore (The Canadian Fishing Industry, n.d.).

Three MPAs have been established within the Scotian Shelf – known as St. Anns Bank, The Gully, and Musquash Estuary – and they are the base on which the Government of Canada intends to build a network of protected areas in the bioregion. In 2018, CBC News released a map depicting 24 Areas of Interest (AOIs) identified by the Fisheries and Oceans Canada (DFO) for the development of an MPA network capable of protecting 25% of the Scotian Shelf (Withers, 2018). The bioregion's unique habitats, comprised of estuaries, salt marshes (DFO, 2019b), deep-sea canyons, abyssal plain, continental slope, and shallow sandy banks are of importance for conservation efforts (DFO, 2020e). This is because these ecosystems support a range of communities and species, including important fish stocks (King et al., 2016).

If the proposed network is approved, the potential for user-conflict on the Scotian Shelf will increase. According to the executive director of the Groundfish Enterprise Allocation Council, many of the AOIs are anticipated to overlap with productive fishing areas (Withers, 2018). The fishing industry is one of the most prominent sectors in the Maritimes. In 2018, $3 billion of seafood and marine products were landed in the region (DFO, 2019a). The same year saw contributions of $1.5 billion to the Maritime economy stemming from the fishing and fish processing industries (Government of Canada, 2019). Approximately 34,000 Atlantic Canadians were employed in the fish and fish processing industry according to the 2016 Census, and in 2018 over 14,000 vessels and 70,000 licenses were issued in the Atlantic (Government of Canada, 2019). Within the Atlantic fisheries industry, the groundfish sector plays a prominent role. The most recently available statistics from 2015 indicated that a value of $91 million contributed to the Maritime economy via landings of fish and fish products from groundfish licenses (DFO, 2018a).

While the groundfish industry provides economic contributions to Canada's Maritime region, it is likely to experience conflict with future MPAs designated for benthic species, especially within the Scotian Shelf. Important benthic species, such as corals, sponges, and sea pens, are found to play an essential role on the Shelf by providing structural habitat that supports other species via the production of nurseries, refugia, and spawning and breeding grounds (Hoff *et al*., 2019, DFO, 2010b, Baillon *et al*., 2012, Baker *et al*., 2012a, and Baker *et al*., 2012b in DFO, 2015). The role these benthic species play in the ecosystem makes them a priority for conservation efforts since their sedentary nature leaves them vulnerable to disturbance (Clark et al., 2016).

The groundfish industry may be especially impactful to these benthic species because the gear types this industry uses are associated with a high risk of disturbance. Certain bottom-contact fishing gears, such as longline, gillnet, and trawl, have the potential to plough and scrape the seabed, resulting in the suspension of sediments that settle over and smother vulnerable and sessile species (Clark et al., 2016). Longline and gillnet damage benthic habitats via the breaking and crushing of corals during the gear retrieval (Fossa et al., 2002, Mortensen et al., 2008, and Welsford and Kilpatrick, 2008 in Clark et al., 2016). Trawling alters the physical properties of the seabed via erosion, uprooting rocks and sessile fauna, or the creation of particulate plumes, among other impacts (Clark et al., 2016). To conserve vulnerable benthic species, it is imperative that harmful activities– such as bottom-contact fishing – do not occur within their habitat range.

This report aims to address the feasibility of developing an MPA network for the Scotian Shelf bioregion that is capable of conserving sensitive benthic areas (SBAs) while limiting socioeconomic impacts to the groundfish industry. This will be addressed through the following questions: (1) where are SBAs found; (2) what are the most pressing threats to sensitive benthic species; (3) where will the impact to stakeholders – namely the groundfish industry – be felt (i.e., where is the overlap between fishing activity and significant benthic areas); and (4) do the identified areas have the potential to complement existing conservation measures and contribute to an MPA network within the Scotian Shelf bioregion?

Overall, this research aims to determine how an MPA network focused on the conservation of SBAs may affect the groundfish industry operating within the Scotian Shelf bioregion. The designation of MPAs may be in conflict with the socioeconomic goals of this industry as MPAs established in economically important areas, such as productive fishing grounds, may result in fishers experiencing a decrease to the available fishable area, quota reductions in catch due to fishing territory decline, increased expenses associated with longer travel time to fishing grounds (to avoid MPAs) and limited time for fishing as a result.

This research will identify AOIs that may be suitable for MPA designation on the Scotian Shelf – which includes the slope and deep-water study areas – with the backdrop of aiming to support the continuance of the groundfish industry. The primary conservation objective for these sites would be to protect benthic areas and the species residing within them. For the purpose of this research, these sites are described as "MPAs" and "AOIs." This study will not consider the personal accounts of stakeholders who may be affected by MPA designation for the proposed Scotian Shelf MPA network; however, a stakeholder analysis and prioritization grid will demonstrate how MPA designation could impact these groups. The groundfish industry will be emphasized as they are expected to be greatly affected by benthic MPAs. Understanding how benthic MPA designation may impact the groundfish industry is critical for mitigating conflict and attaining the support of this stakeholder during consultation sessions for MPA designation. Preserving Nova Scotia's economy and maintaining the livelihoods of the province's fishers is essential for the successful development of an MPA network for the Scotian Shelf bioregion.

### *1.2 National Conservation Goals*

The *World Summit on Sustainable Development, 2002*, called for the development of MPAs that were "consistent with international law and based on scientific information, including representative networks by 2012 and…develop national, regional, and international programmes for halting the loss of marine biodiversity, including in coral reefs," (United Nations, 2002). The goal was to have a network conserving 10% of coastal and marine regions by 2012; however, this was not met (United Nations, 2002). At the 2010 United Nations Convention on Biological Diversity (UN CBD) in Nagoya, Aichi Prefecture, Japan, the pressure to develop a global network of MPAs was revived. Here, the CBD outlined a framework for all United Nations partners to conserve biodiversity and implement management and policy procedures (CBD, 2010). The Strategic Plan for Biodiversity 2011-2020 established strategic goals comprised of 20 targets. Strategic Goal C called for the status of biodiversity to be improved by safeguarding ecosystems, including a representation of all species and their genetic diversity (CBD, 2010). Under this goal, one target called for the conservation of "10 percent coastal and marine waters, especially areas of particular importance for biodiversity and ecosystem services, [which] are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascapes," (Secretariat of the CBD, 2010).

At the UN CBD, Canada committed to reaching the 10% target, commonly referred to as Aichi Target 11 (DFO, 2019f). Using the foundational principles of science-based decision making, transparency, and advancements in reconciliation with Indigenous groups, Canada proved its commitment to the agreement and to the conservation of their marine resources. Canada's government invested $81 million over 5 years to meet the 5% and 10% marine conservation targets alongside a $40 million per year increase to fisheries and ocean sciences (DFO, 2019f). In addition, $1.5 billion over 5 years was contributed for oceans protection to increase the likelihood that Canada would meet its objectives (DFO, 2019f). To achieve Aichi Target 11, Canada aimed to follow a five-point plan that consisted of the elements outlined in Figure 1.

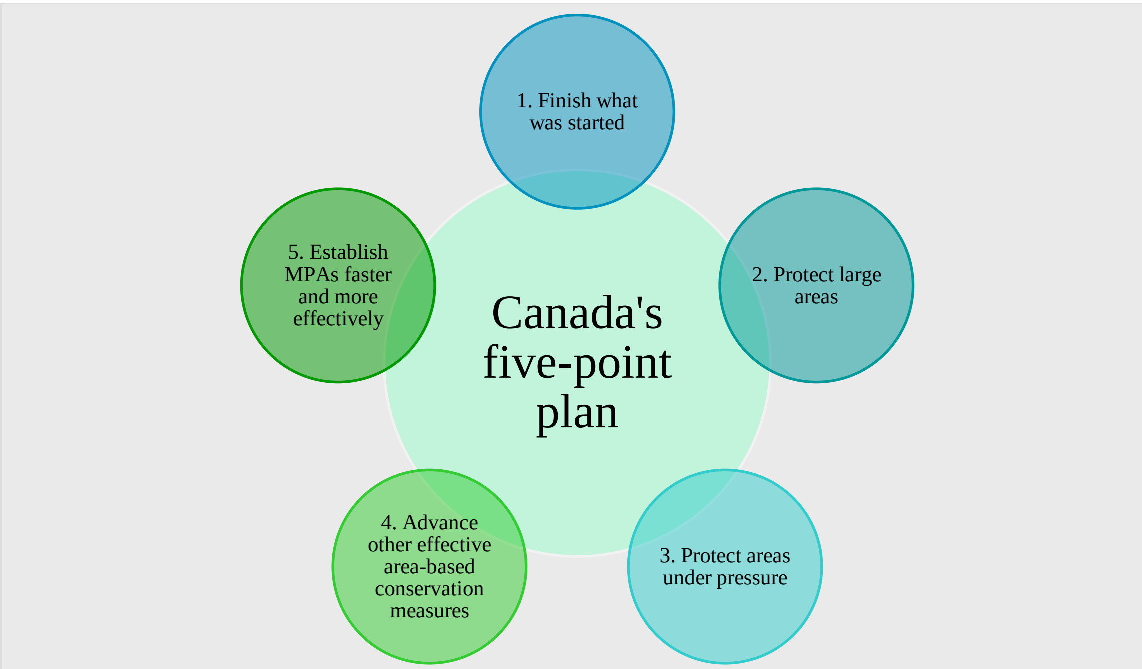


**Figure 1**. Canada's five-point plan for meeting its marine conservation targets (DFO, 2019f)

Element 1 called to advance and complete work that was already underway to establish MPAs (DFO, 2019f). Element 2 aimed to develop large MPAs in offshore areas, designated under Canada's *Oceans Act* (DFO, 2019f). Element 3 focused on creating MPAs in five priority bioregions under pressure from human activities (DFO, 2019f). These bioregions are the Northern Shelf, Western Arctic, Estuary and Gulf of St. Lawrence, Scotian Shelf, and Newfoundland-Labrador Shelves (DFO, 2019f). Element 4 aimed to identify existing and prospective other effective area-based conservation measures (OECMs) that could contribute to the target (DFO, 2019f). Finally, element 5 intended to amend the *Oceans Act* so that the MPA designation process may be swifter and able to provide interim protection to vulnerable regions while scientific research and consultation processes are undertaken (DFO, 2019f).

By 2020, Canada surpassed the 10% coverage target set under Aichi Target 11 by reaching 13.81% (DFO, 2019f). In achieving this percentage and the timeline for Aichi Target 11 now passed, Canada is considering advancements to its marine conservation targets. Canada's Minister of Fisheries, Oceans and the Canadian Coast Guard was provided a Mandate Letter in December 2019 that outlined the nation's new goals. The Letter stated that Canada intended to conserve 25% of their oceans by 2025 and 30% by 2030 (Trudeau, 2019). The MPAs and OECMS contributing to these goals should be grounded in science, Indigenous knowledge, and local perspectives (Trudeau, 2019). In July 2020, the Minister reaffirmed Canada's commitments to these targets via the United Kingdom-led Global Ocean Alliance (Newswire, 2020). The primary objective of the Alliance is to work alongside international partners to protect at least 30% of the world's oceans by 2030 (Newswire, 2020). With their national targets and in joining the Global Ocean Alliance, it is clear that Canada is looking to continue its marine conservation goals in the coming years.

## Chapter 2. Marine Protected Areas

MPAs are a globally utilized tool implemented for the conservation and management of biodiversity. These protected areas “conserve biodiversity, improve fisheries, mitigate climate change, reduce disaster risk, and restore ecosystems,” (Watson & Hewson, 2018). They may serve a secondary purpose of providing sociological, economic, and cultural heritage benefits to communities living near protected sites (Pasquad and Lobry, 2011). This may occur via the creation of opportunities for enjoyment of natural spaces, prospects for employment, and allowing for the expression of culturally and historically important Indigenous activities.

In theory, socioeconomic benefits associated with MPAs may arise from the closure of areas where commercially important species reside. Closing regions may allow species to live longer and reach maturity – a critical process for population dynamics and sustainable fisheries (Forcada et al., 2009). Closures may also result in spillover effects. These are defined as the net movement of individuals from an MPA to active fishing grounds and are observed if juvenile and adult fish populations are increased in regions adjacent to an MPA (Forcada et al., 2009). This could be evidence of a spillover effect as it indicates migration from an MPA to adjacent waters.

While real-life demonstrations of spillover effects are difficult to attain, Murawski et al. (2005) identified that this phenomenon may be occurring on Georges Bank and other sites in New England. Georges Bank was an area of importance for trawl fishers who targeted groundfish prior to its closure (Murawski et al., 2005). Following the closure, researchers found that Georges Bank continued to attract fishers, but that fishing effort had been reallocated to the boundary lines of year-round closures (Murawski et al., 2005). The authors theorized that fishers operating adjacent to closed area boundaries could be explained by real or perceived benefits, such as increased catch rates, associated with fishing near the MPA (Murawski et al., 2005). Density gradients for some species, such as haddock and yellowtail founder, also appeared to be synonymous with a spillover effect (Murawski et al., 2005). While the authors surmised that their findings for year-round closures did not demonstrate "universal positive impacts on the abundance and spillover potential of all groundfish stocks," they concluded that their "analyses confirm that large-scale year-round closed areas…affect the abundance and spatial distribution of some target species and the allocation of trawling effort," (Murawski et al., 2005). Despite the evidence of spillover effects occurring in coastal areas, the presence of spillover effects in offshore regions has not been as thoroughly researched. As such, it is not clear if spillover effects occur in the open ocean, and this is an area that should be further explored to determine if the fishing industry can expect to experience benefits due to MPA establishment.

### *2.1 Federal Legislation for Designating Marine Protected Areas*

In Canada, MPAs are established under various pieces of federal legislation, including the *Oceans Act*, the *Canadian Wildlife Act*, and the *National Marine Conservation Act*. These Acts are applied by the relevant federal departments to establish marine conservation areas.

The *Oceans Act* defines an MPA as an "area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada," (*Oceans Act*, 1996, Section 35.2). MPAs are designated to conserve commercial and non-commercial fishery resources, endangered or threatened species, unique habitats, areas of high biodiversity and productivity, to maintain ecological integrity, or as necessary to fulfill the mandate of the Minister of Fisheries, Oceans and the Canadian Coast Guard (*Oceans Act*, 1996, p Section 35.2). The Minister may prohibit activities that are inconsistent with a site's conservation objectives from occurring within the MPA (*Oceans Act*, 1996, Section 35.2). Prohibited activities include those that "disturbs, damages, destroys, or removes from that marine protected area any unique geological or archeological features or any living marine organism or part of its habitat or is likely to do so," (*Oceans Act*, 1996, Section 35.2). The *Canadian Wildlife Act* is applied by Environment and Climate Change Canada (ECCC) to protect critical habitat, migratory birds, and other at-risk wildlife listed under the *Species at Risk Act* (*Canadian Wildlife Act*, 1985). These are conserved within National Wildlife Areas (NWAs) and prohibit hunting and fishing in all sites, unless otherwise specified by the Minister of Environment and Climate Change (ECCC, 2020). The Parks Canada Agency (PCA) designates national Marine Conservation Areas (NMCAs) under the *National Marine Conservation Areas Act* to conserve sensitive ecosystems while managing for continued resource use (*National Marine Conservation Areas Act*, 2002).

In response to the variability of allowed and prohibited activities in MPAs nationally, new protection standards have been adopted. As of 2019, these standards apply to all new federal MPAs, including *Oceans Act* MPAs, marine NWAs, and NMCAs (DFO, 2019e). The standards ban four key industrial activities from occurring within a site, including oil and gas activity, mining, dumping, and bottom trawling (DFO, 2019e). All mobile bottom-contact fishing gear (including otter trawls, beam trawls, shrimp trawls, hydraulic clam dredges, and scallop dredges) for commercial and recreational purposes will be prohibited (DFO, 2019e). Bottom-trawling for Indigenous food, social, and ceremonial (FSC) purposes and scientific research will be permitted where it does not threaten an MPAs conservation objectives (DFO, 2019e). If any of the industrial activities presently occur in existing MPAs, they will be reviewed to determine if they should be allowed to continue (DFO, 2019e). These evaluations take place during the regular management review cycle and will be conducted with stakeholder collaboration.

Other Effect Area-Based Conservation Measures (OECMs) are not MPAs but contribute to a nation's conservation targets (DFO, 2020d). They were first described at the 10th meeting of the Conference of the Parties to the UN CBD that led to the creation of Aichi Target 11 (DFO, 2020d). In 2017, to meet Target 11, the Government of Canada developed guidance for ‘other measures’ (DFO, 2020d). This guidance is used to determine whether non-MPA marine management measures can contribute to Canada’s conservation targets (DFO, 2020d). These OECMs often take the form of marine refuges – a fisheries management tool that protects important species and their habitats as well as aggregations of corals and sponges (DFO, 2020d). The operational guidance for identifying OECMs includes five broad-scale criteria:

1. Site is in a clear, spatially defined area
2. Conservation or stock management objectives have a biological or ecological basis and directly reference a species or habitat of importance
3. The site contains ecological components of interest, such as species or habitat(s)
4. The measure is entrenched in legislation, regulation and/or made clear that it is intended for long-term implementation (minimum 25 years)
5. Ecological components of interest are effectively conserved, including prohibiting activities that threaten the conservation objectives (DFO, 2017e).

OECMs must abide by these criteria in order to count towards the target (DFO, 2017e). Ecological monitoring, surveillance, and enforcement programs support these management objectives (DFO, 2017e). The activities permitted to occur within an OECM are assessed on a case-by-case basis with the Minister of Fisheries, Oceans and the Canadian Coast Guard deciding on the activities that pose a minimal threat and may be permitted to occur within the site without compromising its conservation objectives (DFO, 2019e). By 2019, marine refuges comprised 4.93% of Canada’s protected marine space (DFO, 2020g).

To date, the Canadian government has established 14 *Oceans Act* MPAs, 3 *National Marine Conservation Act* MPAs, 1 marine *National Wildlife Area*, and 59 marine refuges to contribute towards the 30% by 2030 target (DFO, 2019f). These areas comprise 13.81% of Canada's marine and coastal areas, with 8.9% in the form of protected areas (DFO, 2020a). Of these, ECCC is responsible for 5%, PCA is responsible for 15%, and DFO is responsible for 80% (DFO, 2020a). DFO's 80% is comprised of MPAs and OECMs.

### *2.2 Process for Designating Marine Protected Areas in Canada*

This paper seeks to propose a network of AOIs for MPA designation in the Scotian Shelf bioregion. It will not include a subdivision of NWAs, NMCAs, or OECMSs that contribute to the 30% by 2030 target because the protection of corals and sponges fall primarily within DFO's mandate and are more likely to be conserved within *Oceans Act* MPAs over the conservation tools utilized by other departments; however, NWAs, NMCAs, or OECMs could be considered for future advancements to the network. To designate MPAs under the *Oceans Act*, a five-step process is undertaken by DFO (Figure 2).


**Figure 2**. Framework of MPA designation in Canada (DFO, 2020c)

Identifying AOIs is the first step DFO takes (2020c). It includes establishing an AOI Advisory Committee comprised of interested and affected stakeholders who can provide input regarding the designation of an MPA (DFO, 2020c).

The second step consists of ecological/biophysical, social, cultural, and economic assessments (DFO, 2020c). Here, stakeholders have the first opportunity to contribute their professional expertise or their local and traditional knowledge into the designation process;

however, the contribution of stakeholder input and knowledge continues throughout the duration of the process.

The development of the regulatory approach and consultation with interested/affected parties is the third step (DFO, 2020c). The assessment reports conducted in step two contribute to the refinement of an MPA's objectives and to the development of regulatory measures. Identification of permitted human activities in the MPA should be determined alongside a risk assessment of the site (DFO, 2020c). Consultation with stakeholders should continue during step three (DFO, 2020c).

The regulatory process and designation of the MPA occurs during step four (DFO, 2020c). Key documents are produced, including the Strategic Environmental Assessment, the Triage Statement Form, the Cost/Benefit Analysis, the Regulatory Impact Analysis Statement, instructions for drafting the regulations, and the Regulatory Communications Plan (DFO, 2020c). Simultaneously, the Department of Justice lawyers draft the MPA's regulations based on the regulatory approach, and the Treasury Board approves the pre-publication draft of regulations in the *Canada Gazette, Part I* (DFO, 2020c). Following modification to the Regulatory Impact Analysis Statement and Regulations based on received public comments, the regulations will be published in the *Canada Gazette, Part II* and the MPA will be established (DFO, 2020c).

The final step is to manage an MPA for its goals and objectives (DFO, 2020c). Key elements in an MPA management framework include (1) conservation objectives; (2) the MPA management plan; (3) the MPA monitoring plan (which contains indicators, protocols, and strategies); (4) compliance and enforcement; and (5) public education and outreach (DFO, 2020c). This step features the management plan review cycle, which occurs every 5 years and assesses the existing management plans for necessary adjustments (DFO, 2020c). This is akin to an adaptive management framework whereby knowledge attained from monitoring and reporting programs inform management decisions to better achieve an MPA's conservation objectives (DFO, 2018b).

### *2.3 Existing Scotian Shelf Bioregion Marine Protected Areas*

Two MPAs and six OECMs have been established within the Scotian Shelf bioregion that contribute to SBA conservation or the preservation important groundfish habitat (Figure 3) (DFO, 2020b; DFO, 2020f). The MPAs are known as the Gully and St. Anns Bank and both contain unique and ecologically important species and habitats (DFO, 2020f).

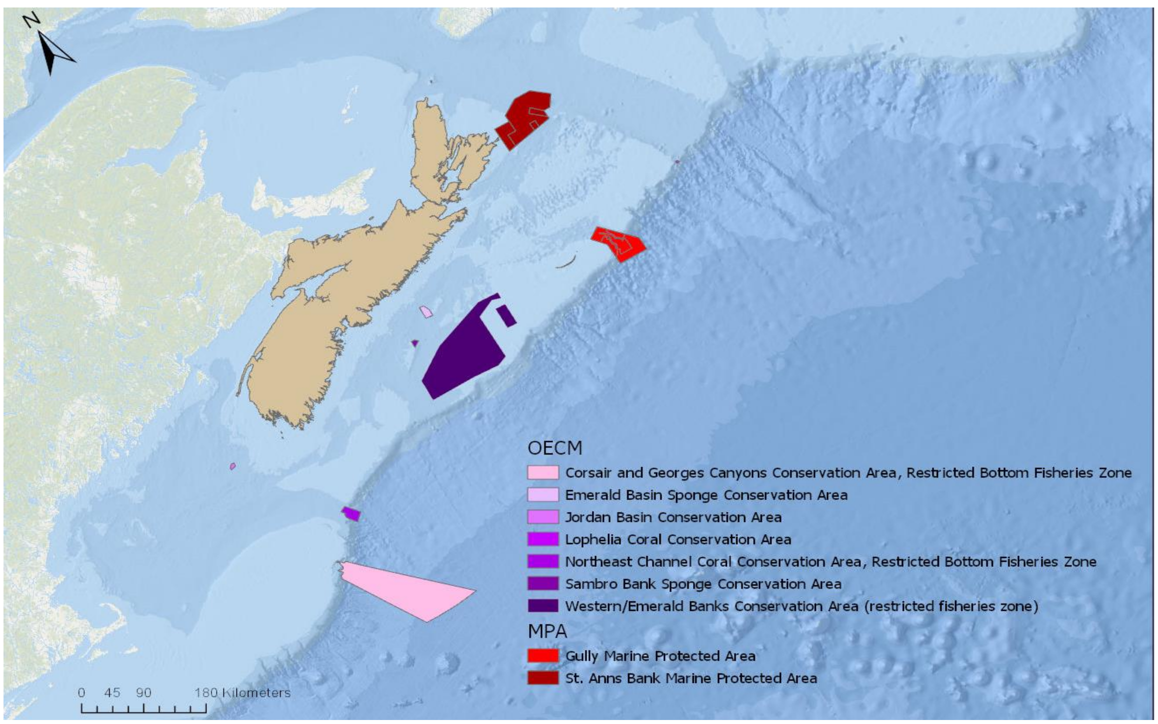


**Figure 3**. Existing *Oceans Act* MPAs (dataset from Philippe, 2019) and OECMs (dataset from Philippe, 2017) on the Scotian Shelf, Nova Scotia, Canada that contribute to SBA conservation or preservation of groundfish habitat. The scale is set at 180 km.

The Gully MPA is located east of Sable Island and contains a range of habitat features, such as shallow sandy banks, a submarine canyon, continental slope, and abyssal plain (DFO, 2020e). These ecosystems support various species, including whales, dolphins, sharks, anemones, brittle stars, sea pens, and the most extensive collection of cold-water corals in Atlantic Canada (DFO, 2020e). These corals congregate along the slopes of the Gully's deep-water canyon environment

(DFO, 2020e). As such, one of the conservation objectives for this MPA is to “minimize the disturbance of seafloor habitat and associated benthic communities caused by human activities,” (DFO, 2020e). The site’s Regulations make it an offence for any person to “disturb, damage or destroy in the Gully Marine Protected Area, or remove from it, any living marine organism or any part of its habitat,” (DFO, 2020e). As such, while commercial fishing may occur within specified zones of the Gully – with permitted longline and harpoon gear types – the deep canyon zone that contains essential habitat for cold-water corals prohibits all forms of commercial fishing (DFO, 2017d; Minister of Justice, 2004).

St. Anns Bank MPA is located east of Cape Breton Island and contains over 100 species, including fish, corals, sponges, and sea pens (DFO, 2019g; Ford & Serdynska, 2013). The MPA features a conservation objective to “conserve and protect all major benthic, demersal (i.e., close to the seafloor)…habitats within the MPA, along with their associated physical, chemical, geological and biological properties and processes,” (DFO, 2019g). St. Anns Bank acts as an important migration corridor for fish and marine mammals transiting between the Gulf of St. Lawrence and the St. Lawrence Estuary (DFO, 2019g). Four zones have been established within the MPA – one of which is a core protection zone that prohibits most human activities while the other three are adaptive management zones that accommodate specified activities (DFO, 2017f). No commercial fishing is permitted in the core protection zone; however, bottom-contact commercial fishing activity is allowed in the adaptive management zones if executed with a bottom-longline, handline, pot, trap, or gillnet (DFO, 2017f).

The difference between these sites is that the Gully features species of hard corals – such as gorgonians – that have habitat-forming structures and are often identified in reef communities (DFO, 2006). Gorgonians provide structural habitat, including nurseries, refugia, and spawning and breeding grounds that support entire ecosystems (DFO, 2015). In comparison, St. Anns Bank contains dense concentrations of soft corals, such as sea pens (DFO, 2019g). Sea pen fields are essential for providing a food source (Birkeland, 1974; Murillo et al., 2018) and biogenic habitat for suprabenthic and benthic species (De Clippele et al. 2015; Murillo et al., 2018). They have the potential to alter bottom-water currents, resulting in the retention of nutrients and organic particles near the sediment (Tissot et al., 2006 in Murillo et al., 2018).

The OECMs on the Scotian Shelf also provide protection to benthic areas. Five marine refuges have been designated under the *Fisheries Act* to conserve sensitive coral and sponge species while a sixth has a focus of preserving groundfish and their habitat (Table 1) (DFO, 2020b; DFO, 2020g). All DFO marine refuges restrict bottom-contact gear (DFO, 2015).

**Table 1**. OECMs on the Scotian Shelf and their conservation objectives (DFO, 2020b; DFO, 2020g)

| OECM | Conservation Objective(s) |
|---|---|
| Corsair and Georges Canyons Conservation Area (restricted bottom fisheries zone) | Protection of cold-water corals |
| Emerald Basin and Sambro Bank Sponge Conservation Area | Protection of a globally unique population of *Vazelle pourtalesi* (glass sponge) |
| Jordan Basin Conservation Area | Protection of cold-water corals |
| Lophelia Coral Conservation Area | Protection of the only known living *Lophelia pertusa* coral reef in Atlantic Canada waters |
| Northeast Channel Coral Conservation Area (restricted bottom fisheries zone) | Protection of cold-water corals |
| Western/Emerald Banks Conservation Area (restricted fisheries zone) | To support the productivity of commercially, FSC, and/or recreationally important groundfish; and to manage benthic habitats that support groundfish |

These MPAs and OECMs play a vital role in protecting sensitive benthic species on the Scotian Shelf and are being used to advance the network for this bioregion. Presently, the MPAs and OECMs established by DFO within the Scotian Shelf bioregion – that contribute to the conservation of corals and sponges – account for approximately 26,473 km$^2$ (DFO, 2020b). This coverage provides approximately 0.49% to Canada’s marine conservation targets (DFO, 2020b). This is a significant contribution to Canada’s marine conservation targets and the development of a network in the Scotian Shelf; however, there is still potential to advance the network and increase the contribution to the marine conservation targets in this bioregion that should be further explored and considered.

### *2.4 MPA Network Design for the Scotian Shelf*

A network of MPAs is classified as an "organized collection of individual sites, designed to link individual areas and to comprehensively represent the region's spectrum of marine life characteristics," (IUCN, 2008). Networks may "enhance the contributions of individual MPAs to achieve great ecological benefits that translate into economic, social and cultural benefits," (DFO, 2018c). Such benefits may include biodiversity and productivity goals, preservation of ecological processes and habitats, increasing connectivity between these processes, protection of at-risk species, or improving ecosystem resilience to climate change (DFO, 2018c).

MPA networks should display ecological, social, and economic benefits and be capable of fulfilling conservation objectives that a single MPA cannot (IUCN, 2008). According to the CBD, effective networks should include Ecologically or Biologically Significant Areas, representativity, connectivity, replicated ecological features, and adequate and viable sites (DFO, 2012). Networks of MPAs should be connected via ecological processes of sufficient size and protection level (DFO, 2012). Within Canada, networks are advancing in five priority bioregions, including the Pacific Northern Shelf, the Western Arctic, the Newfoundland-Labrador Shelves, the Gulf of St. Lawrence, and the Scotian Shelf (DFO, 2018c).

# Chapter 3: Sensitive Benthic Areas

## *3.1 What Are Sensitive Benthic Areas?*

An SBA is a region of the ocean that is "ecologically and biologically important…with features or structures that provide a particularly significant or essential biological or ecological function within the broader ecosystem," (DFO, 2009b). These ecosystem functions may be exemplified via habitat-building capabilities, offering shelter from strong currents, or providing food sources (NOAA, 2019). An SBA is a subclassification of a significant benthic area but is considered sensitive due to its vulnerability from proposed or ongoing fishing activity (DFO, 2017b). It is worth noting that not all significant benthic areas contain a sensitive area. Instead, the occurrence of a region being considered 'sensitive' stems from the definitive presence and threat from fishing. Figure 4 has been adapted from DFO (2017b) to visually show this relationship.

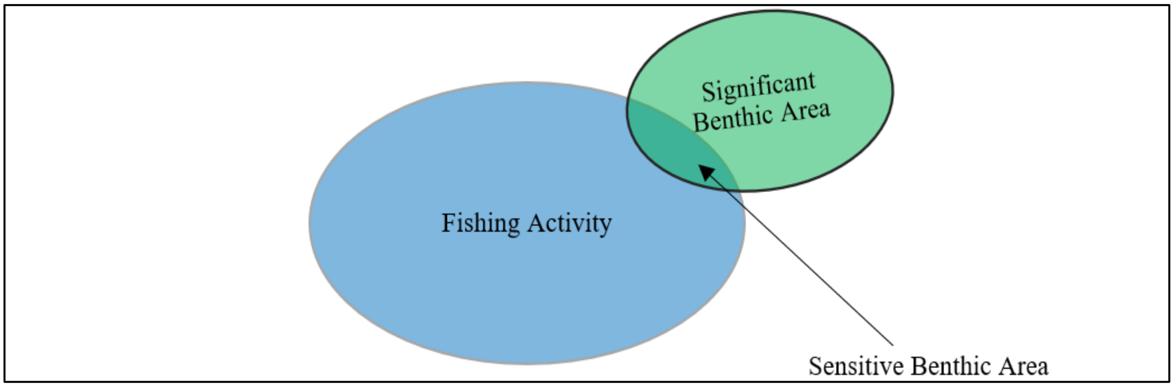


**Figure 4**. Relationship between significant benthic areas and fishing activity, resulting in a sensitive benthic area. Adapted from DFO (2017b).

Prominent species identified within SBAs include corals, sponges, and sea pens. Canada's Atlantic coast is home to approximately 30 species of cold-water corals (DFO, 2017a). Many of these species form dense concentrations and are found in depths exceeding 150 metres (DFO, 2017a). Large habitat-forming species usually gather along the continental shelf and in deep channels (DFO, 2017a). Within the Scotian Shelf, areas found to have high coral concentrations include the Northeast Channel, the Gully MPA, and the Stone Fence, among others (DFO, 2017a).

The Atlantic coast also contains a significant population of sponges with 34 identified species (DFO, 2017a). While some species are found in the shallow intertidal zone, others are located as deep as 8 km (DFO, 2017a). Sponge-dominated communities can influence the occurrence of other invertebrates and fish since they are a spot for feeding, reproduction, and rest (DFO, 2017a). Sponges serve the vital function of filtering water and providing a pathway for energy transference between pelagic and benthic systems (DFO, 2017a).

For the purposes of this study, SBAs are defined as areas that are vulnerable to proposed or existing fishing activity and contain significant concentrations of at least one or more of the following three species groups: large and small gorgonian corals (*Alcyonacea*, formerly under the class *Gorgonacea*), sponges (*Porifera*), and sea pens (*Pennatulacea*).

### *3.1.1 Sensitive Benthic Species on the Scotian Shelf*

Gorgonian corals are named from the proteinaceous material (gorgonin) found in the axial skeletons of some octocoral families (Sánchez *et al*., 2019). These corals have habitat-forming structures and are often identified in dense communities on reefs and hard substratum (DFO, 2006). Gorgonians form branching structures that allow them to access resources within the water column (Lasker and Sánchez, 2002, Sánchez, 2004 in Sánchez *et al*., 2019). On the Scotian Shelf, abundant large gorgonian coral species are *Acanthogorgia armata* (accounting for 68% of all observed corals in a DFO-based study by Beazley, Lirette, and Guijarro, 2019a), *Keratoisis grayi* (28%), *Primnoa resedaeformis* (3%), and *Pragorgia arborea* (1%). The most abundant small gorgonian coral species on the Shelf observed in the same study were *Acanella arbuscula*, cf., *Anthothela grandiflora*, and *Radicipes* spp. (Beazley *et al*., 2019a).

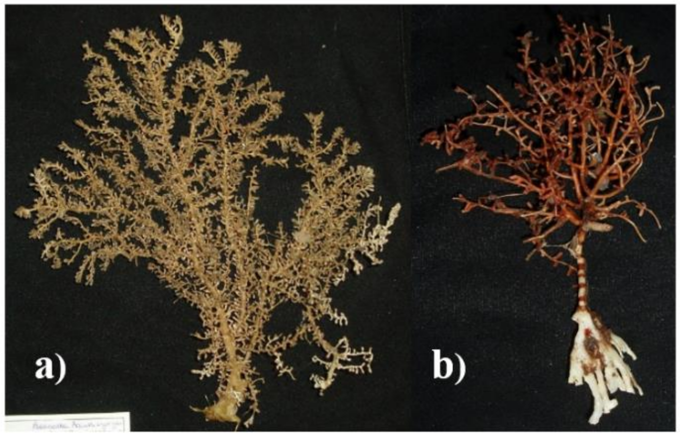


**Figure 5**. *Acanthogorgia armata* (a) and *Acanella arbuscula* (b) (Wareham, 2011a; Wareham, 2011b)

Sponges are aquatic invertebrates found in habitats extending from the poles to the tropics (MESA, n.d.). They attach to soft and hard substrates and come in a variety of shapes, including tree-like, fan, cup, tub, and ball-shaped, and shapeless formations (MESA, n.d.). Most sponges operate as filter feeders that eat bacteria and other particles in the water column (MESA, n.d.). In the same study that identified gorgonian coral aggregations, Beazley et al. (2019) categorized that the most common large-sized sponges on the Scotian Shelf include those within the taxon Polymastiidae spp. (accounting for 75% of classified species). They were followed by Large-Sized Porifera spp. (24%) and the glass sponge *Asconema foliatum* (16%) (Beazley *et al*., 2019a).

**Figure 6**. *Asconema foliatum* sheets from a DFO trawl survey in the Gulf of St. Lawrence (Nozéres, 2011)

Sea pens of the order Pennatulacea were given their name due to the similarities in their appearance to quill pens (Britannica, n.d.). These animals feature a lower part known as the peduncle, which anchors the animal into mud or sand, and an upper part called the rachis that bears polyps (Murillo et al., 2018). Sea pens take in and expel water via the hollow interconnecting canals of the polyps and feed on small organisms captured on the polyp's tentacles (Britannica, n.d.). The Beazley et al. (2019a) benthic survey identified abundant sea pen species on the Scotian Shelf. This survey found that the most commonly found species were *Pennatula aculeata* (41%), *Kophobelemnon* spp. (21%), and Pennatulacea Type 1 (16%) (Beazley et al., 2019a).

**Figure 7**. *Pennatula aculeata* (Wareham, 2010).

Corals, sponges, and sea pens are essential because they provide biogenic habitat that groundfish use for breeding, spawning, rearing, and feeding grounds (DFO, 2015). As such, the preservation of SBAs should help to maintain and support the productivity of groundfish populations and the fishing industry.

*3.1.2 Mapping Coral and Sponge Distribution in the Scotian Shelf Bioregion*

Distribution data used to map the locations of corals and sponges within the Scotian Shelf bioregion was provided from the following dataset: "Delineation of coral and sponge significant benthic areas in Eastern Canada using kernel density analyses and species distribution models," (Kenchington et al., 2018). Data was gathered via research vessel trawl surveys and was focused on gorgonian coral, sponge, and sea pen taxa. Kenchington et al. (2018) applied a KDE to determine a biomass surface area for each taxon. To this, an aerial expansion method was applied with the purpose of identifying where significant concentrations of each benthic taxa could be found on the Shelf (Kenchington et al., 2018). A Kernel Density Estimation (KDE) analysis identified hotspots where dense aggregations of corals, sponges, and sea pens could be found. The KDE is a "simple nonparametric neighbour-based smoothing function that relies on few assumptions about the structure of the observed data. It has been used in ecology to identify hotspots – areas of relatively high biomass/abundance," (DFO, 2017b). These areas are significant in terms of their ecological value and function; however, they cannot be considered sensitive or SBAs as per the previous definition used for SBAs. While the Kenchington et al. (2018) study provided data for Canada's entire eastern coast, only data for the Scotian Shelf bioregion was used in this research.

Kenchington et al.'s (2018) data was used to create distribution maps by applying the data atop an oceans basemap in ArcGIS Pro. The maps depicted where *Alcyonacea*, *Porifera*, and *Pennatulacea* can be found within the Scotian Shelf bioregion (Figure 8). Gorgonian corals were found in the offshore portions of the western, central, eastern Scotian Shelf, and Cabot Strait (Kenchington et al., 2018). They were found in significant concentrations in the Gully MPA (DFO, 2020d). Sponges were located near Browns Bank in the western Scotian Shelf, Sambro Bank in the Central Scotian Shelf (Kenchington et al., 2018), and within St. Anns Bank MPA (DFO, 2019g; Ford & Serdynska, 2013). Similar to gorgonian corals, sea pens were located in the offshore portions of the western, central, eastern Scotian Shelf, and Cabot Strait (Kenchington et al., 2018). The KDE identified notable concentrations of sea pens within the central Shelf between the inshore and offshore regions near La Have Bank, adjacent to the Sable Island Bank, and within St. Anns Bank MPA (Kenchington et al., 2018). In the creation of Figure 9a, Kenchington et al.'s (2018) data was merged in ArcGIS Pro to create an overview of SBAs on the Scotian Shelf.

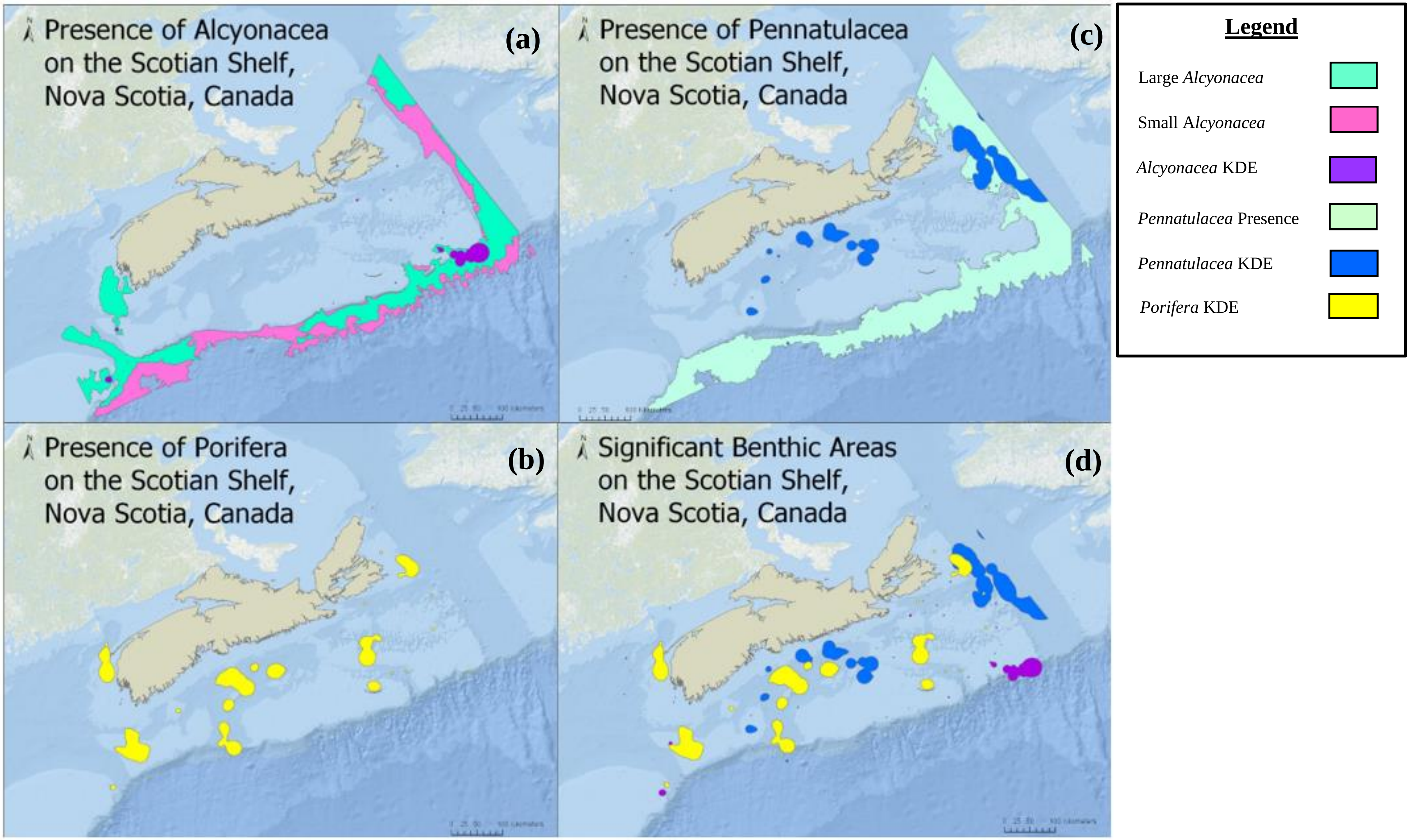


**Figure 8**. Presence of *Alcyonacea* (a), *Porifera* (b), and *Pennatulacea* (c) on the Scotian Shelf. Maps (a) and (c) depict both presence and a Kernel Density Estimation (KDE) analysis while (b) and (d) depict only KDE data for significant benthic areas. Maps are set at a scale of 100 km. Note: only KDE data was available for Porifera. Data for these maps was provided by Kenchington et al. (2018).

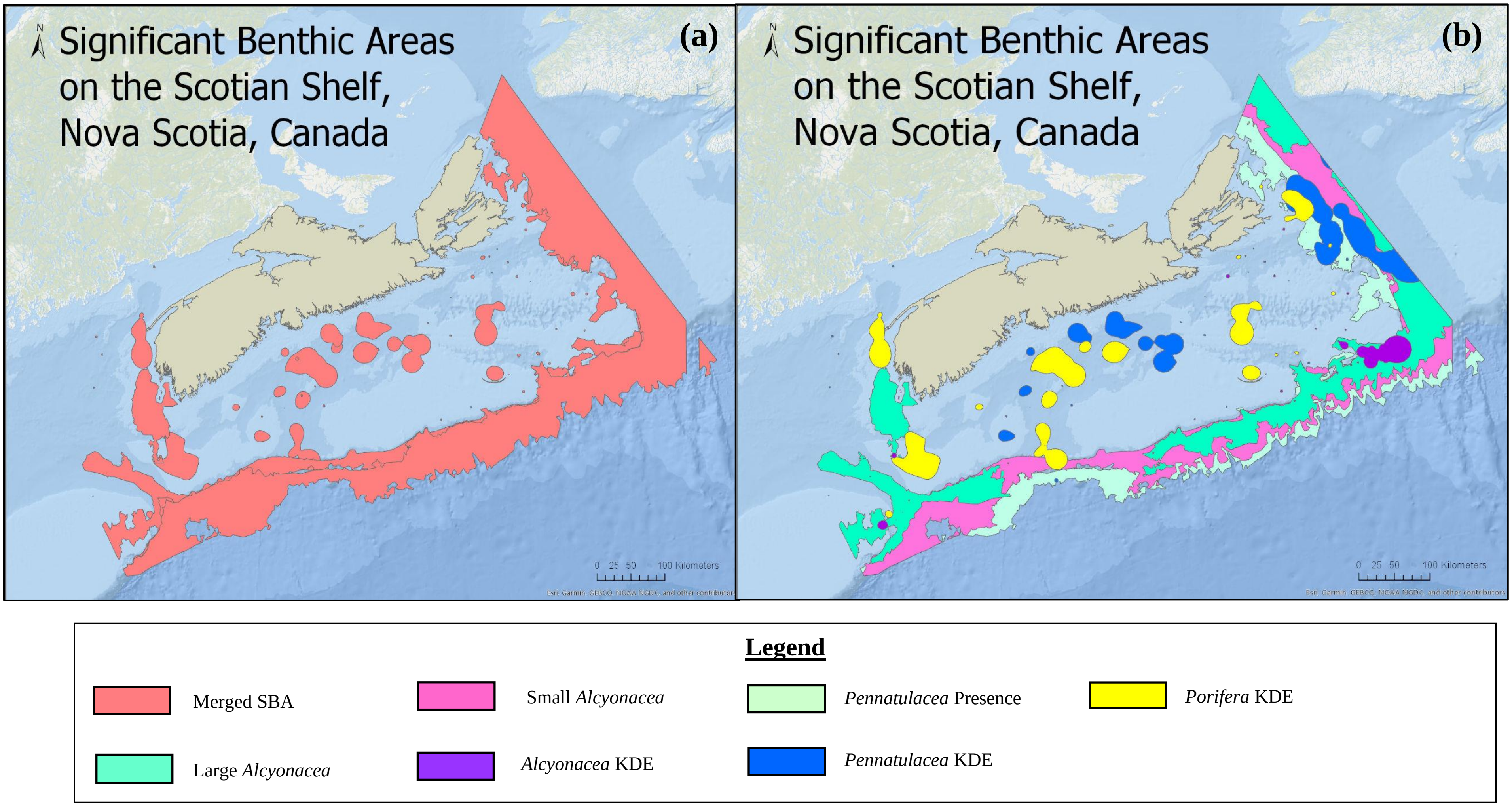


**Figure 9**. Comprehensive overview of the presence of *Alcyonacea*, *Porifera*, and *Pennatulacea* on the Scotian Shelf where (a) contains the merged *Alcyonacea*, *Porifera*, and *Pennatulacea* datafiles and (b) contains a comprehensive breakdown by species presence and KDE. The maps are set at a scale of 100 km. Note: only KDE data was available for *Porifera*. Data for these maps was provided by Kenchington et al. (2018).

### *3.2 Policy Measures for Sensitive Benthic Area Conservation*

Due to the vulnerable nature of SBAs and their ability to be negatively impacted by anthropogenic factors, DFO has taken steps to ensure their protection via conservation strategies, marine refuges/fisheries closures, and MPA designation.

Under the *Oceans Act*, DFO designates MPAs but policies may be used to inform the conservation of benthic areas in Canada. One example is the Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas (DFO, 2009b). This Policy guides a framework that delivers legislative tools for the management of Canada's marine resources, such as the *Oceans Act*, the *Fisheries Act*, the *Species at Risk Act*, the Oceans Action Plan, and the New Emerging Fisheries Policy (DFO, 2009b). The intention of the Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas is to "manage fisheries to mitigate impacts of fishing on sensitive benthic areas or avoid impacts of fishing that are likely to cause serious or irreversible harm to sensitive marine habitat, communities and species," (DFO, 2009b).

In 2015, DFO released the Coral and Sponge Conservation Strategy for Eastern Canada. This Strategy was developed from frameworks associated with the Maritimes Coral Conservation Plan (DFO, 2006). The Government of Canada's National Centre of Expertise in Cold-Water Coral and Sponge Reefs (2007-2012) via its Health of the Oceans Initiative was critical in the creation of the Strategy (DFO, 2015). The Coral and Sponge Conservation Strategy for Eastern Canada identified objectives for conservation, management, and research with targets and actions that can be implemented across the five eastern DFO regions, including Central and Arctic, Quebec, Gulf, Maritimes, and Newfoundland and Labrador (DFO, 2015). It bridges existing legislation and policy with an ecosystem-based management approach that promotes transparency and accountability in site management (DFO, 2015).

These policy measures, alongside MPAs and OECMs, are critical for managing Canada's benthic ecosystems. The commitment to 30% ocean conserved by 2030, suggests that Canada intends to focus resources for conservation in this area. In pursuing the 30% target, the nation must also ensure the preservation of ocean-based industries that could be affected by MPA designation.

## Chapter 4: Atlantic Groundfish Industry

For this study, a stakeholder identification analysis and power-interest matrix were used to determine the stakeholders that interacted with SBAs and had the potential to be affected by the designation of MPAs that conserved corals and sponges. While the methodology and results of these analyses will be further expanded upon within Chapter 5: Research Methodology and Chapter 6: Results, it was deduced that the groundfish industry operating within the Scotian Shelf bioregion should be the focus of this study due to this industry's capacity to affect SBAs and be affected by MPA designation.

### *4.1 Historical Context of the Atlantic Canadian Fisheries*

Fisheries have a lengthy history in Canada. As early as the 1500s, the northwest Atlantic hosted European fishers, where British vessels fished for cod off Newfoundland's coast (Canadian Council of Professional Fish Harvesters (CCPFH), n.d.). French ships frequented the Atlantic and Québec waters, but their presence was removed when the British colonized Nova Scotia in 1713 and the rest of New France in 1763 (CCPFH, n.d.). They fished for cod and other groundfish, including halibut, haddock, and Pollock in the Atlantic (CCPFH, n.d.). During this time, hook-and-line was the most commonly used gear type, but by the 1800s, many fishers switched to using longlines that placed hundreds of hooks on groundlines on the bottom of the ocean (CCPFH, n.d.).

As the Maritime coastal economy grew to include shipbuilding and lumber by the end of the 19$^{th}$ century, fishing for scallops and the trade of fresh fish increased (CCPFH, n.d.). Steam-powered trawlers pulling conical nets across the seafloor were common and by the 1900s these trawlers allowed harvesters to have more mobility when fishing (CCPFH, n.d.). This improvement to fishing capability caused near-shore, river, and estuarial fish stocks to decrease (CCPFH, n.d.).

Canada's Confederation in 1867 resulted in the implementation of regulations by Fishery Officers to conserve salmon and inshore fisheries (CCPFH, n.d.). This included limitations to gear types, size limits, and the development of seasonal fisheries. The early 20th century saw a rise in fishing companies, while the Second World War resulted in the development of radar, radio, sonar, nylon lines and nets, bigger hulls, better engines, hydraulics, and large trawlers and smaller draggers (Berry, 2020; CCPFH, n.d.). These inventions grew the industry in the Atlantic as exploratory expeditions identified new and productive waters (CCPFH, n.d.). While shrimp, scallops, crabs, and clam fisheries increased in importance, the groundfish industry developed into the most widespread and highest-employing fishery in the Atlantic (CCPFH, n.d.).

Fisheries management increased between 1968-1982, with DFO moving to limit the number of available licenses in most of Canada's fisheries (CCPFH, n.d.). This was in addition to limitations set in place during the Confederation of Canada in 1867. During Confederation, Canada extended its jurisdiction from 12 nautical miles to 200 nautical miles from the coast (DFO, 2018a). Despite these measures, groundfish stocks began to deplete and were in danger of collapse. In the late 1980s, scientists used population estimates supplied by DFO to identify that the cod stock was being overfished by at least 100% (Berry, 2020). These scientists recommended a 50% reduction in fishing quotas – a recommendation that was ignored by government officials, resulting in a groundfish collapse in the Atlantic during the early 1990s due to overfishing and environmental factors (CCPFH, n.d.). One of the most notable collapsed stocks is Atlantic Cod. The collapse of this stock led to a moratorium on cod fishing in 1992 (Berry, 2020; DFO, 2018a).

### *4.2 Bottom-Contact Gear Types in the Atlantic Groundfish Industry*

Today, the groundfish industry in the Atlantic has shifted focus from cod to haddock, pollock, redfish, and hake (DFO, 2018a). A variety of gear types are used to harvest these stocks.

The most prominent gear types used in the modern groundfish industry are fixed gear – in the form of longline and gillnet – and mobile gear, such as trawlers (DFO, 2018a).

Bottom-contact longlines are comprised of thousands of individual baited hooks stemming from the main line (Oceana, n.d.). Often, longlines extend more than 80 km across the seafloor and target various groundfish species (Oceana, n.d.). They carry a high risk of bycatch since the hooks are non-discriminatory, meaning that both targeted and non-targeted species have the potential to be caught (Oceana, n.d.). Other fixed bottom-contact gear includes gillnets. These walls of netting are suspended in the water column and are typically made from monofilament or multifilament nylon (NOAA, n.d.). Gillnets are designed to allow fish to get their head through the mesh but not their bodies, causing the fish's gills to become trapped in the mesh as the fish attempts to free itself (NOAA, n.d.). Two variations of gillnets are often used: set gillnets and drift gillnets. Set gillnets are attached to fixed poles in the substrate to prevent movement, while drift gillnets are kept at a specific depth via a system of weights and buoys attached to a floatline (NOAA, n.d.). On the Scotian Shelf, longlines and gillnets are common in <45' and 45-65' fleets, and have been used to target halibut, cod, haddock, pollock, and dogfish (DFO, 2018a).

Trawlers are a mobile fishing gear type in Canada's groundfish industry. Bottom-trawls may be more destructive to habitat than fixed gear because of smothering and physical damage to coral reefs (DFO, 2015). This gear uses weighted nets that are dragged along the seafloor to capture all in their path (Oceana, n.d.). As such, the potential for bycatch is high because there is no way to catch only targeted species. These mobile fleets are often <65' with target species on the Shelf including silver hake, redfish, haddock, pollock, and flounder (DFO, 2018a).

Both fixed and mobile gear types in the groundfish industry will result in bycatch. On the Scotian Shelf, common bycatch species arising from groundfish industry include cusk, skate, sculpin, white hake, wolffish, monkfish, and flounder (DFO, 2018a), as well as sessile benthic fauna (Table 2) (Ford & Serdynska, 2013).

**Table 2**. Groundfish industry sectors operating in the Atlantic region by gear type, including fixed gear (longline and gillnet), mobile gear (trawl), and common by-catch species resulting from these fisheries (DFO, 2018a). Fishery observer records contributed to by-catch reports for corals and other sessile benthic fauna (Ford & Serdynska, 2013). **Moratoriums are presently in place for both the cod and haddock fisheries (haddock fisheries moratorium in place only for Browns and Georges Bank (Butler and Coffen-Smout, 2017b).*

| Fixed Gear Fleets Targeted Species (Longline and Gillnet) | Mobile Gear Fleets Targeted Species (Trawl) | Common Groundfish By-Catch Species (Fixed and Mobile) |
|---|---|---|
| Halibut | Silver Hake | Cusk |
| *Cod | Redfish | Skate |
| *Haddock | *Haddock | Sculpin |
| Pollock | Pollock | White Hake |
| Dogfish | Flounder | Wolffish |
| | | Monkfish |
| | | Flounder |
| | | Coral |
| | | Sponge |
| | | Sea pen |

### *4.3 Locations of the Groundfish Industry on the Scotian Shelf*

The majority of the groundfish industry in the Atlantic are classified as commercial fisheries. In the 2015/16 season, 2,491 groundfish licenses were issued in the Atlantic (DFO, 2018a). Of these, the inshore fishery featured 299 mobile gear fleets that were greater than 65’ in addition to 11 First Nations and Indigenous mobile gear fleets (DFO, 2018a). The midshore contained 10 mobile gear fleets between 65’-100’ while the offshore included 25 mobile gear fleets greater than 100’ (DFO, 2018a).

Fisheries within the inshore region of the Shelf operate approximately 16-25 km from the shore (The Canadian Fishing Industry, n.d.). Mobile gear fleets operating in the inshore are comprised of otter trawl, midwater trawls, Danish, and Scottish Seines (DFO, 2018a). Approximately 70% of groundfish in the Maritimes Region were harvested from the inshore area in 2016/17 (DFO, 2018a). The most common gear type in the midshore is mobile otter trawls (DFO, 2018a). Target species for inshore and midshore fleets include haddock, pollock, silver hake, and redfish (DFO, 2018a). The offshore features longline as the primary gear type and targets Atlantic halibut in addition to the haddock, pollock, silver hake, and redfish stocks harvested by the inshore and midshore fleets (DFO, 2018a). There is presently a moratorium on haddock fishing in the 4TVW management region in the eastern Scotian Shelf (DFO, 2017c).

Bottom longline groundfish industries congregate along inshore, midshore, and offshore areas (Butler & Coffen-Smout, 2017a). Densely fished areas were noted around Browns Bank, the Northeast Channel, Georges Basin, Baccaro Bank, Roseway Bank, La Have Bank, the Gully Canyon, Cabot Straight, Eastern Shoal, and Sable Island Bank (Butler & Coffen-Smout, 2017a). Other notable but less-densely fished regions were noted around the inshore Bay of Fundy, Cape Breton Island, and Sidney Bight (Butler & Coffen-Smout, 2017a).

The bottom-contact gillnet fishery was densely concentrated near Truxton Swell and Croswell Basin while less densely fished regions were identified near Roseway Bank and La Have Bank (Butler & Coffen-Smout, 2017a). Other locations were noted in a sporadic matter across the inshore and midshore (Butler & Coffen-Smout, 2017a).

Significant fishing effort for the bottom trawl industry was located near Georges Bank, the Fundian Channel, Croswell Basin, La Have Bank, near Sambro Bank and Emerald Basin, and adjacent to the Eastern Shoal (Butler & Coffen-Smout, 2017a). Other notable concentrations were located in Saint Marys Bay, the offshore Cape Breton Island adjacent to the Laurentian Channel, the Bay of Fundy, and Saint Marys Bay (Butler & Coffen-Smout, 2017a).

Maps depicting where the groundfish industry operates within the Scotian Shelf bioregion were produced using DFO supplied data on Maritime landings (Figure 10). The landings data provided by Butler and Coffen-Smout (2017a) included a screening layer designed to protect the locations of fishing activity on the Shelf. This screening layer was applied to the data prior to its usage in this study.

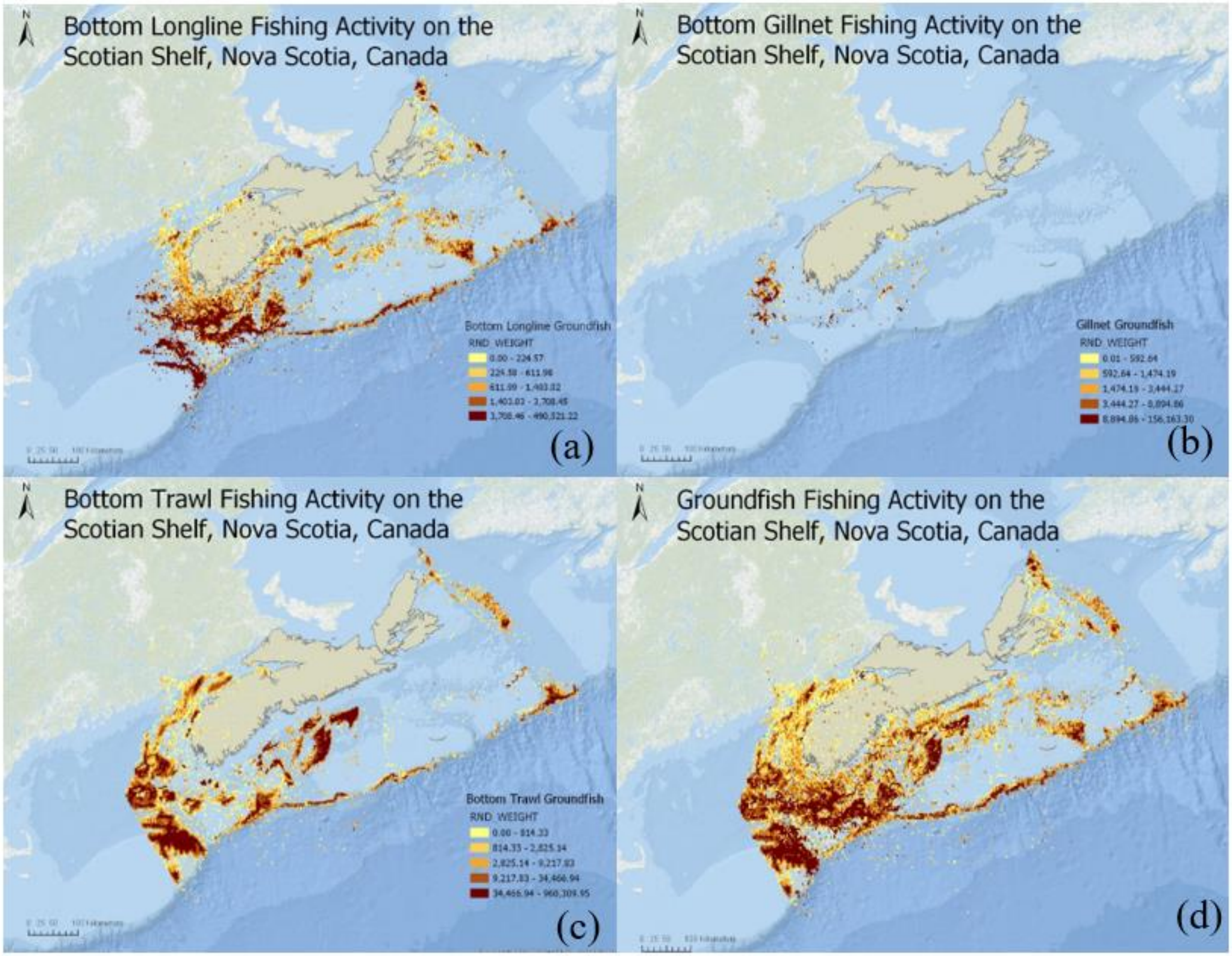


**Figure 10**. These maps depict a comprehensive overview of where all bottom-contact groundfish industry operations occurred between 2010-2014 on the Scotian Shelf, Nova Scotia, Canada. Important fishing areas were identified using aggregate landed weight (kg) per 2x2-minute grid cells for specific gear types. These maps indicate (a) is longline, (b) is gillnet, (c) is trawl, and (d) is a combination of all bottom-contact gear types. Scale was set at 100 km. Yellow areas had lower aggregated landed weight while dark red areas featured higher aggregated landed weight. Screening layers were applied to maintain privacy for maritime fishers operating within this region. Data provided by Butler and Coffen-Smout (2017a).

### *4.4 Economic Considerations of the Atlantic Groundfish Industry*

The demand for Maritime groundfish is evident. In 2015, the groundfish industry accounted for 7% of the regional total for the Maritime provinces of Nova Scotia, New Brunswick, P.E.I., and Newfoundland and Labrador (DFO, 2018a). This 7% equated to a total value of $91 million, which is a substantial decrease from the $200 million that the industry accumulated in 1991 (DFO, 2018a). This decrease stems partially from the closure of the Atlantic cod fishery in the 1990s. Despite the reduced prominence of the groundfish industry, it is still a vital sector to the Maritimes and those who work in the industry.

In 2015, approximately 2,517 groundfish licenses were issued in the Atlantic, but less than 25% were active (DFO, 2018a). The midshore and offshore fleets were allotted 25 licenses, of which 16 were active during 2015 (DFO, 2018a). These fleets averaged $868,000 in landed value per active license (DFO, 2018a). Across both the mobile gear <65’ fleet and the Indigenous mobile gear fleet, there were 313 issued licenses – of which 75 were active – with each active license averaging $500,000 in landed value (DFO, 2018a). The fixed gear 45’-65’ fleet had 35 active licenses out of 57 issued licenses, bringing approximately $280,000 in landed value per active license (DFO, 2018a). Most of the Atlantic’s groundfish licenses were held by the fixed gear <45’ fleet, which featured 2,122 licenses (DFO, 2018a). Of these, 435 were active, averaging $50,000 in landed value per active license (DFO, 2018a).

The majority of annual regional landed value stems from halibut and haddock, valued at $38 million and $26 million, respectively (DFO, 2018a). Since these fishing fleets are drivers of the Maritime and Canadian economy, groundfish industry activity must be able to continue on the Scotian Shelf even as conservation action to protect SBAs is pursued.

### *4.5 Impacts of the Groundfish Industry on Sensitive Benthic Areas*

All forms of bottom-contact fishing gear may harm SBAs and the species within them. As noted, longline, gillnet, and trawls all carry the risk of bycatch for benthic species such as corals, sponges, and sea pens, but this is not the only threat that these gears place upon SBAs.

Bottom-longline fishing may damage habitat via the weights, hooks, line types, and a vessel's hauling speed and technique (Fuller et al., 2008). Gillnets are a threat because they come into direct contact with the seafloor and may damage sensitive corals that interact with the nets (Fuller et al., 2008). Bottom-trawls damage SBAs via the dragging of nets along the ocean floor that can crush, rip up, and smother vulnerable corals, sponges, and sea pens (DFO, 2015).

Long-term damage on SBAs due to bottom-contact fishing gear is significant. Trawling has the potential to limit the complexity, productivity, and biodiversity of benthic habitats (Puig et al., 2012). This is especially true for areas with concentrations of corals and sponges. A study from the National Academy of Sciences suggested that coral colonies disturbed by trawling may result in a 90% reduction of coral presence (Puig et al., 2012). Also noted was a decline in sponge health, whereby two-thirds of sponges were damaged by trawling activity (Puig et al., 2012).

Moreover, damage sustained to cold-water coral habitat may not ever recover. Bottom trawling may modify the continental slope in areas where this fishing technique is practiced (Puig et al., 2012). This is because trawling is comparable to intensive agricultural activities, such as terrestrial hill slopes that have been transformed into crop fields because of heavy ploughing (Puig et al., 2012). In the ocean, this would be akin to replacing the natural variation of a seascape with an array of troughs and crests (Puig et al., 2012). Continued trawling may level the surface and irrevocably alter the chemistry and geology of a habitat, resulting in severe impacts to biological function and ecosystem composition (Puig et al., 2012).

### *4.6 Management of the Groundfish Industry*

In Canada, DFO regulates all groundfish industry activity in accordance with the *Fisheries Act* (DFO, 2018a). The Minister of Fisheries, Oceans and the Canadian Coast Guard is responsible for implementing this Act, which oversees the management of fisheries, habitat, and aquaculture (DFO, 2018a). The *Fisheries Act* allows the Minister to issue groundfish licenses; however, the Fishery (General) Regulations and the Atlantic Fishery Regulations, 1985, provide the regulations that govern this fishery (DFO, 2018a). Under these regulations, the Total Allowable Catch (TAC) and Enterprise Allocation (which is the initial allocation of quotas to large fishing companies) for the fishery were determined (DFO, 2018a).

These Regulations are complemented by a collection of policies that govern access to the fishery, economic prosperity, resource conservation, and traditional Indigenous use (DFO, 2018a; DFO, 2020h). Such policies include the Commercial Fisheries Licensing Policy for Eastern Canada 1996 and policies created under the Sustainable Fisheries Framework – including the Precautionary Approach Framework, Sensitive Benthic Area Policy, and the Bycatch Policy (DFO, 2018a; DFO, 2020h). The Sustainable Fisheries Framework ensures that Canadian fisheries are conducted in a manner consistent with the nation's conservation and sustainable use goals (DFO, 2018a; DFO, 2020h). Upon its creation, the Framework provided tools that may be used to monitor and assess environmentally sustainable fishery initiatives and that are capable of identifying areas for improvement (DFO, 2018a; DFO, 2020h). It is under this Framework that an ecosystem-based and precautionary approach to fisheries management may be applied (DFO, 2018a; DFO, 2020h).

Another important element of the management of the groundfish industry on the Scotian Shelf is the Scotia-Fundy Groundfish Advisory Committee. This committee is the leading consultative forum pertaining to groundfish-related issues, including discussions pertaining to

TAC, licensing policies, and other management measures (DFO, 2018a). Mobile gear fleets within the <65’ sector and fixed gear fleets within the <45’ sector have also designated advisory processes that offer advice to DFO for issues that impact their fleets (DFO, 2018a). Midshore and offshore fleets are consulted at the national level or through regional advisory committees where required (DFO, 2018a). Indigenous representatives are included within the Advisory Committee to ensure FSC fishery needs and issues are addressed (DFO, 2018a). In addition, DFO consults directly with rights holders and their representatives to discuss fisheries management (DFO, 2018a).

Additional management comes in the form of stock assessments that are conducted to ensure that targeted species are maintaining viable and healthy populations. The Canadian Stock Assessment Secretariat provides scientific advice via the Regional Advisory Process to evaluate the status of the stocks (DFO, 2018a). The majority of groundfish stocks are assessed on a multi-year schedule with framework meetings occurring every 3-5 years, and stock assessments occurring every 2-5 years (DFO, 2018a). Commercially important stocks may be assessed more frequently to ensure their sustainability (DFO, 2018a).

Managing the groundfish industry on the Scotian Shelf is critical for providing for long-term economic opportunities for Maritime Canadians. At the same time, conserving sensitive benthic species, such as coral, sponge, and sea pens, is crucial for supporting healthy ecosystems. MPA practitioners should strive to balance the need for effective conservation with the continuation of sustainable fisheries.

# Chapter 5. Research Methodology

## *5.1 Stakeholder Identification and Prioritization Analyses*

To narrow the focus of this research, a stakeholder identification analysis was used to determine where the largest impacts of benthic MPA development on the Scotian Shelf would be experienced. Stakeholders were identified as belonging to groups or organizations that could be that could be positively, negatively, or neutrally affected by MPA designation within the Scotian Shelf bioregion. Stakeholder support of MPAs is crucial for the designation of new sites and so all affected stakeholder groups should be considered and analyzed during the designation process.

Stakeholders were identified via a brainstorming session that followed the methodology provided in a standard stakeholder analysis approach, such as the one proposed by Neil Jeffrey (2009) from the Doughty Centre, Cranfield University School of Management. In his report, *Stakeholder Engagement: A Road Map to Meaningful Engagement*, Jeffrey (2009) explains the wants and needs of stakeholders. While this document was not developed for stakeholder engagement for MPA designation, the concepts introduced in this report are applicable in this case. Jeffrey (2009) stated that after stakeholders have been identified, it is important to determine what motivates the stakeholders, the objectives and expectations they seek from the process, the issues they anticipate from the process, and which of these issues must be addressed by the leading management authority. These themes were adapted for the purpose of this study and have been redefined as 'roles', 'expectations', 'fears', and 'support required'.

A stakeholder's role was defined as the expected position they take in the MPA designation process. For example, some roles pertained to economic prosperity, while others focused on conserving natural spaces. Expectations associated with these stakeholders pertained to what they hoped to get out of the MPA designation process, such as wanting their concerns addressed by

MPA practitioners or ensuring that they would be allowed to continue their business operations without being affected by the presence of an MPA, among others. Fears were determined based on what stakeholders may be hesitant about in the process, namely job loss, ineffective management of natural spaces, or infringed rights. Finally, support was classified as what the stakeholders required for the MPA designation process to be successful.

Following the identification analysis, stakeholders were organized in a power-interest matrix. This was outlined by Riahi (2017) as a tool that provides insight as to who the important stakeholders are in a process based on their personal interest or stake in the process and their ability to impact its success (Figure 11).

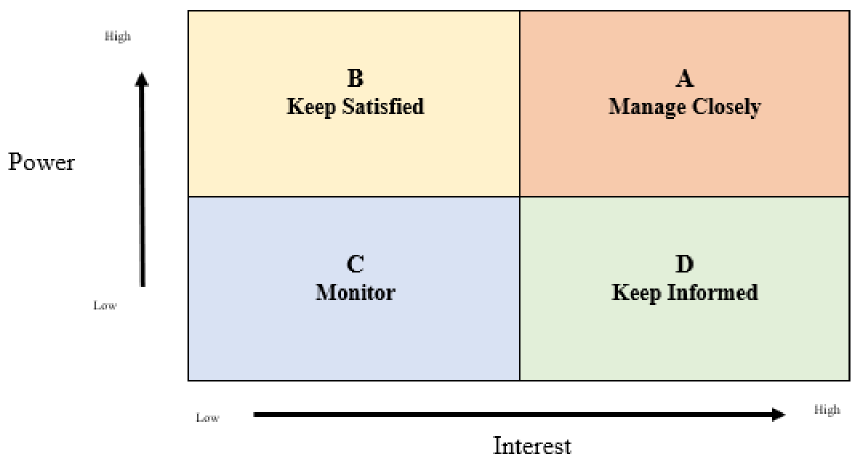


**Figure 11**. Power-interest matrix for managing stakeholders. Adapted from Riahi (2017)

Stakeholders classified within Quadrant A are assumed to have a power and interest in the process that may impact the project's success (Riahi, 2017). The stakeholders in Quadrant B should be kept satisfied because if left unattended they may feel dissatisfied with the process and hinder its progress (Riahi, 2017). Quadrant C consists of stakeholders that may not appear to be important but have an interest in the project while Quadrant D is comprised of stakeholders who have skills and tools that may influence cooperation (Riahi, 2017).

As with the identification analysis, the placement of stakeholders in this matrix occurred via a brainstorming session. This was done by examining the roles, expectation, fears, and required support that each identified stakeholder had in the process of designating benthic MPAs and theorizing who would be the most heavily affected. Since the conservation objectives of this research is focused on benthic habitats, stakeholders who came into direct contact with these environments would be more significantly affected by MPA designation, thereby granting them a higher power and interest in the process and a placement in Quadrant A. In comparison, stakeholders who did not directly interact with the benthic environments but may have an interest in these habitats were considered to be of lower priority and placed in Quadrant D. All other stakeholders were placed accordingly across Quadrants B and C.

This matrix concluded that the Atlantic groundfish industry was identified as a stakeholder with high influence and interest in the process of designating MPAs for SBA protection because their activities directly impact the benthic environment. Due to this, the groundfish industry became a central point of this research to determine how they would be affected by MPA designation. This correlated to the groundfish industry becoming the focus of the geographic information system (GIS) analysis alongside SBAs with an aim to identify how to minimally impact this fishing sector while advancing conservation on the Scotian Shelf.

### *5.2 GIS Tools and Inputs*

The GIS tools in this study were used to visualize the regions at high risk of conflict between SBAs and groundfish industry operations. These tools consisted of Marxan and ArcMap, as well as ArcMap's affiliate program ArcGIS Pro.

To determine potential sites for MPA designation, the conservation decision support tool Marxan was used. Marxan is software used by conservation planners to identify prospective sites for new conservation areas (Game and Grantham, 2008). It is used to solve a design problem that is commonly referred to as the ‘minimum set problem’ under which planners aim to conserve a minimum representation of the biodiversity features of a given region for the smallest possible cost (McDonnell et al., 2002 in Game and Grantham, 2008). In this research project, the biodiversity features referred to the coral, sponge, and sea pen species comprising SBAs whereas the cost is defined as the loss in fishing territory experienced by the groundfish industry as a result of MPA designation.

For this simulation, eight species data models were included as conservation features. They were: (1) large gorgonian extrapolated area; (2) large gorgonian presence (3) small gorgonian extrapolated area; (4) small gorgonian presence; (5) sea pen extrapolated area; (6) sea pen presence; (7) sponge extrapolated area; and (8) sponge presence. These data models were used because the species were representative of the cold-water coral and sponge reefs found within the Scotian Shelf bioregion. Extrapolated area refers to locations where populations of each species have been assumed to exist; however, no concrete data exists to confirm their presence in those regions (Beazley et al., 2019b). In contrast, predictive probability refers to areas where the species are known to be located (Beazley et al., 2019b).

These features were analyzed against the cost – defined as where the Maritime groundfish (longline, gillnet, and trawl) industries are affected by the proposed designation of MPAs within the Scotian Shelf bioregion. A dataset for the Shelf was supplied by DFO to be used as the simulation’s planning units (Pardy, 2020). The planning units were hexagonal in shape with an area of 10 $km^2$. The Marxan analysis presented 45,808 selection units that could be identified as AOIs for MPA designation.

In total, five Marxan scenarios were run and analyzed. The first determined the best locations for MPA designation based upon fishing activity and a conservation target of 15% for

SBAs protected within the Scotian Shelf bioregion. Subsequent scenarios were run with conservation targets of 25%, 35%, 45%, 50%. The cost to the Atlantic groundfish industry operators did not change as the software aimed to identify AOIs with the smallest amount of cost to the fishing industry. A boundary length modifier (BLM) of 0.25 was applied to all scenarios. Results from the Marxan analyses were transferred to ArcMap for examination.

Marxan results were compared against known fishing territories to identify where there was overlap between the locations of sensitive coral and sponge reefs and where the groundfish industry operated. For the purpose of this study, acceptable rates of overlap were defined as those not exceeding a threshold of 25%. This limit was selected with the knowledge that Marxan aimed to identify AOIs with minimal cost to the fishing industry. It was anticipated that overlap would occur in less productive fishing territory where fewer license holders would be affected.

Additional scenarios of 75% and 100% were run but later omitted from the results of the study due to the unrealistic expectation for MPA designation within the Scotian Shelf bioregion that accompanied these scenarios. The 75% and 100% scenarios resulted in nearly the entire Scotian Shelf identified as AOIs with little-to-no territory available for the groundfish industry to conduct their operations. As such, their exclusion from the study was based on the idea that they would not be able to provide a realistic approach to MPA network development on the Shelf.

## Chapter 6. Results

The primary research question this paper aims to address pertains to the feasibility of developing a network of MPAs on the Scotian Shelf bioregion that is capable of conserving SBAs while limiting socioeconomic impacts to the groundfish industry. Four sub-questions supported this question, and these were: (1) where are SBAs found; (2) what are the most pressing threats to sensitive benthic species; (3) where will the impact to stakeholders – namely the groundfish industry – be felt (i.e., where is the overlap between fishing activity and SBAs); and (4) do the identified areas have the potential to complement existing conservation measures and contribute to an MPA network within the Scotian Shelf bioregion?

The introductory chapters of this report answered the first two sub-questions via the development of maps depicting the locations of benthic species on the Scotian Shelf and through the analysis of the groundfish industry in Atlantic Canada. The results of the stakeholder identification analysis and stakeholder prioritization matrix demonstrated the user groups that were likely to be affected by MPA establishment and found that the groundfish industry had high potential to affect SBAs and be affected by the establishment of MPAs to conserve corals and sponges. The Marxan analysis aimed to determine where impacts to the groundfish industry would be felt, such as in areas where there is overlap between fishing activity and SBAs. The results from the Marxan analysis will be illustrated alongside existing *Oceans Act* MPAs within the Scotian Shelf bioregion – that contribute to the preservation of corals and sponges – to determine how the bioregional network can be supported by the proposed AOIs.

The stakeholder identification analysis was used to classify all stakeholders who should be involved in consultations during the MPA designation process. This led to the creation of the prioritization grid by examining the stakeholders who would be most affected by benthic MPA designation, such as those who could be displaced from a region and experience socioeconomic/cultural impacts as a result. The prioritization grid indicated that the groundfish industry were to be the focus of the Marxan analysis alongside SBAs due to their high potential to damage the benthic environment. This stakeholder identification, prioritization, and the subsequent Marxan analysis will be elaborated on in the remainder of this chapter.

### *6.1 Stakeholder Identification Analysis*

The stakeholder identification analysis included examining stakeholders through the categories adapted from Jeffrey (2009) which included the roles, expectations, fears, and required support each stakeholder group was anticipated to experience throughout the MPA designation process. Several key themes were identified across the stakeholder groups and will be summarized here before being elaborated on in the subsequent sub-sections.

Two themes were identified pertaining to roles, and they were (1) to deliver a service to Canadians and (2) having the intention to support the MPA designation process. Identified themes for expectations were (1) the belief that the designation of benthic MPAs will not impact the stakeholders; (2) that adequate measures will be implemented to protected SBAs; and (3) that the consultation process will be thorough and address stakeholder concerns. Prominent fears related to (1) an ineffective consultation process or (2) no longer being allowed to conduct their operations on the Scotian Shelf. The central theme identified for required support was the ability of government agencies to address concerns about prospective MPAs during the consultation and engagement process.

The stakeholder identification analysis results are available in Table 3.

**Table 3.** Stakeholder identification analysis, including the roles, expectations, fears, and support required when considering MPA network development for benthic areas on the Scotian Shelf, Nova Scotia, Canada

| Stakeholder Groups | Roles | Expectations | Fears | Support Required |
|---|---|---|---|---|
| *Groundfish Industry (Trawl, Longline, and Gillnet)* | To operate an industry that is economically viable and supports the livelihood of Maritime Canadians | That MPAs/networks will be developed that are non-intrusive to their current fishing operations | That they will lose the right to fish in productive areas, compromising the livelihoods of Maritime Canadians | Belief that the government will allow them to retain the right to fish in economically viable areas and that they will not be negatively impacted by MPA designation |
| *Coastal communities* | To support the development of MPAs by providing input during the stakeholder engagement process | That their comments and concerns during the engagement process will be considered and addressed in future phases of MPA development | That MPA practitioners and government agencies will not address their comments and concerns and that they will be negatively impacted by the development of an MPA | Belief that MPA practitioners and government agencies are committed to using all feedback from the engagement process to better develop MPAs that protect at-risk areas without risking the livelihoods of coastal communities |
| *Recreational fishing and tourism* | To operate businesses offering recreational activities, such as sea kayaking and sport fishing, on the Scotian Shelf | That they will be allowed to continue their operations without being affected by MPA designation. That an MPA may allow for increased ecotourism ventures | That they will no longer be able to offer recreational fishing and tourism activities, leading to a loss of revenue and job loss | Belief that the government will allow them to retain the right to conduct their businesses viable areas and that they will not be negatively impacted by the development of an MPA |
| *Aquaculture* | To provide food and employment to Canadians | That they will be allowed to continue and grow their operations without impediment should an MPA be designated near their sites | That the development of MPAs will hinder their ability to operate on the Scotian Shelf, leading to a reduction in revenue, decreased food production, and job loss for Canadians | Belief that food security and employment are a top concern for the Canadian government and that their industry will not be impacted by an MPA |
| *Shipping and Transport* | To facilitate the transiting of goods across Maritime boundaries in a timely manner | That they will continue to meet their deadlines for transporting goods and services | That an MPA will negatively impact their shipping schedules, leading to missed deadlines and economic repercussions | Belief that the timely transiting of goods is a top concern for the Canadian government and that they will not be negatively impacted by MPAs on the Scotian Shelf |

| | | | | |
|---|---|---|---|---|
| *Oil and Gas Industry* | To operate an industry that is economically viable and supports the livelihood of Maritime Canadians | That they will be allowed to continue to conduct oil and gas exploration and production operations | That an MPA will impact their ability to pursue oil and gas exploration and production operations | Belief that they will be able to retain the right to conduct an economically viable industry and that they will not be negatively impacted by MPA designation |
| *Government Agencies* | To provide support to coastal communities, uphold the mandate of their organization(s), and protect areas of high ecological and economic importance | That coastal communities, the Maritime groundfish industry, and recreational marine-based activities will be able to coexist without issue in MPAs on the Scotian Shelf | That opposition from coastal communities and Maritime industries will make it challenging for an inclusive engagement process to be undertaken and that it will be difficult to create MPAs on the Scotian Shelf | Belief that they are creating MPAs that will adequately protect SBAs without negatively impacting Canadians conducting business on the Scotian Shelf |
| *Environmental Conservation Groups (private industry and NGO)* | To collaborate with government agencies in the development of MPAs, including the identification of potential sites and subsequent management | That ecologically important areas will be properly identified, protected, and monitored on the Scotian Shelf | That ecologically important areas will not be adequately protected, leading to continued environmental degradation | Belief that the government will use sound scientific methods to identify AOIs and will invest in protective measures that ensure the survival of these ecosystems and species. |
| *Indigenous Groups* | To provide input and contribute Traditional Knowledge that is useful in the identification of prospective sites, as well as to engage in co-management of MPAs | That they will be engaged and communicated with during the development and subsequent monitoring of protected areas | That their expertise will not be considered, and that their Traditional ecological, social, and cultural rights will be infringed upon | Belief that MPA practitioners and government agencies are committed to collaborating with Indigenous groups in a process that results in MPAs being designated that protect SBAs and maintain economic opportunities |
| *Research Institutions* | To provide accurate and unbiased science to the academic community | That they will be able to conduct data collection within the MPA | That they will be denied entry to MPAs and will be unable to conduct their research | Belief that research within the MPAs are of use for effective monitoring of the region(s) |

*6.1.1 Roles*

Two primary themes arose concerning the roles undertaken by the stakeholders involved in the MPA designation process. The first was to deliver a service to Canadians, while the second pertained to the intention to support the MPA designation process.

Under the first theme, stakeholders, including commercial and recreational fisheries, tourism, aquaculture, shipping and transport, the oil and gas industry, and research institutions would all seek to maintain their ability to deliver a service. These stakeholders aim to operate economically viable industries on the Scotian Shelf. Within the context of the commercial fishery, aquaculture, and oil and gas industries, stakeholders may seek to work in an industry capable of supporting the livelihoods of Maritime Canadians, producing food, and/or delivering goods as an international export. Similarly, recreational fisheries and tourism aimed to provide a service that is attractive to Canadians and tourists and may support coastal communities. The shipping and transportation industry aimed to deliver goods and services within Canada and abroad in a manner consistent with their current routes and speeds. Research institutions would intend to continue delivering sound scientific research capable of informing decision making and provide context to regions with limited existing knowledge.

The second identified theme – the intention to support the MPA designation process – was acknowledged in coastal communities, government agencies, environmental non-governmental organizations (ENGOs), Indigenous groups, and research institutions. Each of these stakeholder groups was perceived to have an interest in seeing MPAs designated for the sake of preserving SBAs. These groups were anticipated to have a breadth of knowledge external to an economic-based industry that could influence the MPA designation process. They were all predicted to be in-favour of the designation of benthic MPAs on the Scotian Shelf, provided that a proper engagement process was conducted. Research institutions were found to identify with both themes as they deliver services via scientific research that can be impacted by MPA designation. Despite this, they are also anticipated to consider MPAs favourably as protected areas offer unique experiences to conduct long-term research.

*6.1.2 Expectations*

Three primary themes were identified as stakeholder expectations. The first was the belief that they will not be affected by the designation of MPAs on the Scotian Shelf. The second was that adequate measures would be implemented to protect SBAs within the Shelf. Finally, the third theme was that the consultation process would be thorough and address the concerns stakeholders have about the process.

Commercial and recreational fisheries, tourism operators, aquaculture, shipping and transport, Indigenous groups, the oil and gas industry, and research institutions were identified to believe that the designation of benthic MPAs may impact them. Each of these stakeholder groups participates in activities occurring on the Scotian Shelf and would be concerned about their ability to conduct their operations because of MPA designation. Of these, the commercial groundfish and oil and gas industries would be the most likely to be impacted by MPAs designated for conserving SBAs because these industries cannot operate where benthic MPAs are located. In the case of the groundfish industry, their expectations would also include that fishers who are displaced from areas where an MPA has been designated are not negatively economically affected.

The second theme, which saw stakeholders anticipating that adequate protection measures would be implemented, was most prominent among government agencies and ENGOs. This is because these stakeholders have a high interest in ensuring that SBAs are properly conserved and sustainably managed.

Regarding the theme of a thorough consultation process, all stakeholders were assumed to be interested in this occurring. This is because each stakeholder would have different goals and expectations that they expected arise during the planning process. As a result, they would all anticipate a comprehensive engagement period that allowed them to voice their fears and oppositions with appropriate time for feedback and adjustments to the MPA plan prior to its designation. Within this, government agencies leading the MPA consultation process would expect to provide a process that allows other stakeholder groups to voice their opinions, with the optimal result of an MPA network that effectively conserves SBAs and minimally impacts the socioeconomic and cultural interests of stakeholders.

*6.1.3 Fears*

The most commonly assumed fears stemmed from either an ineffective consultation process or no longer being allowed to conduct their operations on the Scotian Shelf.

All stakeholders are anticipated to have concerns over an ineffective consultation process. As indicated by their expectations, the stakeholders would assume that their concerns about the process would be recognized and remedied before designing new MPAs on the Scotian Shelf. Many could be fearful that they would lose their ability to conduct business in viable regions, translating to a lack of income or job loss. ENGOs may be fearful of ineffective conservation measures, while Indigenous groups could be concerned about having their Traditional ecological, social, and cultural rights infringed upon. Academic institutions may be concerned about a refusal to conduct scientific research. At the same time, government agencies may be fearful that the consultation and engagement process will not be sufficient, thereby making it challenging to designate future MPAs on the Shelf.

*6.1.4 Support Required*

The main themes relating to support required by stakeholders for MPAs to be successfully designated refers to government agencies and their ability to address concerns raised in the consultation and engagement process.

Stakeholders, such as commercial and recreational fisheries, aquaculture, shipping and transport, and the oil and gas industry would anticipate that the government ensures that their ability to conduct business is not affected. Other groups, such as ENGOs and research institutions would require governmental support to indicate that sound scientific research and effective conservation measures are implemented to protect SBAs. Indigenous groups may aim to have support indicating that their Traditional practices would be able to continue without impediment and that their knowledge would influence the designation process. Similarly, coastal communities would require government aid to respond to their concerns about the process to ensure that their livelihoods are not put at risk due to benthic MPA designation. Finally, government agencies would need to believe that they are operating in the best interests of Canadians to preserve the livelihoods and economic viability of marine-related industries while believing that they are meeting the marine conservation targets consistent with their national and international agreements.

***6.2 Stakeholder Prioritization Analysis***

Following the stakeholder identification analysis, all stakeholders were prioritized based on their power and interest in the benthic MPA designation process (Figure 12). As noted, this analysis stemmed from a brainstorming session to determine who the priority stakeholders were in the designation of benthic MPAs.

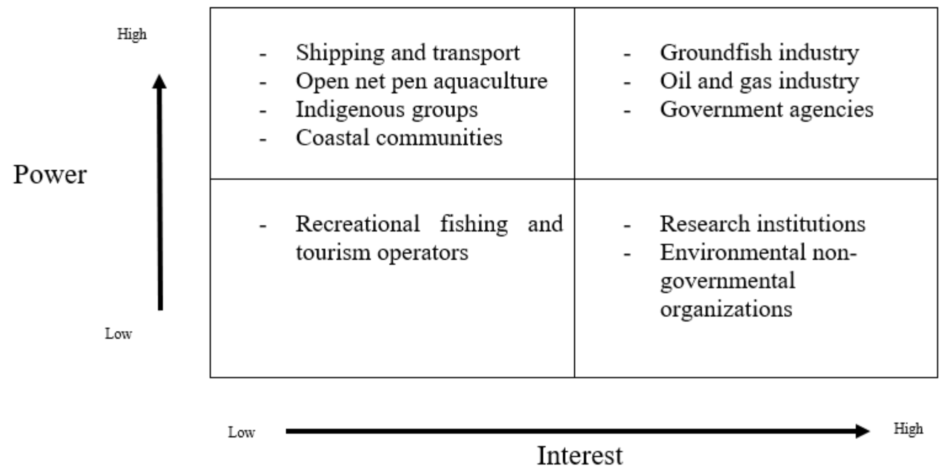


**Figure 12.** Stakeholder prioritization analysis grid. Stakeholders with a higher influence and greater interest in the development of MPAs on the Scotian Shelf for sensitive benthic areas should be prioritized over stakeholders with less influence and interest.

The results from the stakeholder power-interest matrix concluded that the focus of the Marxan analysis should be centred on the impacts to those working within the commercial groundfish industry (i.e., bottom-contact longline, gillnet, and trawl operators) as they had the potential to be significantly affected by the designation of benthic MPAs. Government agencies, such as DFO, also have high power and interest because they designate *Oceans Act* MPAs. Both of these stakeholders were placed in Quadrant A because of their high power and interest in the process. While the oil and gas industry was also placed in Quadrant A due to their inability to operate within all future MPAs under the new protection standards, the groundfish industry was prioritized. This was because there is little oil and gas activity presently underway on the Scotian Shelf. In 2018, two oil and gas projects in the bioregion finished producing and are in the process of being decommissioned (Canadian Association of Petroleum Producers (CAPP), 2020). Nova Scotia is anticipated to have significant resource potential but there is no current exploration activity underway despite the fact that several companies have been provided offshore exploration licenses (CAPP, 2020). As such, the groundfish industry was considered to be facing more pressing threat from benthic MPA designation than the oil and gas industry and prioritized for this study.

Stakeholders placed in Quadrant B included shipping and transport industry operators, aquaculturists, and coastal communities and Indigenous groups. These stakeholders were selected for Quadrant B due to the desire to keep them satisfied with the process. While these stakeholders are not perceived to have a significant impact on SBAs due to actions that can be taken to mitigate potential harm to the benthic environment (i.e., implementing regulations that prohibit vessel anchoring in MPAs but permit transiting or specifying minimum distance limits between where an aquaculture facility is permitted to be in relation to an MPA, among others). These stakeholders would be likely satisfied so long as they were able to conduct economically viable businesses following benthic MPA designation. Coastal communities and Indigenous groups were placed into Quadrant B because they would be able to provide considerable insight into the proposed AOIs via the integration of local and Traditional Knowledge. The activities they conduct in MPAs, such as FSC harvesting, would not be likely to impact SBAs. Indigenous stakeholders would have an interest in ensuring that their rights are not infringed upon during MPA establishment.

Quadrant C consisted of recreational fishing and tourism operators who have low power and low interest due to their non-impactful activities but are necessary to monitor. These stakeholders are not anticipated to affect benthic MPAs but as they conduct business on the Scotian Shelf, they may be important to include in consultation sessions. Their interest in the process is reduced as their primary condition would be the continuation of their activities on the Scotian Shelf.

Quadrant D was comprised of stakeholders who had low power but high interest and included research institutions and ENGOs. Neither of these stakeholders were anticipated to cause significant harm to SBAs when conducting their activities due to their commitment to conservation and increasing knowledge that may influence the management of a site.

### *6.3 Marxan Analysis*

Since the groundfish industry was deemed to be a stakeholder with high power and interest, they became the focus of the Marxan analysis in order to determine how to limit negative impacts to this industry while conserving SBAs within a network of benthic MPAs.

The Marxan analysis revealed that 45,808 units had the potential to be selected by the program as AOIs for future MPA designation. Marxan identified the best solution for each of the scenarios described in the methodology when considering the marine conservation target, the eight conservation features, and the cost to the groundfish industry. The results from these solutions have been outlined below. The outputs from the analysis are available in Figure 13.

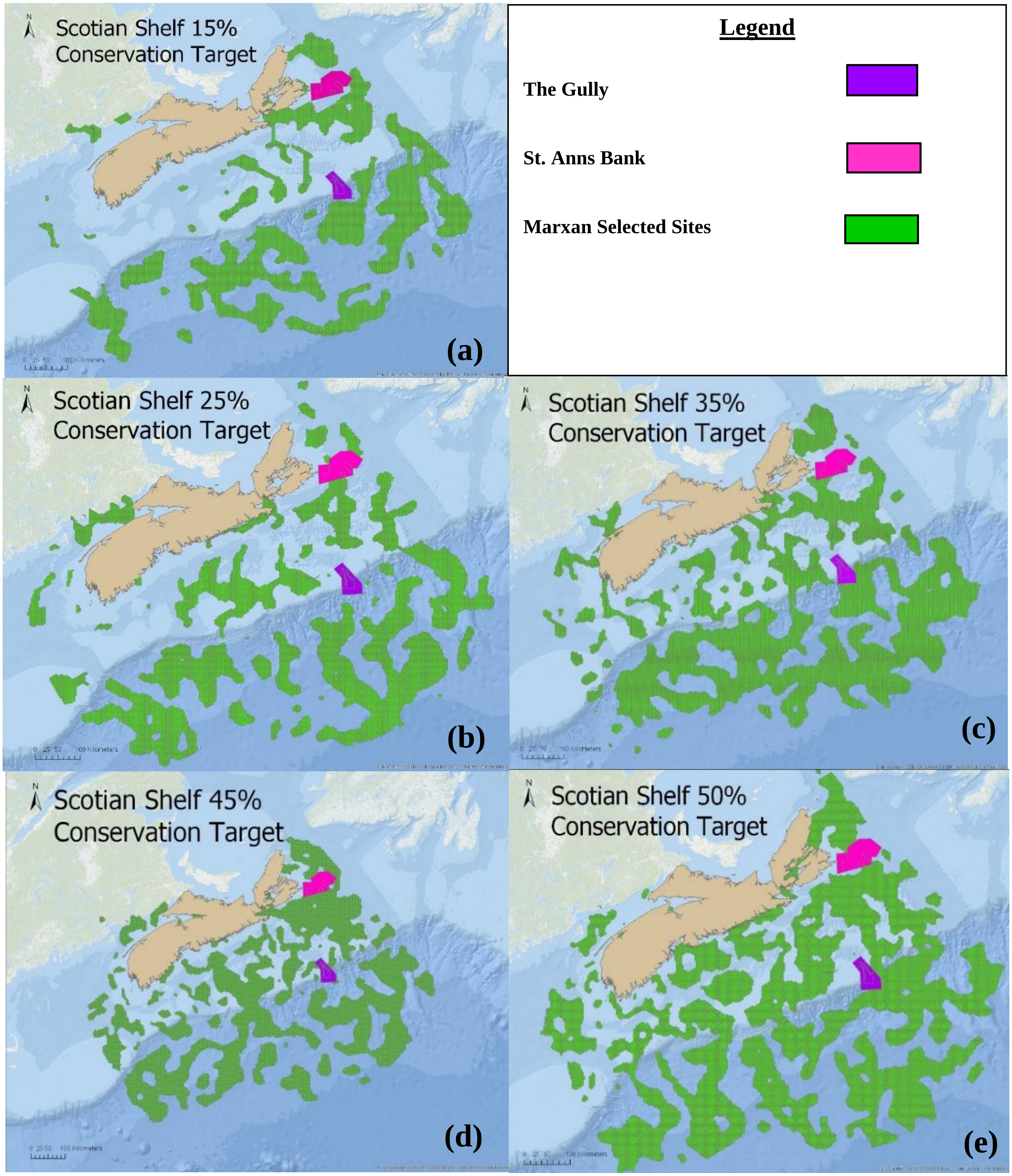


**Figure 13.** Outputs for each scenario from the Marxan analysis showing where prospective MPAs could be placed on the Scotian Shelf where (a) is 15% of SBAs conserved; (b) is 25%; (c) is 35%; (d) is 45%; and (e) is 50%. These percentages were set against known fishing territory for the groundfish industry (trawl, gillnet, and longline) to produce the final locations of prospective sites (green). A BLM for each scenario was set at 0.25 Existing MPAs on the Scotian Shelf have been placed for reference. The scale is set at 100 km.

*6.3.1 Marxan Scenario 1: Marine Conservation Target 15%*

The first Marxan scenario was set with a 15% marine conservation target for SBAs within the Scotian Shelf bioregion (Figure 13a). The program selected 13,464 planning units as AOIs out of the possible 45,808 available units and included representation from all conservation features. Marxan selected units within this scenario that were concentrated primarily around the offshore Scotian Shelf, including regions adjacent to Georges Bank, Browns Bank, and Sable Island Bank. The central and eastern portions of the offshore Shelf were also heavily selected, as was the outer offshore. Clumping of AOIs were identified near both The Gully and St. Anns Bank MPAs. Marxan did not select a high concentration of planning units near the south and western portions of the inshore, midshore, and offshore Scotian Shelf.

*6.3.2 Marxan Scenario 2: Marine Conservation Target 25%*

The second Marxan scenario featured a 25% marine conservation target for SBAs on the Scotian Shelf (Figure 13b). The program selected 14,595 planning units as AOIs and included representation from all conservation features. Marxan primarily selected units in the western, central, and eastern offshore, and outer offshore portions of the Shelf. Clumping was notable near Emerald Bank, Western Bank, Sable Island Bank, and Misaine Bank. Selected inshore and coastal areas were located near the Bay of Fundy and Chedabucto Bay. Sites were selected near St. Anns Bank MPA; however, fewer units were identified adjacent to the Gully MPA when compared against the 15% scenario. Marxan did not select a high abundance of sites near the south and southwest portions of the Shelf.

*6.3.3 Marxan Scenario 3: Marine Conservation Target 35%*

The third Marxan scenario featured a 35% marine conservation target for SBAs on the Scotian Shelf (Figure 13c). The program selected 19,185 planning units as AOIs and included representation from all conservation features. Marxan selected sites that were primarily situated in the western, central, eastern offshore, and outer offshore regions; however, in comparison to the previous scenarios, there was increased selection around the inshore and coastal regions. In particular, the southwestern portion of the inshore and midshore featured increased selection – as did coastal areas near the Eastern and Cape Breton Shores. Selection around the Gully and St. Anns Bank MPAs were also more densely concentrated.

*6.3.4 Marxan Scenario 4: Marine Conservation Target 45%*

The fourth Marxan scenario had a 45% marine conservation target for SBAs on the Scotian Shelf (Figure 13d). The program selected 19,656 planning units as AOIs and included representation from all conservation features. As in the previous scenarios, selection in the offshore Scotian Shelf was significant, particularly in the central, eastern, and outer offshore regions. The south and western regions featured more selection compared to previous scenarios but less than the central and eastern areas. Increased selection within the inshore and coastal areas was noted, especially near the Bay of Fundy, South Shore, and Chedabucto Bay. Compared to St. Anns Bank MPA, selection around the Gully MPA was sparser but still exhibited AOI potential.

*6.3.5 Marxan Scenario 5: Marine Conservation Target 50%*

The fifth Marxan scenario was set with a 50% marine conservation target for SBAs on the Scotian Shelf (Figure 13e). The program selected 21,506 planning units as AOIs and included representation from all conservation features. While the offshore and outer offshore continued to be heavily selected by Marxan, distribution was more even across all areas. The increased conservation target contributed to a denser concentration of AOIs selected in proximity to the coastal and inshore regions. Both the Gully and St. Anns Bank MPAs demonstrated a high density of AOI selection near their boundaries.

*6.3.6 Marxan Best Solutions*

When compared against patterns of groundfish industry activity on the Scotian Shelf, it is clear that there is a degree of overlap between AOIs and where the groundfish industry is known to operate (Figure 14). Overlap was determined by the percentage of selected sites that intersected with known groundfish industry territory.

Each of the five scenarios featured overlap; however, the percentage varied across the conservation targets. In the 15% scenario (Figure 14a), there was overlap of 16.9% – indicating that 16.9% of selected sites intersected with known fishing territory. The 25% (Figure 14b) and 35% (Figure 14c) conservation target scenarios featured overlap of 20.5% and 22.7% overlap, respectively. As such, these three scenarios each fell below the 25% overlap threshold proposed for the study. In comparison, the 45% (Figure 14d) scenario and 50% (Figure 14e) scenarios exceeded the threshold limit at 28.7% and 30.5%, respectively.

The 15% and 25% conservation targets each had minimal overlap in densely fished areas, such as near the southern Scotian Shelf region. Overlap for these scenarios was more heavily concentrated towards the central offshore region and adjacent to Cape Breton Island. The 35% scenario continued this trend of overlap in the central offshore and adjacent to Cape Breton Island; however, there was a notable increase to overlap in the western offshore region and near the Bay of Fundy that had been avoided in the preceding scenarios.

The 45% and 50% scenarios followed the trends from the 35% scenario but featured denser concentrations of selection in the southern Scotian Shelf where fishing was heaviest. While there was still productive fishing territory available in these scenarios, there was also evidence of increased fragmentation between fishing grounds.

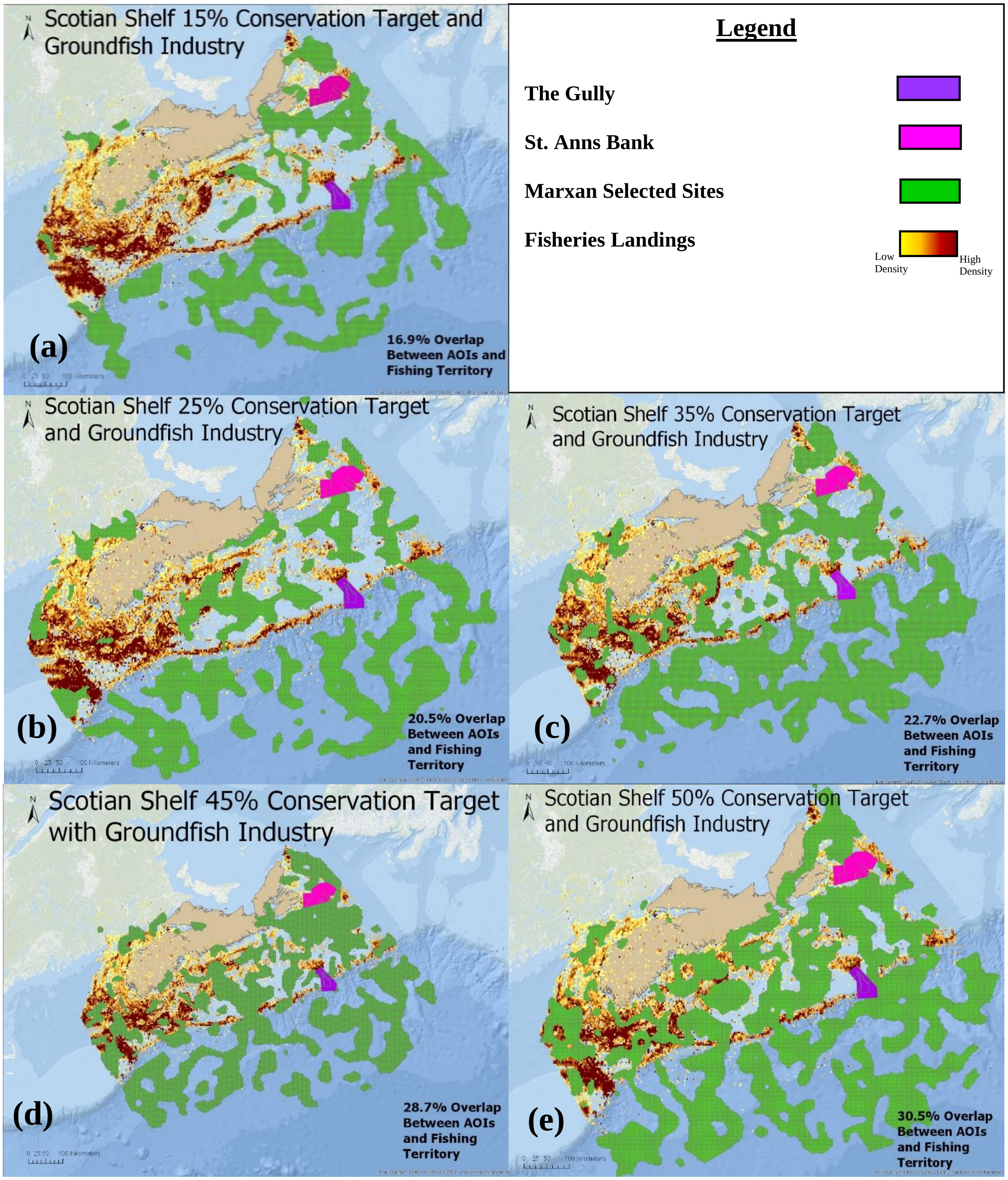


**Figure 14.** Outputs from the Marxan analysis showing where prospective MPAs could be found on the Scotian Shelf where (a) is 15% of SBAs conserved; (b) is 25%; (c) is 35%; (d) is 45%; and (e) is 50%. Groundfish industry landings (bottom-contact longline, gillnet, trawl) are represented to show overlap between selected sites (green) and fishing territory (where yellow is lower density of fishing activity and red is higher density of fishing activity). A BLM was set at 0.25 Existing MPAs with benthic conservation objectives on the Scotian Shelf (The Gully and St. Anns Bank) have been placed for reference. The scale is set at 100 km.

## Chapter 7. Discussion and Recommendations

This research classified and prioritized key stakeholders for the benthic MPA designation process. It also identified AOIs on the Scotian Shelf which may be suitable for benthic MPA network designation. Key findings have been summarized in table 4 and will be further discussed.

**Table 4.** Summary of key results and their implications on the MPA network designation process for benthic areas.

| Result | Implication |
|---|---|
| ***Stakeholder Considerations*** | |
| Groundfish industry operators (longline, gillnet, and trawl) are more likely to be negatively impacted from the designation of MPAs for benthic areas on the Scotian Shelf than other stakeholders (i.e., tourism, shipping, academia, etc.). | The groundfish industry is a key stakeholder and understanding the socioeconomic impacts they could experience (i.e., job or income loss due to reduced fishing territory) due to benthic MPA designation is critical. |
| The groundfish industry was prioritized in Quadrant A (manage closely). | The groundfish industry should be carefully consulted with during the AOI selection and subsequent MPA designation process. Efforts to mitigate socioeconomic impacts to this sector should be undertaken. They should have opportunities to provide input into the process so that regions can be selected that conserve SBAs and limit affects of the fishing industry. |
| ***Marxan Output Results*** | |
| All 5 Marxan scenarios featured dense AOI selection in the central and eastern offshore, as well as the outer offshore regions of the Scotian Shelf. | The offshore region contains considerable populations of sensitive benthic species (corals, sponges, and sea pens) and should be of high interest to MPA practitioners for AOI selection refinement. |
| AOIs were not selected as prominently towards the coastal and inshore areas of the Scotian Shelf, or near the south and western regions. | Groundfish industry operations were conducted with the highest density in these regions. Selecting an abundance of sites in this part of the Scotian Shelf would result in greater impacts to this industry. |
| Marxan identified AOIs in close proximity to existing MPAs (the Gully and St. Anns Bank) on the Scotian Shelf. | Indicates potential to expand upon existing sites and continue research to explore connectivity between regions. |
| All 5 Marxan scenarios had overlap between where sensitive benthic species were found and where groundfish industry operations were occurring. | The 15, 25, and 35% scenarios are featured less than 25% overlap – meeting the goal that had been set for the study. In comparison, the 45% and 50% scenarios overlapped greater than 25% threshold limit. |

Overall, the groundfish industry was anticipated to be the stakeholder with greatest potential to be affected by the designation of a MPA network on the Scotian Shelf developed to conserve sensitive coral, sponge, and sea pen species. The locations of where these species are located on the Shelf were found to correlate in some instances with productive fishing territory. These areas of overlap would be more at risk from the groundfish industry and as such can be described as 'sensitive' per the definition of SBAs previously supplied in this study in which significant benthic areas that overlapped with fishing territory could be termed 'sensitive.'

Of the three fishing gear types included within this study, bottom-contact gillnet had the least potential to be affected since the presence of this sector was not as prominent as the bottom-contact longline and trawl sectors. In the western portion of the Shelf where the gillnet industry was known to operate, there were known and predictive concentrations of both gorgonian corals and sponges in nearby areas. When factoring in the bottom-contact longline and trawl sectors of the groundfish industry, the potential for conflict between conservation and fisheries increased due to heightened overlap. As groundfish industry activity from these sectors expanded to include portions of the central and eastern offshore portions of the Scotian Shelf bioregion where the presence of sensitive benthic species increased in concentration, overlap was more likely to occur. Since the western offshore portions of the Shelf did not include as significant concentrations of these sensitive benthic species (per the KDE), the overlap in these regions was anticipated to be minimal when compared to the rest of the bioregion.

The results from the Marxan analysis demonstrated this as the scenarios all featured dense selection of AOIs in the offshore areas of the central and eastern Scotian Shelf bioregion. Scenarios with lower conservation targets for SBAs, such as the 15%, 25%, and 35% did not select areas in the southwestern offshore portions of the Shelf as notably.

In comparison, the 45% and 50% scenarios were more even in their distribution of selection across the bioregion, including areas where fishing was productive and nearer to coastal and inshore locations. The rates of overlap were higher in these scenarios compared to the 15-35%

analyses. Differences between the 45% and 50% scenarios were not blatantly clear as both featured considerable selection across the entire Scotian Shelf bioregion. The 45% scenario had less overlap than the 50% scenario by a difference of 1.8%. Inspection of the southwestern offshore portion of the Shelf where the groundfish industry operated with the highest density was the best example of where the differences between these two scenarios could be identified. This was because the 45% scenario did not feature as much selection in this region as the 50% scenario; however, both scenarios exceeded the 25% overlap threshold limit that had been selected for this study.

As such, the socioeconomic impacts to the groundfish industry associated with the 45% and 50% scenarios were expected to be too great to consider as viable solutions for a benthic MPA network. If practitioners were to investigate these scenarios for MPA designation, they would likely experience resistance from the groundfish industry stakeholders during consultation and engagement sessions. This is because the proportion of groundfish industry license holders who have the potential to be displaced by benthic MPA designation in these scenarios is high. Displaced fishers could experience socioeconomic impacts associated with a decrease to the available fishable area, quota reductions in catch due to this decline in fishing territory, increased expenses associated with longer travel time to fishing grounds (to avoid MPAs) and limited time for fishing as a result. Due to this, scenarios that overlap too much with productive fishing territory would make it difficult to attain the support of the groundfish sector during the MPA designation process.

While the 45% and 50% scenarios exceeded the overlap threshold, the 15%, 25%, and 35% Marxan scenarios all fell within the acceptable overlap limit proposed for the study at 16.9%, 20.5%, and 22.7% respectively. Even though all were within the limit, the range of overlap in the 35% Marxan scenario was concentrated in productive fishing territory located in the southwest and western portions of the offshore Scotian Shelf bioregion. Despite the fact that the groundfish industry would still be able to operate productively under this scenario, heightened conflict would be expected to occur with this industry during consultation and engagement processes for the same reasons associated with the 45% and 50% scenarios.

These considerations indicate that the 15% and 25% scenarios should be pursued by practitioners for benthic MPA network designation within the Scotian Shelf bioregion. In both of these scenarios, AOI selection was primarily identified in the central and eastern offshore, as well as the outer offshore portions of the Scotian Shelf. Productive fishing territory in the southwest and western offshore of the Shelf did not feature a significant amount of overlap and each scenario fell below the overlap threshold. The groundfish industry is not likely to be as heavily affected from these scenarios; however, if MPAs are designated where overlap is present then there may be some displacement for fishers. This would most likely affect the longline or trawl sectors as the overlap present in these scenarios is mostly concentrated in the central and southwest offshore regions of the Shelf where these fisheries operate in greater density. Gillnet operators are not anticipated to be as highly affected due to lower rates of fishing in these areas. Fishing effort for all three groundfish sectors is limited in the outer offshore so MPA designation in this region of the Scotian Shelf is not as likely to be met with groundfish stakeholder conflict.

In respect to existing conservation plans within the Scotian Shelf – such as where existing MPAs are already in place – both the 15% and 25% scenarios were found to identify AOIs in adjacent waters. The abundance of AOIs near each of these MPAs varied according to the scenario but this selection indicates that there could be reason to expand the borders of these MPAs to encompass some of these additional sites. It is possible that the aggregations of corals, sponges, and sea pens in the AOIs adjacent to these existing MPAs may be important for the genetic diversity of the reefs. If there is transmission of genetic material between these reefs, or if they provide important biogenic habitat that supports the different life history stages of important species, then they may be critical to pursue for conservation efforts.

This study has identified potential AOIs for benthic MPA designation with the intention of ensuring the continuance of the groundfish industry within the Scotian Shelf bioregion. Not conducted within this research was an economic assessment of the identified AOIs to determine the full extent to which the groundfish industry will be affected by benthic MPA designation. This knowledge could be critical in attaining the support of the groundfish industry, which is necessary stakeholder support is essential for successful MPA designation (Christie et al., 2003; Christie, 2004; Voyer et al., 2013 in Catalano, 2016). Prior to consultation and engagement sessions with the groundfish industry, MPA practitioners should strive to understand the full extent of economic impacts that these fishers may experience and, if possible, provide a plan for how to limit negative impacts to fishers who are displaced from their normal fishing territory. Having this information when entering consultation and engagement sessions may allow for more productive conversations as it implies that the Government of Canada is willing to safeguard the livelihoods of Canadians while advancing conservation of sensitive areas.

The creation of a bioregional network of protected areas for SBA conservation on the Scotian Shelf results in several important considerations. First is whether inshore or offshore MPAs should be prioritized. A broad representation of species, habitats, and ecosystems should be incapsulated within the Scotian Shelf network and the Marxan analysis supported this via the selection of AOIs across the inshore, offshore, and outer offshore regions of the Shelf. The inshore and offshore areas would likely be met with more resistance from the groundfish industry since these are regions of productive fishing. In comparison, practitioners would likely be able to designate large MPAs in the outer offshore due to decreased competing interests in that portion of the Scotian Shelf. Limited groundfish industry activity was found to occur in the outer offshore so it is likely that this industry would not be concerned if MPAs were to be designated there.

Inshore and offshore areas may be under more immediate threat because of the of human activities occurring in these locations while the outer offshore may be more pristine and unaffected by human presence (DFO, 2017e). Since all three of these regions contain populations and dense concentrations of corals and sponges, determining what to conserve first may be a challenge to MPA practitioners. The inshore and offshore areas may be threatened by stakeholders external to the groundfish industry because of increased and competing human uses in these areas; however, they would be easier to manage due to decreased travel times to access the MPA and the ability to have more frequent patrols closer to the shore. Conversely, the corals and sponges found in more pristine outer offshore areas may allow for larger MPAs to be established due to decreased overlap and competition in the marine space, but the trade-off in these areas would be the fact that they are harder to manage because of their distance from the shore. Protecting both areas under pressure and pristine offshore regions are attributes of Canada's five-point plan to reach their national and international targets (DFO, 2017e) but deciding what to designate first is still an area of uncertainty.

It is also important to determine whether an *Oceans Act* MPA is the appropriate tool to implement. A previous chapter of this report – chapter 2 – described a variety of protected areas that could contributed to conservation and network development, such as marine NWAs, NMCAs, and OECMs. Of these, OECMs could be used effectively on the Scotian Shelf in working towards the development of a network. Since six OECMs have already been designated on the Scotian Shelf that contribute to the conservation of SBAs and/or groundfish, these would be a logical tool to apply in addition to new *Oceans Act* MPAs.

To date, all OECMs that have been designated on the Scotian Shelf have been fisheries closures, which are more commonly referred to as marine refuges (DFO, 2020b). Marine refuges contribute to fisheries management by protecting important species and their habitats in addition to coral and sponge aggregations (DFO, 2020f). These long-term measures must be in place for a minimum of 25 years and are designated under the *Fisheries Act* (DFO, 2017e). A marine refuge could be a different tool to practitioners could consider if an MPA is not considered to be a suitable option to meet the socioeconomic and conservation objectives for a given area. As the establishment of OECMs was considered important under Canada's five-point plan to achieve Aichi Target 11 (DFO, 2019f), they are a logical tool to include in addition to *Oceans Act* MPAs while advancing towards the 30% target by 2030. Currently, the OECMs on the Scotian Shelf contribute approximately 0.37% to Canada's marine conservation targets (DFO, 2020b).

**Table 5.** Recommendations for the designation of MPAs that have conservation goals of protecting SBAs and the species within them while preserving the groundfish industry within the Scotian Shelf bioregion, Nova Scotia, Canada.

| |
|---|
| 1. MPA practitioners should consider the AOIs identified in the 15% and 25% Marxan scenarios as a baseline for determining the best locations of MPAs within the Scotian Shelf for purpose of conserving SBAs. |
| 2. AOIs that are in close proximity to existing measures – such as AOIs adjacent to the Gully and St. Anns Bank MPAs – should undergo examination to determine if there is transfer of genetic material occurring between regions and/or if the reefs provide biogenic habitat for important species at different life history stages. This may provide a case to extend the boundaries of existing MPAs or to designate other MPAs. |
| 3. Economic assessment of fisheries impacts should be undertaken to determine the full extent to which the groundfish industry will be affected by MPA designation. This should be coupled with the identification of a management plan for displaced fishers to provide economic support. |
| 4. Consultation and engagement with the groundfish industry should be conducted and should include plans for how to compensate and socioeconomically manage fishers who are to be displaced due to MPA designation. |
| 5. Network design for the Scotian Shelf bioregion must consider if certain regions need to be prioritized over others and whether the focus should be on protecting ecosystems that are under immediate pressure (i.e., where there is overlap) or on pristine outer offshore ecosystems that are largely undisturbed by human presence. |
| 6. Protected area practitioners should consider where *Oceans Act* MPAs are the best tool to implement for conservation of SBAs or if other measures, such as marine refuges, would be more sensible. |

**Chapter 8. Conclusion**

MPAs are an essential tool that must be utilized if Canada is going to meet its new national and international conservation targets. To meet the target of having 30% oceans conserved by 2030 (Trudeau, 2019), Canada must designate an additional 16.19%. MPAs should be established with the support of stakeholders if they are to be effective in conserving ecologically, culturally, and historically important areas (Christie et al., 2003; Christie, 2004; Voyer et al., 2013 in Catalano, 2016). Networks of MPAs must be indicative of the broad range of species and habitats featured in Canada's oceanic ecosystems, enhance the ecological benefits and contributions that arise from a single MPA, and feature aspects of connectivity replication across sites to ensure resilience (DFO, 2018c; IUCN, 2008).

Ensuring the continuation of the groundfish industry while designating MPAs aimed at conserving SBAs on the Scotian Shelf bioregion is possible. The outputs produced from the 15% and 25% Marxan analyses demonstrated that there are AOIs on the Shelf that may be capable of providing protection to essential coral and sponge aggregations without significantly overlapping with productive groundfish territory. Scenarios with higher conservation targets (35%, 45%, and 50%) featured increased overlap between AOIs and fishing territory. The displacement and socioeconomic impacts the groundfish industry would experience if these scenarios were pursued would likely lead to conflict due to competing interests for the bioregion. As such, since the 15% and 25% options would result in fewer negative impacts to the groundfish industry while allowing for the conservation of SBAs, the AOIs proposed in those scenarios should be pursued for further study and potential MPA or OECM establishment.

The designation of MPAs may lead to benefits for coastal communities and marine-based industries. Even though the relationship between MPAs and industry stakeholders is complex, it may be mutually beneficial as MPAs have the potential to result in increased catches for fisheries via spillover effects, as discussed in chapter 2 (Murawski et al., 2005). While evidence of spillover effects is minimal, case studies from Georges Bank and other sites in New England suggest that it is a possible by-product of effective conversation (Murawski et al., 2005). Coastal communities and marine-based industries may experience benefits from MPAs via increased profits and employment as depleted fish stocks stabilize and can be used sustainably.

At the same time, MPAs must be representative of the species, habitats, and ecosystems they aim to conserve. Where possible, MPAs should be established in ecologically and biologically significant regions and avoid areas of economic importance.

**8.1 Limitations and Future Areas of Research**

Limited data on fishing activity may have influenced the results of the study. As all fisheries data was organized using privacy screened layers, the exact locations of groundfish industry operations are not known. As such, there may be more or less overlap in fishing territory and locations of SBAs that was not adequately considered within the scope of this research. Additionally, this study evaluated only the commercial groundfish industry and it was not investigated as to whether there are Indigenous harvesters that utilize the AOIs for FSC harvesting. Qualitative data and Traditional Knowledge were not gathered for this research, suggesting that the opinions of and use of ocean space by Indigenous harvesters can only be speculated.

As this study focused on the Atlantic groundfish industry due to the high potential for impacts on SBAs, there was a wide variety of stakeholders, such as aquaculturists, tourism operators, shipping and transport industry representatives, oil and gas industry representatives, First Nations and Indigenous groups, and ENGOs, who were not considered. These stakeholders should be provided the opportunity to provide knowledge about the identified AOIs that were not considered within the scope of this project, such as the locations of popular ecotourism operations, important shipping lanes, and historically and culturally significant areas that may be used for FSC harvesting practices. Once attained, this information can be used to refine the proposed AOIs into feasible sites for MPA designation within the Scotian Shelf bioregion.

While most of the activities associated with these stakeholders and their industries are not anticipated to be damaging to benthic areas, they must still be consulted with so that all uses of the water column and seafloor can be managed in the MPA via zoning. This is essential because the water column was another unexplored aspect of this study. Since the proposed AOIs were focused on SBA conservation, species external to the benthic environment were not considered. This would be an important aspect to explore as an MPA network for the Scotian Shelf bioregion would need to conserve more than benthic ecosystems. Despite this, since benthic species support a variety of ecosystem components via important habitat such as breeding, spawning, and feeding grounds (DFO, 2015) ensuring their protection is critical in designing a network for this bioregion.

Further, the socioeconomic uses of the water column would be essential to understand moving forward in this process. As stated, the new protection standards prevent oil and gas activity, mining, dumping, and bottom trawling from occurring within all future MPAs (DFO, 2019e). Even though bottom trawling is a prohibited gear type, other types of fishing may be permitted to continue, such as surface and midwater industries. These fisheries were not included within this research but would need to be consulted during the MPA establishment and zoning process.

As this study did not include a measure of connectivity between identified AOIs, future research should determine where the transfer of genetic material is occurring and identify critical habitat for life-history strategies, such as mating, spawning, and rearing grounds for corals, sponges and sea pens. Classifying these areas may increase the efficiency of MPAs, creating conservation efforts for SBAs that are more likely to be successful.

Other avenues of study on this topic could investigate the use of zoning in the identified AOIs for MPA designation on the Scotian Shelf. Additionally, investigation into the socioeconomic impacts to other prohibited activities, such as oil and gas or mining, on the Scotian Shelf due to the designation of benthic MPAs could also be a topic of study. Understanding how the creation of an MPA network on the Scotian Shelf will affect the socioeconomic interests of Canada’s Maritime industries is critical for developing a collection of MPAs capable of preserving SBAs and maintaining economically viable businesses.

## Acknowledgements

To my internship host, the NHQ Marine Conservation Operations team at Fisheries and Oceans Canada, thank you for hosting me this past summer. I appreciate all of your efforts to make me feel welcome and providing an incredible opportunity to learn and grow.

Thank you to my supervisor, Maxine Westhead, for your support, guidance, and advice throughout the MMM program and this project. I have immensely enjoyed working with you and could not have completed this project without your incredible wealth of knowledge and expertise.

Thank you to Marty King who helped me to scope and focus this project during its early stages and to Scott Coffen-Smout, Ellen Kenchington, Lindsay Beazley, Rémi Daigle, and Gary Pardy for providing me with data for this project. Thank you to Norma Serra from PacMARA who provided me with resources that helped me to learn how to use MARXAN. Thank you to my second reader, Elise Will. This project could not have been possible without the contributions of these individuals and their willingness to share their data and knowledge.

Special thank you to the Marine Affairs Program faculty and staff for bestowing your expertise and excitement for the ocean on me over the duration of this program. To my fellow classmates who made every day of this program memorable and enjoyable, thank you for every experience that we have shared together. Meeting all of you has influenced my passion for the ocean and for that I will always be grateful.

To my friends who have listened to me talk incessantly about the ocean for years, thank you for the endless support and for always making the time to listen to me rant. Finally, to my parents and sister. Thank you for always being in my corner and for providing unending encouragement and love throughout all that I have done. Your support has been invaluable. There is no one else I would rather have in my corner than the three of you.

## References

Beazley, L., Lirette, C., and Guijarro, J. (2019a). Characterization of the corals and sponges on the eastern Scotian slop from a benthic imagery survey. *DFO Ocean and Ecosystem Sciences Division. Canadian Technical Report of Fisheries and Aquatic Sciences, 3302*. Retrieved from https://waves-vagues.dfo-mpo.gc.ca/Library/4078132x.pdf

Beazley, L., Kenchington, E., Murillo-Perez, J., Lirette, C., Guijarro-Sabaniel, J., McMillan, A., Knudby, A. (2019b). Species distribution modelling of corals and sponges in the Maritimes region for use in the identification of significant benthic areas. Mendeley Data, v1. DOI: 10.17632/mwsns7fgb4.1

Berry, D. (2020). Cod moratorium of 1992. *The Canadian Encyclopedia*. Retrieved from https://thecanadianencyclopedia.ca/en/article/cod-moratorium-of-1992#:~:text=On%202%20July%201992%2C%20the,the%20province's%20economy%20and%20culture.

Birkland, C. (1974). Interactions between a sea pen and seven of its predators. Ecological Morphology, 44(2): 211-232. DOI: 10.2307/1942312

Britannica (n.d.). Sea pen. Retrieved from https://www.britannica.com/animal/sea-pen

Butler, S, and Coffen-Smout, S. (2017a). Composite landings 2010-2014 dataset. Department of Fisheries and Oceans Canada.

Butler, S. and Coffen-Smout, S. (2017b). Maritimes region fisheries atlas: catch weight landings mapping (2010-2014). Canadian Technical Report of Fisheries and Aquatic Sciences 3199: 57 pp.

Bundy, A., Themelis, D., Sperl, J., and den Heyer, N. (2014). Inshore Scotian Shelf ecosystem overview report: Status and trends. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Document, 2014/065. xii + 213 p.

The Canadian Association of Petroleum Producers (2020). Offshore projects and exploration in Nova Scotia. Retrieved from http://atlanticcanadaoffshore.ca/offshore-projects-exploration-nova-scotia/

The Canadian Council of Professional Fish Harvesters (n.d.). History of Fishing in Canada. *Government of Canada*. Retrieved from http://www.fishharvesterspecheurs.ca/fishing-industry/history

The Canadian Fishing Industry (n.d.). About the Canadian Fishing Industry. Retrieved from https://canadafishingindustry.weebly.com/about.html#:~:text=People%20who%20are%20involved%20in,up%20to%20370km%20from%20shore.

*Canadian Wildlife Act* (R.S.C., 1985, c.W-9). Retrieved from https://laws-lois.justice.gc.ca/PDF/W-9.pdf

Catalano, N. (2016). Stakeholder engagement in marine protected area network planning in Southern California: Understanding fishing, government, and environmental perspectives. *San Jose State University Master's Thesis, 4718*: 1-252. Retrieved from https://scholarworks.sjsu.edu/cgi/viewcontent.cgi?article=8265&context=etd_theses

Clark, M.R., Althaus, F., Schlacher, T.A., Williams, A., Bowden, D.A., and Rowden, A.A. (2016). The impacts of deep-sea fisheries on benthic communities: a review. *Marine Science, 73*: 51-69. Doi: 10.1093/icesjms/fsv123

Convention on Biological Diversity (2010). Strategic plan for biodiversity 2011-2020, including Aichi biodiversity targets. Retrieved from https://www.cbd.int/sp/#:~:text=In%20decision%20X%2F2%2C%20the,for%20the%202011%2D2020%20period.

De Clippele, L., Buhl-Mortensen, L., and Buhl-Mortensen, P. (2015). Fauna associated with cold water gorgonians and sea pens. Continental Shelf Research, 105: 67-78. Doi: 10.1016/j.csr.2015.06.007

Environment and Climate Change Canada (2017). Selection and management of migratory bird sanctuaries. *Government of Canada*. Retrieved from https://www.canada.ca/en/environment-climate-change/services/migratory-bird-sanctuaries/selection-criteria/management.html

Environment and Climate Change Canada (2020). Management plans and activities for national wildlife areas. *Government of Canada*. Retrieved from https://www.canada.ca/en/environment-climate-change/services/national-wildlife-areas/site-selection/management-plans-activities.html

Fisheries and Oceans Canada (2006). Coral Conservation Plan Maritimes Region (2006-2010). *Government of Canada*. Retrieved from https://waves-vagues.dfo-mpo.gc.ca/Library/322312.pdf

Fisheries and Oceans Canada (2009a). Development of a framework and principle for the biogeographic classification of Canadian marine areas. Canada Science Advisory Secretariat Science Advisory Report. 2009/056. *Government of Canada*. Retrieved from https://waves-vagues.dfo-mpo.gc.ca/Library/338958.pdf

Fisheries and Oceans Canada (2009b). Policy for managing the impacts of fishing on sensitive benthic areas. *Government of Canada*. Retrieved from https://dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/benthi-eng.htm#n6

Fisheries and Oceans Canada (2012). Marine protected area network planning in the Scotian Shelf Bioregion: Objectives, data, and methods. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Science Advisory Report, 2012/064.

Fisheries and Oceans Canada (2015). Coral and sponge conservation strategy for Eastern Canada 2015. *Government of Canada*. Retrieved from https://waves-vagues.dfo-mpo.gc.ca/Library/363832.pdf

Fisheries and Oceans Canada (2017a). Corals and sponges of the Maritimes. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/ceccsr-cerceef/corals-coraux-eng.html

Fisheries and Oceans Canada (2017b). Delineation of significant concentrations of cold-water corals and sponge-dominated communities in Canada's Atlantic and Eastern Arctic marine waters and their overlap with fishing activity. *Canadian Science Advisory Secretariat, Science Advisory Report* 2017/007. Retrieved from https://waves-vagues.dfo-mpo.gc.ca/Library/40600099.pdf

Fisheries and Oceans Canada (2017c). Haddock. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/species-especes/profiles-profils/haddock-aiglefin-eng.html

Fisheries and Oceans Canada (2017d). The Gully: Marine Protected Area Management Plan. *Government of Canada, Oceans and Coastal Management Division*. Retrieved from https://waves-vagues.dfo-mpo.gc.ca/Library/4083556x.pdf

Fisheries and Oceans Canada (2017e). Operational guidance for identifying 'other effective area-based conservation measures' in Canada's marine environment. Government of Canada. Retrieved from https://waves-vagues.dfo-mpo.gc.ca/Library/4069060x.pdf

Fisheries and Oceans Canada (2017f). St. Anns Bank Regulatory Impact Analysis Statement. *Canada Gazette Part II*, 151(12): 1205-1245. Retrieved from https://www.dfo-mpo.gc.ca/oceans/documents/mpa-zpm/stanns-sainteanne/St-Anns-Bank-RIAS.pdf

Fisheries and Oceans Canada (2018a). 4VWX5 groundfish – Maritimes Region. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/groundfish-poisson-fond/groundfish-poisson-fond-4vwx5-eng.html#toc4

Fisheries and Oceans Canada (2018b). Guiding Principles. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/networks-reseaux/principles-principes-eng.html

Fisheries and Oceans (2018c). What is the network? *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/networks-reseaux/info-eng.html

Fisheries and Oceans Canada (2019a). Canada's fisheries fast facts. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/stats/stats-eng.htm

Fisheries and Oceans Canada (2019b). Musquash Estuary Marine Protected Area. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/musquash/index-eng.html

Fisheries and Oceans Canada (2019c). Jordan Basin Conservation Area. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/oeabcm-amcepz/refuges/jordan-eng.html

Fisheries and Oceans Canada (2019d). Northeast Channel Coral Conservation Area. Government of Canada. Retrieved from https://www.dfo-mpo.gc.ca/oceans/oeabcm-amcepz/refuges/northeast-nordest-eng.html

Fisheries and Oceans Canada (2019e). Protection standards to better conserve our oceans. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/standards-normes-eng.html

Fisheries and Oceans Canada (2019f). Reaching marine conservation targets. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/conservation/plan/index-eng.html

Fisheries and Oceans Canada (2019g). St. Anns Bank Marine Protected Area. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/stanns-sainteanne/index-eng.html

Fisheries and Oceans Canada (2020a). Canada's Conserved Areas. *Government of Canada*. Retrieved from https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/conserved-areas.html

Fisheries and Oceans Canada (2020b). Canada's marine protected and conserved areas. Government of Canada. Retrieved from https://www.dfo-mpo.gc.ca/oceans/conservation/areas-zones/index-eng.html

Fisheries and Oceans Canada (2020c). Establishing new Marine Protected Areas. Government of Canada. Retrieved from https://www.dfo-mpo.gc.ca/oceans/aoi-si/index-eng.html

Fisheries and Oceans Canada (2020d). Guidance on other measures. *Government of Canada*. Retrieved from http://www.dfo-mpo.gc.ca/oceans/oeabcm-amcepz/guidance-eng.html

Fisheries and Oceans Canada (2020e). The Gully Marine Protected Area. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/gully/index-eng.html

Fisheries and Oceans Canada (2020f). Marine Protected Areas across Canada. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/index-eng.html

Fisheries and Oceans Canada (2020g). Marine refuges across Canada. *Government of Canada*. Retrieved from http://www.dfo-mpo.gc.ca/oceans/oeabcm-amcepz/refuges/index-eng.html

Fisheries and Oceans Canada (2020h). Sustainable Fisheries Framework. *Government of Canada*. Retrieved from https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/overview-cadre-eng.htm

Forcada, A., Valle, C., Bonhomme, P., Criquet, G., Cadiou, G., Lenfant, P., and Sánchez-Lizaso, J.L. (2009). Effects of habitat on spillover from marine protected areas to artisanal fisheries. *Marine Ecology Progress Series, 379*: 197-211. Doi: 10.3354/meps07892.

Ford, J. and Serdynska, A. (2013). Ecological overview of St. Anns Bank, Canadian Technical Report of Fisheries and Aquatic Science, 3023: xiv + 252 p.

Fuller, S., Picco, C., Ford, J., Tsao, C., Morgan, L.E., Hangaard, D., Chuenpagdee (2008). How we fish matters: Addressing the ecological impacts of Canadian fishing gear. *Living Oceans*. Retrieved from https://www.livingoceans.org/sites/default/files/HowWeFish.pdf

Game, E.T., and Grantham, H.S. (2008). Marxan user manual for Marxan version 1.8.10. University of Queensland, St. Lucia, Queensland, Australia, and Pacific Marine Analysis and Research Association (PacMARA), Vancouver, British Columbia, Canada.

Government of Canada (2019). Sectoral profile – fishing and fish processes: Atlantic Region 2019. Retrieved from https://www.jobbank.gc.ca/content_pieces-eng.do?cid=15578

International Union for the Conservation of Nature (2008). Establishing marine protected area networks. Retrieved from https://www.iucn.org/content/establishing-marine-protected-area-networks

Jeffrey, N. (2009). Stakeholder engagement: A roadmap to meaningful engagement. Doughty Centre 'How to do Corporate Responsibility' series. Cranfield University School of Management.

Kenchington, E., Beazley, L., Lirette, C., Murillo-Perez, J., Guijarro-Sabaniel, J., Wareham, V., Gilkinson, K., Koen-Alonso, M., Benoit, H., Bourdages, H., Saint-Marie, B., Treble, M., Siferd, T. (2018). Delineation of coral and sponge significant benthic areas in Eastern Canada using kernel density analyses and species distribution models. Mendeley Data, v1. DOI: 10.17632/hnp4xr2sy3.1

King, M., Fenton, D., Aker, J. and Serdynska, A. (2016). Offshore ecologically and biologically significant areas in the Scotian Shelf bioregion. *Fisheries and Oceans Canada, Canadian Science Advisory Secretariat.* Research Document 2016/007. viii + 92 p.

Minister of Justice (2004). Gully Marine Protected Area Regulations SOR/2004-112. *Government of Canada*. Retrieved from https://laws-lois.justice.gc.ca/eng/regulations/SOR-2004-112/page-1.html

Murillo, F.J., MacDonald, B.W., Kenchington, E., Campana, S.E., Sainte-Marie, B., and Sacau, M. (2018). Morphometry and growth of sea pen species from dense habitats in the Gulf of

St. Lawrence, eastern Canada. Marine Biology Research, 14(4): 366-382. Doi: 10.1080/17451000.2017.1417604

Murawski, S.A., Wigley, S.E., Fogarty, M.J., Rago, P.J., and Mountain, D.G. (2005). Effort distribution and catch patterns adjacent to temperate MPAs. International Council for the Exploration of the Sea Journal of Marine Science, 62(6): 1150-1167. Doi: 10.1016/j.icesjms.2005.04.005

*National Marine Conservation Areas Act* (S.C. 2002, c.18). Retrieved from https://laws-lois.justice.gc.ca/eng/acts/c-7.3/page-5.html#docCont

National Oceanic and Atmospheric Administration (NOAA) (n.d.). Fishing gear: Gillnets. NOAA Fisheries. Retrieved from https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-gillnets

Newswire (2020, July 9). Canada joins Global Ocean Alliance: Advocates for protecting 30 per cent of the world's ocean by 2030. Retrieved from https://www.newswire.ca/news-releases/canada-joins-global-ocean-alliance-advocates-for-protecting-30-per-cent-of-the-world-s-ocean-by-2030-833945175.html

Nozéres, C. (2011). *Asconema foliatum***.** World Register of Marine Species. Retrieved from http://www.marinespecies.org/aphia.php?p=image&tid=172017&pic=38778

Oceana (n.d.). How is seafood caught? A look at fishing gear types in Canada? *Oceana*. Retrieved from https://oceana.ca/en/blog/how-seafood-caught-look-fishing-gear-types-canada

*Oceans Act* (S.C. 1996, c.31). Retrieved from https://laws.justice.gc.ca/eng/acts/O-2.4/section-35.html

Pardy, G. (2020). Planning unit shapefile for Scotian Shelf. *Fisheries and Oceans Canada*.

Pasquad, S., and Lobry, J. (2011). A critical look at the definition of indicators to assess the effectiveness of marine protected areas. *Science Eaux & Territories*. Doi: 10.14758/SET-REVUE.2011.3BIS.23

Philippe, C. (2017). Other effective area-based conservation measures. Fisheries and Oceans Canada. Retrieved from https://open.canada.ca/data/en/dataset/44769543-7a23-4991-a53f-c2cf7c7a946f

Philippe, C. (2019). Oceans Act Marine Protected Areas. *Fisheries and Oceans Canada*. Retrieved from https://open.canada.ca/data/en/dataset/a1e18963-25dd-4219-a33f-1a38c4971250

Puig, P., Canals, M., Company, J.B., Martin, J., Amblas, D., Lastras, G., Palanques, A., and Calafat, A.M. (2012). Ploughing the deep-sea floor. Nature, 489(13): 286-230. DOI: 10.1038/nature11410

Riahi, Y. (2017). Project stakeholders: Analysis and management processes. SSRG International Journal of Economics and management Studies, 4(3): 37-42. Doi: 10.14445/23939125/IJEMS-V4I3P108

Sánchez, J.A., Dueñas, L.F., Rowley, S.J., Gonzalez-Zapata, F.L., Vergara, D.C., Montaño-Salazar, S.M., Calixto-Botía, I., Gómez, C.E., Abeytia, R., Colin, P.K., Cordeiro, R.T.S., and Pérez, C.D. (2019). Gorgonian corals. *Mesophotic Coral Ecosystems, Coral Reefs of the World*, 12. 729-747. Doi: 10.1007/978-3-319-92735-0_39.

Secretariat of the Convention on Biological Diversity (2010). Strategic Plan for Biodiversity 2011-2020 and the Aichi Targets. Retrieved from https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf

Statistics Canada (2016). Highlights of Canada's geography. Government of Canada. Retrieved from https://www150.statcan.gc.ca/n1/pub/11-402-x/2012000/chap/geo/geo-eng.htm

Trudeau, J. (2019). Minister of Fisheries, Oceans, and the Canadian Coast Guard Mandate Letter. Retrieved from https://pm.gc.ca/en/mandate-letters/2019/12/13/minister-fisheries-oceans-and-canadian-coast-guard-mandate-letter

United Nations (2002). Report of the world summit on sustainable development, Johannesburg, South Africa, 26 August – 4 September 2002. *United Nations Publication*, Sales No. E.03.II.A.1 ISBN 92-1-1-4521-5

Wareham, V. (2010). *Pennatula aculeata*. World Register of Marine Species. Retrieved from http://www.marinespecies.org/aphia.php?p=image&tid=128515&pic=41903

Wareham, V. (2011a*). Acanthogorgia armata*. World Register of Marine Species. Retrieved from http://www.marinespecies.org/photogallery.php?album=708&pic=41870

Wareham, V. (2011b). *Acanella arbuscula*. World Register of Marine Species. Retrieved from http://www.marinespecies.org/aphia.php?p=taxdetails&id=125371#images

Watson, M.S., and Hewson, S.M. (2018). Securing protection standards for Canada's marine protected areas. Marine Policy, 95: 117-122. Doi: 10.1016/j.marpol.2018.07.002. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0308597X18302318?via%3Dihub

Withers, P. (2018). Ottawa considers dozens more marine protected areas in the Maritimes. *CBC News*. Retrieved from https://www.cbc.ca/news/canada/nova-scotia/marine-protected-area-maps-maritimes-1.4658048#:~:text=The%20maps%20show%2024%20proposed,in%20the%20Gulf%20of%20St.