# Ecological risk assessment of the Fundian Channel-Browns Bank Area of Interest

Tanya Koropatnick, Lisa Baxter, Bryden Bone, Ulrike Irlich, Emma Marotte, Leah McConney, Gary Pardy, Kasia Rozalska, Catherine Schram & Elise Will

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Koropatnick, T., Baxter, L., Bone, B., Irlich, U., Marotte, E., McConney, L., Pardy, G., Rozalska, K., Schram, C., and Will, E. 2023. Ecological risk assessment of the Fundian Channel-Browns Bank Area of Interest. Can. Tech. Rep. Fish. Aquat. Sci. 3550: v + 325 p.

An ecological risk assessment was conducted for the Fundian Channel-Browns Bank Area of Interest (AOI) to establish the relative risks presented by a variety of human activities to the identified conservation priorities for a potential Marine Protected Area (MPA). Activities considered in the assessment were limited to those that currently occur within the AOI (fisheries, and marine transportation) and those that may occur within the near future (i.e. midwater trawl). Risk levels were determined by assessing the consequence and likelihood of interactions between activity/pressures and conservation priorities for the site. Consequence was determined by estimating the magnitude of each interaction (i.e., exposure based on the expected level of human activity) and the sensitivity of the ecological component to the pressure. Consequence levels were combined with the likelihood (i.e., probability) of the interaction to determine an overall level of risk. The findings of this assessment will contribute to discussion and decision-making on activities that would be allowed under the regulations within a potential Fundian Channel-Browns Bank MPA, and will help inform the design of the boundary and zones for the potential future MPA.



## RÉSUMÉ

Koropatnick, T., Baxter, L., Bone, B., Irlich, U., Marotte, E., McConney, L., Pardy, G., Rozalska, K., Schram, C., and Will, E. 2023. Ecological risk assessment of the Fundian Channel-Browns Bank Area of Interest. Can. Tech. Rep. Fish. Aquat. Sci. 3550: v + 325 p.

Une évaluation des risques écologiques pour le site d’intérêt (SI) du chenal de Fundy et du banc de Browns a été effectuée afin d’établir les risques relatifs que présentent diverses activités humaines pour les priorités de conservation identifiées pour une éventuelle zone de protection marine (ZPM). Les activités prises en compte dans l’évaluation ont été limitées à celles qui se pratiquent déjà dans la zone d’intérêt (pêche et transport maritime) et à celles qui pourraient s’y pratiquer dans un proche avenir (c.-à-d. chalut pélagique). Les niveaux de risque ont été déterminés en évaluant les conséquences et la probabilité d’interactions entre les activités/pressions et les priorités de conservation applicables au site. Les conséquences ont été déterminées en évaluant l’ampleur de chaque interaction (c.-à-d. l’exposition en fonction du niveau prévu d’activité humaine) et la sensibilité de la composante écologique à la pression. Les niveaux de conséquence ont été combinés avec la probabilité de l’interaction pour déterminer le niveau global de risque. Les résultats de cette évaluation contribueront à la discussion et à la prise de décisions concernant les activités qui seraient autorisées en vertu de la réglementation dans une éventuelle ZPM du chenal de Fundy et du banc de Browns, et informeront la conception des limites et des zones de l’éventuelle ZPM.

# 1.0 INTRODUCTION

## 1.1 BACKGROUND

Fisheries and Oceans Canada (DFO) has identified the Fundian Channel-Browns Bank as an Area of Interest (AOI) for marine protected area (MPA) designation under the *Oceans Act*. This site was selected as part of the larger, DFO-led conservation network design effort for the Scotian Shelf Bioregion.

The Fundian Channel-Browns Bank AOI is located approximately 120 km south of Yarmouth, Nova Scotia and includes two geographically separate components (Figure 1.1-1). The western section of this AOI is centred on Georges Basin and the larger eastern section encompasses the Fundian Channel and part of Browns Bank. The boundaries of the AOI reflect a general area of consideration and should not be considered as future MPA boundaries.

This area encompasses important oceanographic processes, diverse benthic habitats, depleted species, and sensitive biogenic habitats (DFO 2020*a*). The cold, nutrient-rich waters of the Labrador Current flow into the Gulf of Maine through the Fundian Channel making this site essential to the circulation and primary productivity patterns of the western portion of the Scotian Shelf Bioregion. The channel represents the main hydrodynamic connection to the Gulf of Maine from the open Atlantic Ocean and many species, including basking sharks, use it as a migration corridor. The area known as the Hell Hole, at the mouth of the Fundian Channel, is a distinct oceanographic feature where high levels of mixing result in the aggregation of large pelagic fishes and other species at certain times of the year. The Fundian Channel-Browns Bank AOI also encompasses a wide range of benthic habitat types, including bank, basin, channel and slope. It is an area of high biodiversity and includes important habitat for many depleted groundfish species. The channel portion of the site contains among the highest density aggregations of large gorgonian corals recorded in the region, and the Browns Bank portion contains a diverse benthic community, including significant concentrations of sponges.

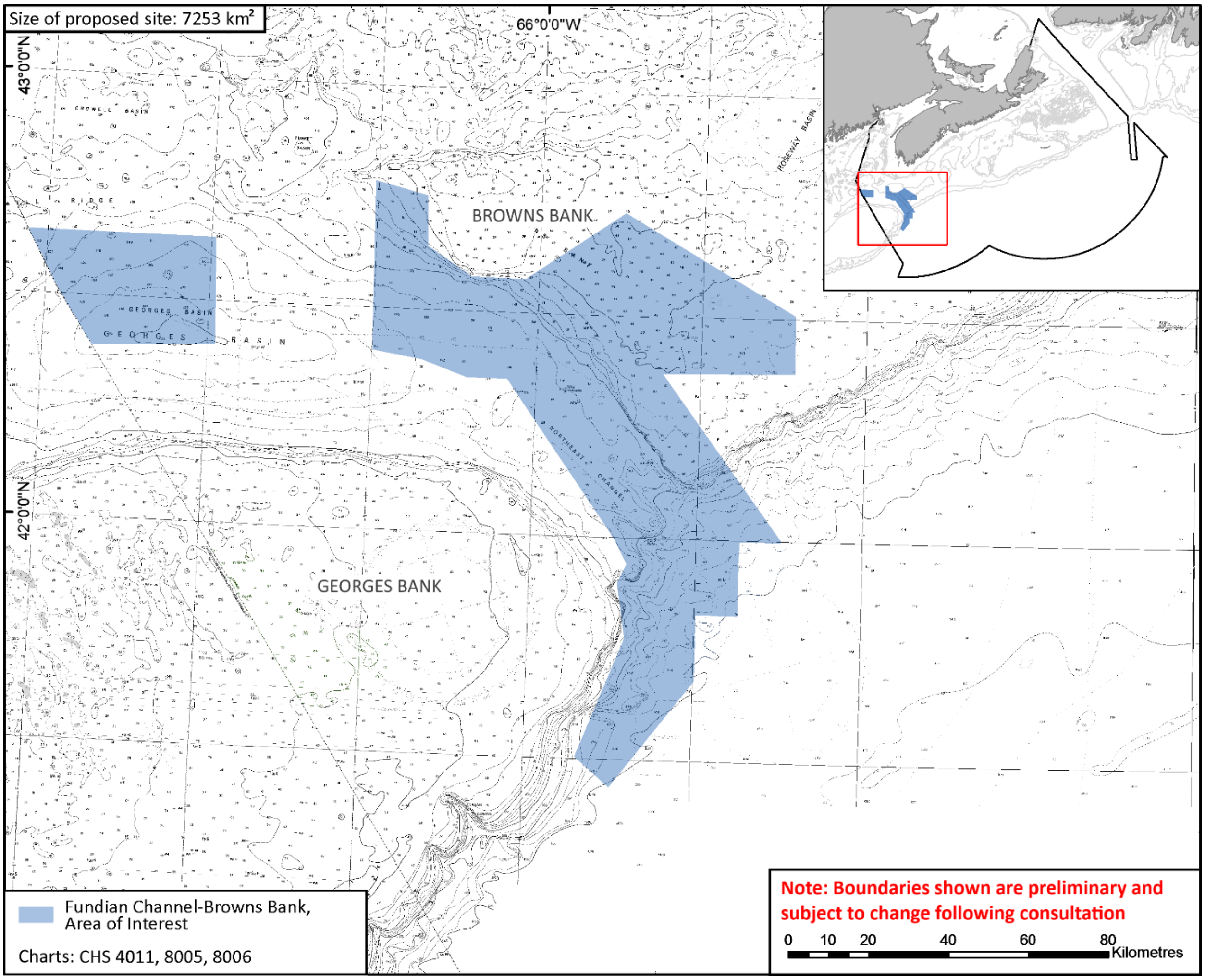



Figure 1.1-1. The Fundian Channel-Browns Bank AOI (shaded blue) within DFO's Maritimes Region (inset). The boundaries for the proposed marine protected area shown on this map are for information, study, and consultation purposes only.

The MPA Establishment Process

The process for establishing and managing *Oceans Act* MPAs includes the following steps[1]:

Step 1: Select and announce the AOI
Step 2: Feasibility assessment, policy development

- Ecological/biophysical, social, cultural and economic overviews completed
- Ecological risk assessment completed
- Conservation objectives are finalized, and MPA boundaries, zoning and allowable activities are determined, in consultation with affected parties

Step 3: Regulatory development

- Regulations, regulatory impact analysis statement are developed

[1] For more information on the establishment and management of MPAs under the *Oceans Act* see: [Establishing new Marine Protected Areas (dfo-mpo.gc.ca)]

- Draft regulations are published in Canada Gazette I for a public comment period
- MPA is designated and final MPA regulations are published in Canada Gazette II

Step 4: MPA management

After the AOI is selected, a Biological and Ecological Overview is drafted to summarize the ecological and biophysical characteristics of the site. Other overview reports, including Indigenous Ecological Knowledge study(ies), a geological resource assessment, and a marine harvest profile are produced to help describe the ecological, social, cultural, and economic importance of the site. The information gathered and assessed in Step 2 of the process, including information and analysis from this risk assessment, will provide the foundation for consultation on site design, including the development of conservation objectives and regulatory measures, including boundary and zoning of a future MPA.

Once the site design process (i.e., determination of boundaries, zoning and allowable activities) is complete and a decision has been made to move forward, regulations are drafted and published in *Canada Gazette I* for a public comment period. The regulations can then be modified based on the public comments received prior to publishing in *Canada Gazette II* and formal designation as an *Oceans Act* MPA.

Consultation is integral to all steps of this process. In addition to using established consultation mechanisms for First Nations and the Province of Nova Scotia, a dedicated AOI Advisory Committee is created to serve as a key platform for multi-sector engagement in the MPA establishment process. The purpose of the Advisory Committee is to provide a forum to share information, exchange views, and provide advice on MPA design prior to designation. Additional meetings with industry and other stakeholder groups, including industry working groups, may be convened to ensure the users of the area have a strong voice in the design of the potential MPA.

## 1.2 RISK ASSESSMENT OVERVIEW

Risk can be expressed as a combination of the consequence of an event and the associated likelihood of occurrence (ISO 2009). In an ecological context, a risk assessment can help to determine the potential risks that human activities pose to specific ecological components (i.e., conservation priorities) of interest. The ecological risk assessment process begins with characterizing both the conservation priorities of interest and relevant human activities in the study area, and determining the potential for interaction. A risk analysis is then conducted to assess the consequence of potential interactions between each activity/pressure and conservation priorities by estimating the magnitude of each interaction and the degree to which each ecological component is sensitive to the activity/pressure. The estimated level of consequence is then combined with the likelihood (i.e., probability) of the pressure interacting with the conservation priority to determine the overall level of risk (ISO 2009). As part of the analysis, existing management measures will be considered, and other identified factors that may affect the consequence of exposure, such as level of uncertainty, will be noted. The risk analysis approach used for the Fundian Channel-Browns Bank AOI is described in detail in section 1.7 below. This method provides a means of analyzing ecological risks posed by individual activities and their associated pressures to conservation priorities identified for the site; however, this approach does not allow for consideration of cumulative impacts posed by multiple activities to conservation priorities of interest.

## 1.3 OBJECTIVES

*Oceans Act* MPA regulations are designed to meet a set of site-specific conservation objectives. MPA regulations typically include general prohibitions to prevent removal or harm to species and/or habitats, some form of zoning scheme, activity approval requirements (e.g., for research or commercial tourism), and exceptions to the regulations (e.g., national security, certain low impact fishing activities).

The ecological risk assessment for the Fundian Channel-Browns Bank AOI will inform discussions about activities that may be allowed to continue and the activities that should be restricted or prohibited in a future MPA. The findings from this assessment will also help to highlight activities and associated interactions that may require careful management and monitoring post MPA designation. It is important to note that the risk assessment findings are not prescriptive and do not represent final decisions about how activities would be managed in the future MPA. Rather, the assessment provides a structure for considering information about the ecological effects of activities in a systematic manner to help inform discussions and decisions. Other factors, including the precautionary approach, social and economic considerations, and feedback from consultations will be taken into account to determine proposed design and management measures for the potential future Fundian Channel-Browns Bank MPA.

MPAs are designated as a tool to conserve and protect ecological integrity, including biodiversity, ecosystem function, productivity, and the special natural features identified for each site. MPAs are designated under section 35 of Canada's *Oceans Act* for special protection [s.35(1)], so tolerance for risk within an MPA is lower than for other areas. This lower risk tolerance can provide a higher level of protection for the ecological features within the site, and may also help to build ecological resilience to cumulative impacts, including from broader external pressures such as climate change, both within and beyond the MPA boundaries. Thus, the risk scores presented here do not necessarily represent DFO's assessment of risks for the same activities elsewhere in the ocean.

## 1.4 SCOPE OF THE ASSESSMENT

An important first step of ecological risk assessment is scoping (Fletcher 2005; Hobday et al. 2011; DFO 2012*a*), which includes defining the spatial and temporal bounds of the assessment, along with the ecosystem components (i.e., conservation priorities) and human activities that will be assessed. These are each described in more detail below.

### 1.4.1 Spatial bounds

The geographic extent of the Fundian Channel-Browns Bank risk assessment is defined by the AOI boundary (Figure 1.1-1).

### 1.4.2 Temporal bounds

In accordance with DFO Science advice (DFO 2012*b*), activities were considered in the assessment if they currently occur within the AOI or if there has been a demonstrated interest in the pursuit of these activities in the near future (i.e., within the next decade).

### 1.4.3 Conservation Priorities

A primary goal for a future Fundian Channel-Browns Bank MPA would be to conserve and protect the ecological integrity of the area, including its naturalness, biodiversity, ecosystem function, productivity, and the special natural features of the site. However, these aspects are not easily considered in a risk assessment approach. Thus, for reasons of practicality, the ecological risk assessment for this AOI will focus on the specific ecological features that have been proposed as conservation priorities for the site, as informed by the science peer review process (DFO 2020*a*). Note that adjustments to this proposed list may occur through the course of the MPA establishment process, including through the addition of priorities identified through the Indigenous Knowledge Study(ies) that will be completed for the site.

The proposed conservation priorities for the future Fundian Channel-Browns Bank MPA are:

- Diverse representation of habitat types, including basin, bank, deep water slope and channel habitats, and their associated fish and invertebrate communities
- Persistent habitat for juvenile Atlantic Halibut
- Concentrations of large mature female lobster
- Suitable beaked whale habitat
- Deep-water corals
- Significant concentrations of sponges
- Representative habitat for Atlantic Cod, Atlantic Wolffish, Winter Skate, Thorny Skate, and White Hake
- Highly suitable habitat for Cusk
- The collection of oceanographic features, such as internal waves, areas of upwelling, and occasional presence of Gulf current and warm-core rings, at the mouth of the Fundian Channel that make it a highly productive area that is associated with the presence of large pelagic fishes, sea turtles, and cetaceans
- A Blue Whale foraging area
- Foraging habitat for most functional guilds of marine birds

For further information about the biophysical and ecological features of the Fundian Channel-Browns Bank AOI, refer to DFO (2020*a*).

Below is a description of the conservation priorities for the Fundian Channel-Browns Bank AOI that will be the focus of this risk assessment. Note that the spatial extent of the conservation priorities was identified based on best available knowledge of the area and the precautionary principle.

Concentrations of large mature female lobster

American Lobster (*Homarus americanus*) generally inhabit coastal waters (<50 m), but can be found in waters as deep as 500 m along slopes and in basins of the Western Scotian Shelf where warm water occurs throughout the year (Pezzack et al. 2015). The offshore lobster population, including in a portion of the AOI, have been found to have higher proportions of large (>140 mm), ovigerous females than coastal populations (Cook et al. 2017; DFO 2020*a*). Lobster abundance in offshore waters varies seasonally and is highest in summer during spawning, which occurs in waters up to 100 m deep (Harding et al. 2005). Data from the Summer RV survey has shown the abundance of lobster caught in the vicinity of the AOI is consistently amongst the highest on the Scotian Shelf (DFO 2020*a*). Additionally, Scotian Shelf ichthyoplankton surveys have reported that most larval lobster found offshore were caught in the vicinity of Browns and Georges Banks (Watson and Miller 1991), with some surveys reporting abundance of early stage larvae up to 2.5 times higher when compared to coastal areas (Harding and Trites 1988). Lobster feed on a variety of prey, including crustaceans, worms, shellfish, and fish (Lavalli and Lawton 1996).

For this assessment, the area of high lobster abundance that overlaps the AOI was determined using the top quintile biomass of lobster caught in the summer RV survey (2014-2019) (Figure 1.4.3-1).

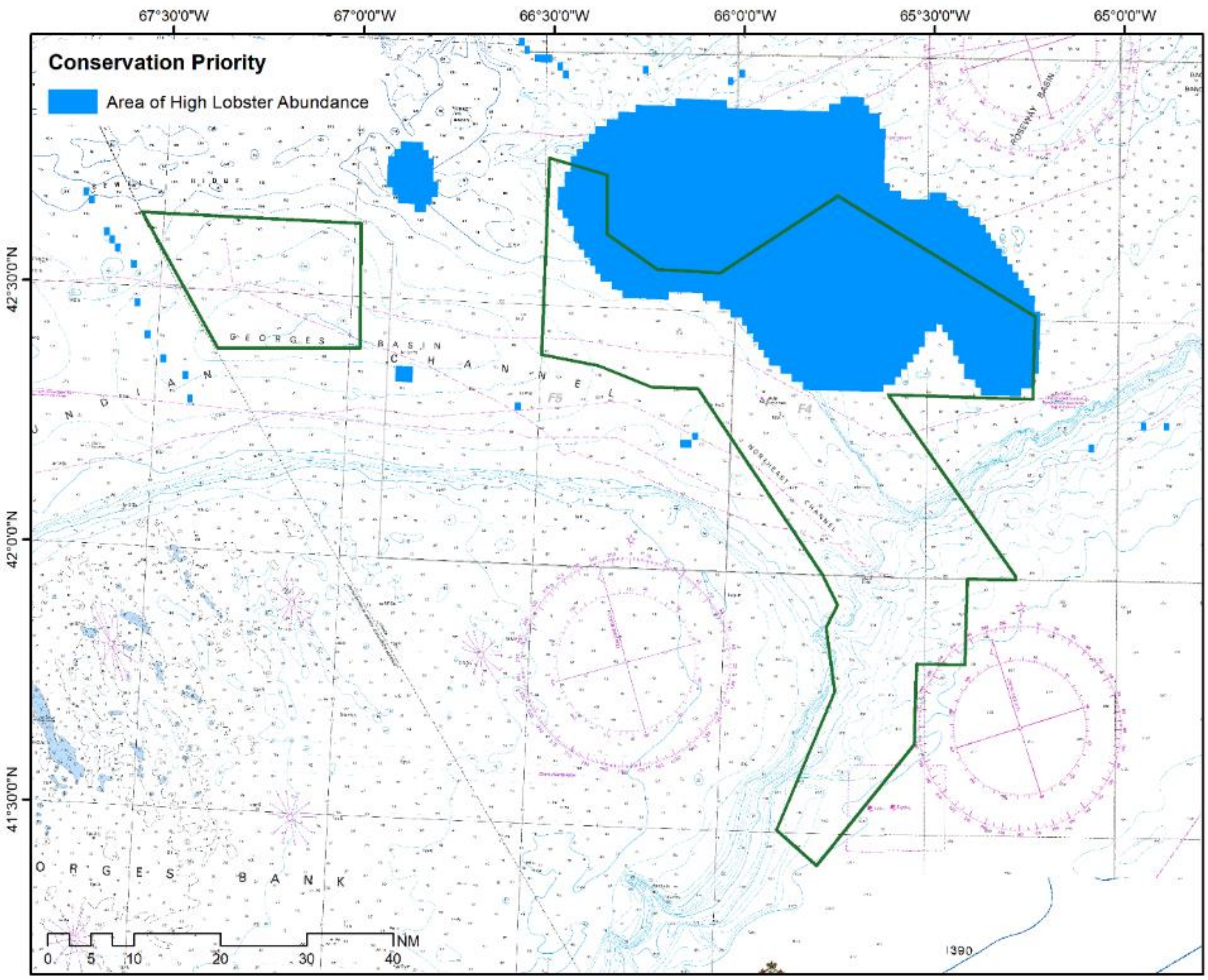



Figure 1.4.3-1. Area of high lobster abundance that overlaps the Fundian Channel-Browns Bank AOI (green polygon).

*Cetaceans*

Suitable habitat for beaked whales

Beaked whales belong to the odontocete (toothed) family Ziphiidae of which 24 species are known to exist (Committee on Taxonomy 2021), and range in size from three to 13 meters (Mead 2009). These whales are some of the most wide-ranging, inhabiting the pelagic waters of the open ocean from the ice edges at either pole to the equator (MacLeod et al. 2006; Mead 2009). They regularly make deep (>1 km) foraging dives over an hour in duration hunting for small deep-water fish and squid (Madsen et al. 2014). Because of the energetically costly nature of these dives, beaked whales spend relatively little time foraging (<20%), which is believed to be the reason they are often found around upwelling areas, such as shelf edges, that provide stable and dense patches of food (Waring et al. 2001; Madsen et al. 2014).

Sowerby's Beaked Whales (*Mesoplodon bidens*) are endemic to the North Atlantic Ocean and are known to frequent the continental slopes off Nova Scotia and Newfoundland and Labrador in waters deeper than 200 m including near canyons and in the open ocean (DFO 2017). They often occur in small groups of three to five individuals, though groups of up to 10 have been observed (Hooker and Baird 1999). While detailed information on spatial and temporal patterns of occurrence is limited, acoustic data show that Sowerby's Beaked Whales are present in the Gully throughout the year (Stanistreet et al. 2017), as well as in areas further south along the continental slope including the Fundian Channel (J. Stanistreet, unpublished data), Georges Bank (Stanistreet et al. 2017) and Heezen Canyon (Rafter et al. 2018). Sowerby's Beaked Whales were assessed as Special Concern by COSEWIC in 1989 and were listed under SARA as Special Concern in 2011 (COSEWIC 2019).

Northern Bottlenose Whales (*Hyperoodon ampullatus*) are also endemic to the North Atlantic Ocean (MacLeod et al. 2006) and generally inhabit waters deeper than 500 m (DFO 2016). They are known to be curious and will often approach vessels to investigate. The Scotian Shelf population consists of approximately 175 individuals, and based on sightings and acoustic data, is known to occur along the shelf edge from the Fundian Channel in the south to the Laurentian Channel and around the Grand Banks in the east (DFO 2020*b*; Feyrer 2021). The population is concentrated primarily in the Gully, Haldimand, and Shortland canyons throughout the year (Whitehead et al. 1997; Wimmer and Whitehead 2004) and critical habitat for this population includes Zone 1 of the Gully MPA and the deep waters (>500 m) of Haldimand and Shortland Canyons (DFO 2016). The whales also use inter-canyon areas for foraging and as movement corridors, so these areas are also considered important for the species (DFO 2020*b*). It should be noted, however, that the full extent of important habitat for this population is still not known and additional research is needed to fully understand Northern Bottlenose Whale habitat on the Scotian Shelf, including areas east and west of currently identified critical habitat (Stanistreet et al. 2021). Given its small size and presence year-round in a relatively small area, the Scotian Shelf population of Northern Bottlenose Whales was assessed as Endangered by COSEWIC in 2002 and was listed under SARA as Endangered in 2006 (COSEWIC 2011).

Passive acoustic monitoring by the Ocean and Ecosystem Sciences Division, Fisheries and Oceans Canada from 2018–2019 has shown acoustic detections of Cuvier's Beaked Whales (*Ziphius cavirostris*) and clicks likely produced by True's Beaked Whales (*Mesoplodon mirus*) in the deep waters of the AOI just north of the Fundian Channel (J. Stanistreet, unpublished data). Sowerby's Beaked Whale presence both near and within the AOI has been confirmed in recent years based on visual and acoustic detections made in the area (for full data summary, see DFO 2020*a*).

Furthermore, acoustic (DFO 2020*b*) and visual (Gomez et al. 2017; Stanistreet et al. 2021) detections of Northern Bottlenose Whales have been recorded near the AOI. Previous habitat suitability models integrating available sightings data and environmental variables (e.g., depth, temperature, and slope) have identified predicted suitable habitat for Northern Bottlenose Whales along the deep-water areas of the continental slope (Gómez-Salazar and Moors-Murphy 2014; Gomez et al. 2017), with model results by Gómez-Salazar and Moors-Murphy (2014) highlighting the western shelf edge area encompassed by the AOI. More recent habitat suitability modelling work also predicts the occurrence of Northern Bottlenose Whale habitat along the edge of the Scotian Shelf, including the Fundian Channel and surrounding shelf edge areas, to be medium-high (20-87%), with the average predicted probability of occurrence within the AOI estimated at >40% (L. Feyrer, DFO Science, personal communication, 2022). These modeling outputs are helping to guide current cetacean monitoring efforts.

For the purpose of this assessment, depths of 500-2500 m were considered suitable beaked whale habitat (Figure 1.4.3-2). This depth range was used because this is where the majority of beaked whale sightings and acoustic detections have occurred, though it is important to note that survey efforts in waters deeper than 2500 m are currently very limited (DFO 2016, Stanistreet et al. 2021).

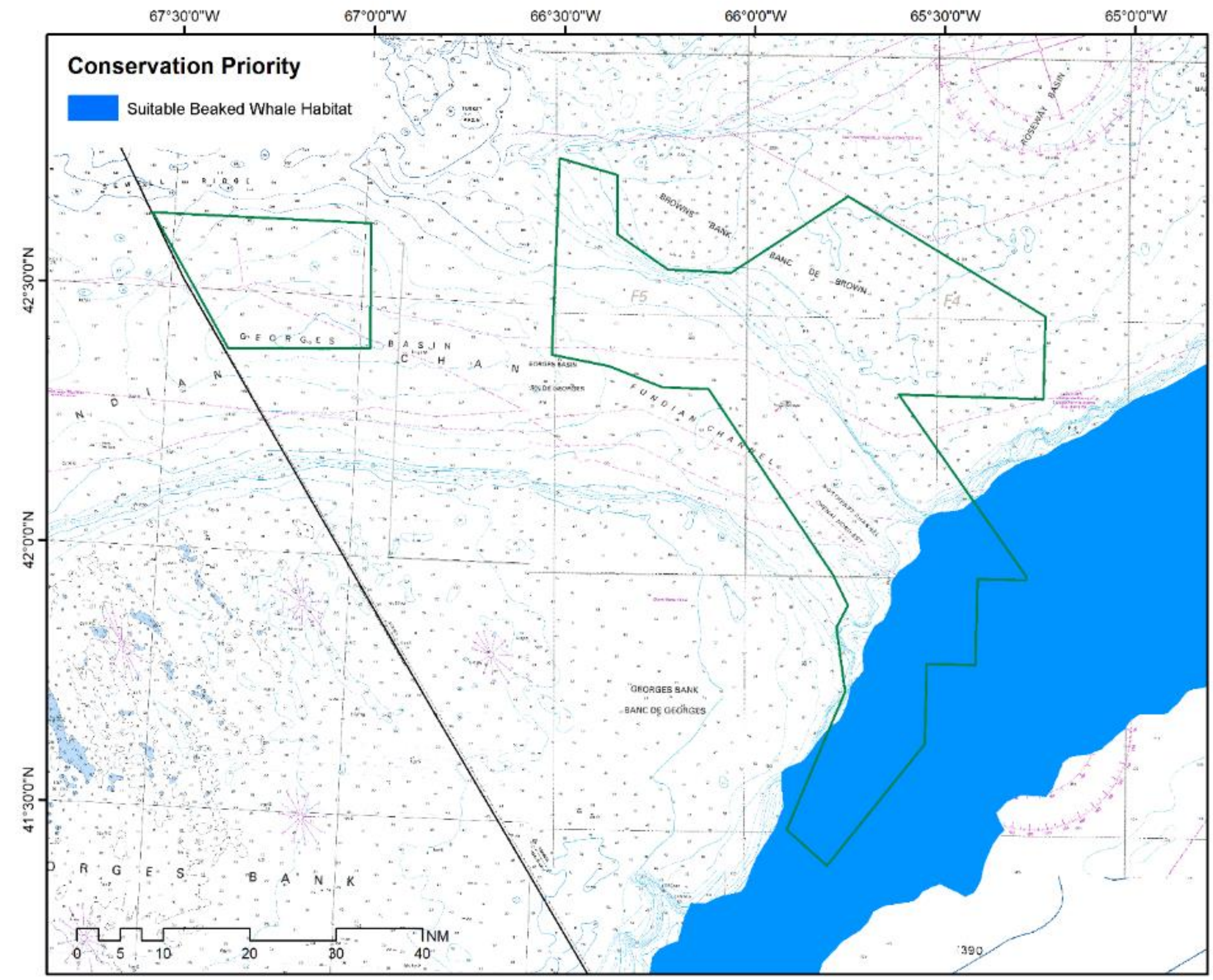



Figure 1.4.3-2. Predicted suitable habitat for beaked whales overlapping the Fundian Channel-Browns Bank AOI (green polygon).

Blue Whale foraging area

The North Atlantic Blue Whale (*Balaenoptera musculus*) population was assessed as Endangered by COSEWIC (2012*a*) in 2002 and subsequently listed as Endangered by SARA in 2005. Most recent minimum population estimates for the western North Atlantic stock is ~402 individuals (NOAA 2020) with indications of low recruitment and calving rates (Beauchamp et al. 2009). These large baleen whales are a migratory species, though at least some individuals occur in Canadian waters throughout the year, and their distribution is often associated with aggregations of krill (Lesage et al. 2018). Areas of potentially highly suitable habitat for enhanced monitoring have been found to comprise much of the western Scotian Shelf break, including the area encompassed by the AOI (Gomez et al. 2017), and results from passive acoustic monitoring efforts have confirmed that at least some Blue Whales remain in parts of the Scotian Shelf throughout the year (Moors-Murphy et al. 2019). Numerous data sources (sightings, passive acoustic detections, predicted krill aggregations, and predicted suitable habitat) indicate that the continental shelf edge off Nova Scotia is also important habitat for Blue

Whales, likely year-round (Lesage et al. 2018). The edge of the continental shelf has therefore been identified as an important Blue Whale foraging area, including a portion of the AOI (Figure 1.4.3-3).

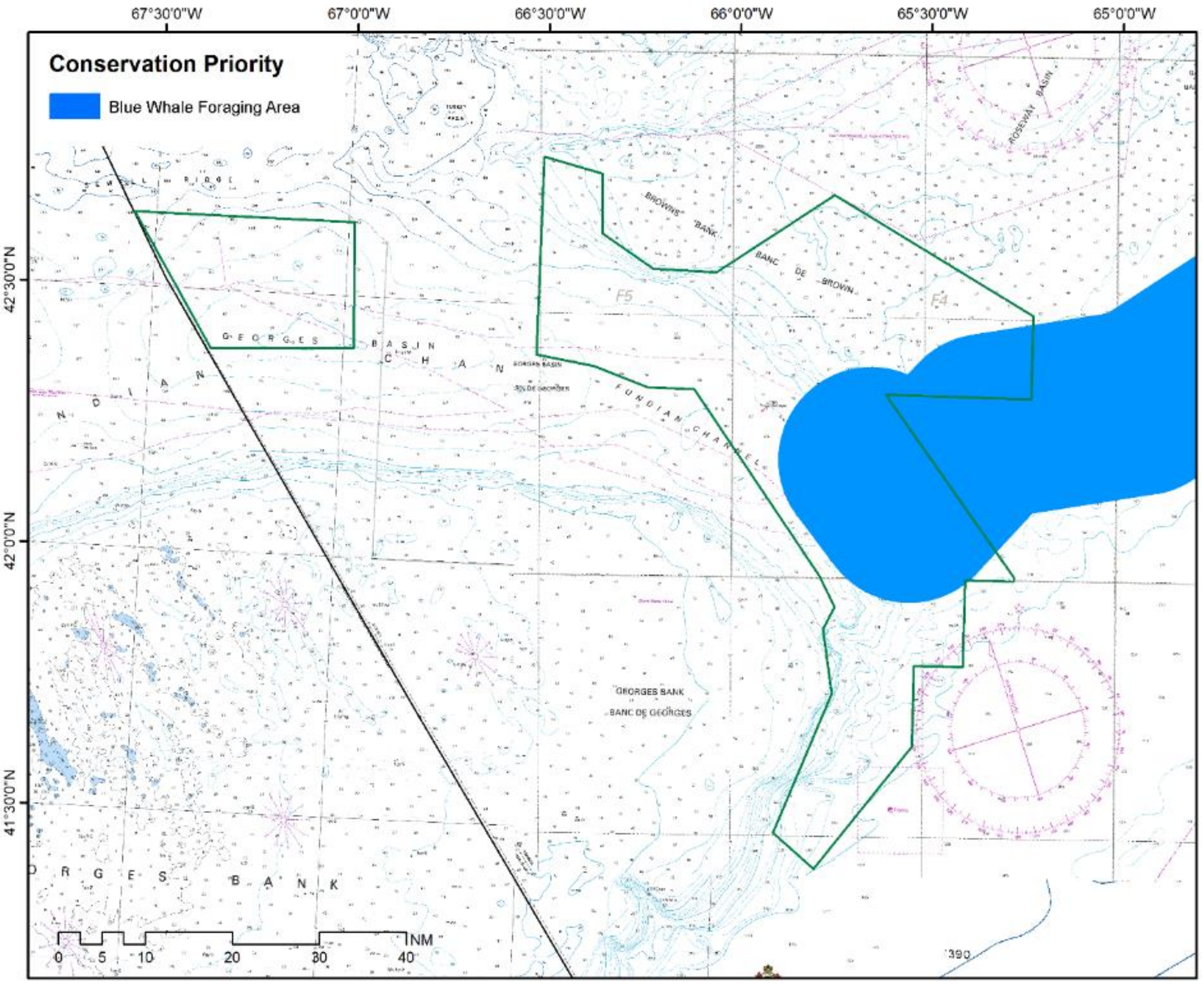



Figure 1.4.3-3. Overlap of important Blue Whale foraging area with the Fundian Channel-Browns Bank AOI (green polygon) (adapted from Lesage et al. 2018).

*Sensitive Benthic Species*

<u>Deep-water corals</u>

Deep-water corals are found between 200-1500 m in depth in canyons, channels and along the edge of the Scotian Shelf, including within the AOI (DFO 2020*a*). Corals are slow growing and long lived (Witherell and Coon 2001), with some individuals within the AOI estimated to be hundreds of years old (Bennecke et al. 2016). These corals provide complex habitat for a variety of species, and can increase species richness and biodiversity in areas where they are found in significant numbers. Ideal habitat for deep-water corals includes presence of strong, relatively warm currents, high levels of nutrients, and hard substrate (DFO 2020*a*). The two most common deep-water corals found in the AOI are *Primnoa resedaeformis* and *Paragorgia arborea*. Within the channel portion of the AOI, these large gorgonian corals can form dense forest-like habitats (DFO 2020*a*).

For the purpose of this assessment, available presence/absence catch data from DFO multispecies trawl surveys and in situ benthic imagery observations of large gorgonian corals was analyzed using a Random Forest model to produce a map of predicted large gorgonian presence probability (methods described in Kenchington et al. 2016, outputs updated with currently available data). A probability threshold of 70% was used to delineate an area of high presence probability for the purpose of the risk analysis (Figure 1.4.3-4); this threshold has been used elsewhere to identify areas of high-quality coral and sponge habitat from MaxEnt presence probability modeling (Miller et al. 2015). A more precautionary area of predicted suitable coral habitat based on a prevalence threshold of 11% probability (method described in Beazley et al. 2016) is also shown and will be considered as part of boundary delineation, as well as management and monitoring for the potential future MPA.

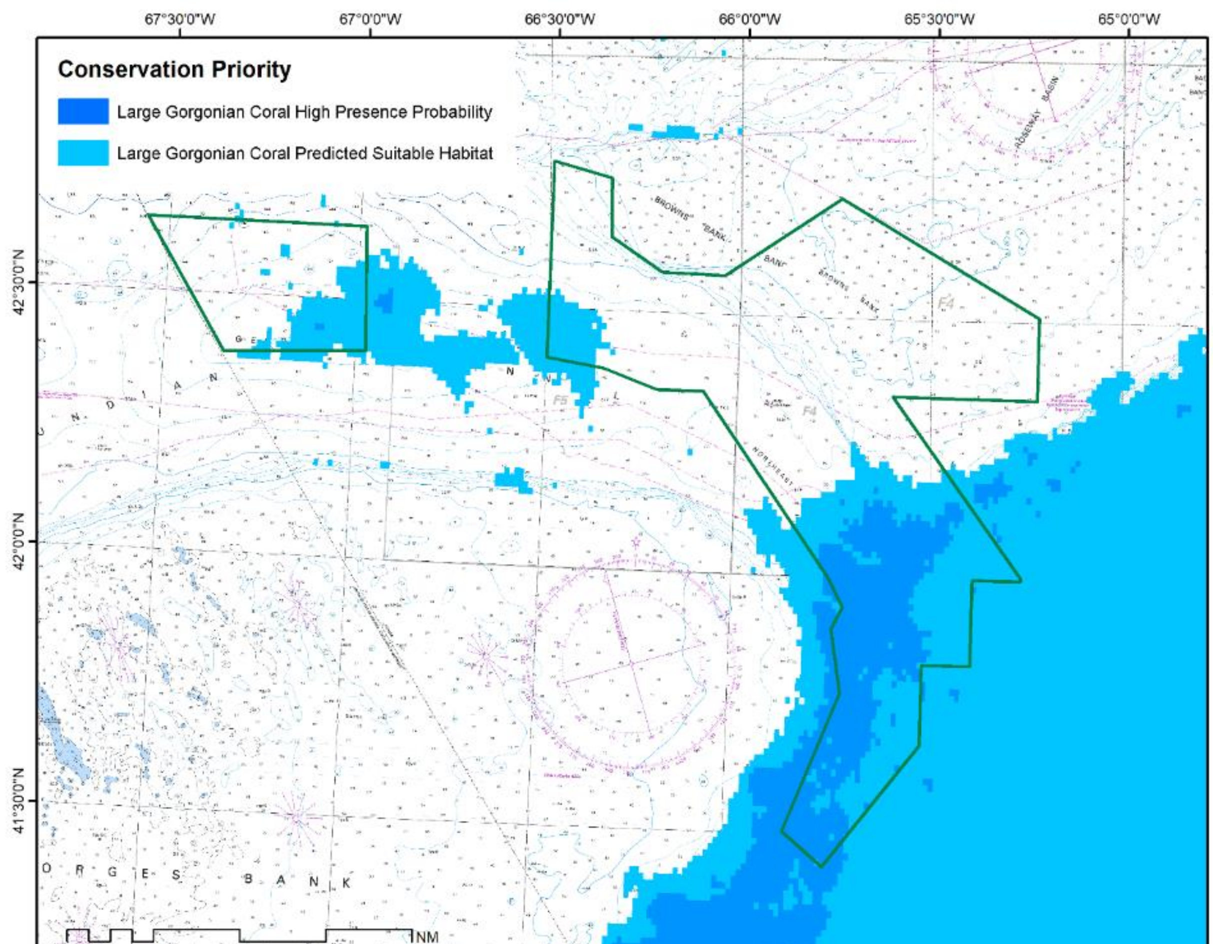



Figure 1.4.3-4. Overlap of the predicted high presence probability (≥70% presence probability) and predicted suitable habitat (≥11% presence probability) for large gorgonian corals with the Fundian Channel-Browns Bank AOI (green polygon).

Significant concentrations of sponges

Like corals, sponges can provide habitat, including refuge, feeding and nursery grounds for a variety of other marine species. In the vicinity of the AOI, the Southern Browns Bank is an area identified as having significant sponge concentrations (Kenchington et al. 2016). Significant concentrations of sponges in the AOI include several species of sponges, with the family Polymastiidae (demosponges) present in all stations sampled during the 2017 RV survey within the AOI (DFO 2020*a*). Polymastiids are massive sponges and are considered indicator taxa for Vulnerable Marine Ecosystems (NAFO 2021). Russian Hat Sponges (*Vazella pourtalesi*) also have a high predicted probability of occurrence in the deep portions of the channel based on a Random Forest model (Beazley et al. 2018), and recent survey work has confirmed these sponges are present, including in high numbers, in certain deep-water locations (Guy and Metaxas 2020). *Vazella pourtalesi* are hexactinellid glass sponges that are susceptible to physical damage (Morrison et al. 2020) and are considered an indicator taxa for Vulnerable Marine Ecosystems (FAO 2009).

For the purpose of this assessment, areas identified as having significant sponge concentrations, as determined by Kenchington et al. (2016), were used to evaluate risks posed to sponges (Figure 1.4.3-5). Where relevant, consideration was also given to potential impacts to Russian Hat Sponges where pressures had the potential to overlap with known locations for that species. Predicted suitable habitat for Russian Hat Sponges (7% threshold; note that certain areas have been masked with hatching to indicate high uncertainty and lack of presence records; adapted from Beazley et al. 2018) is also shown and will be considered as part of boundary delineation, as well as management and monitoring for the potential future MPA.

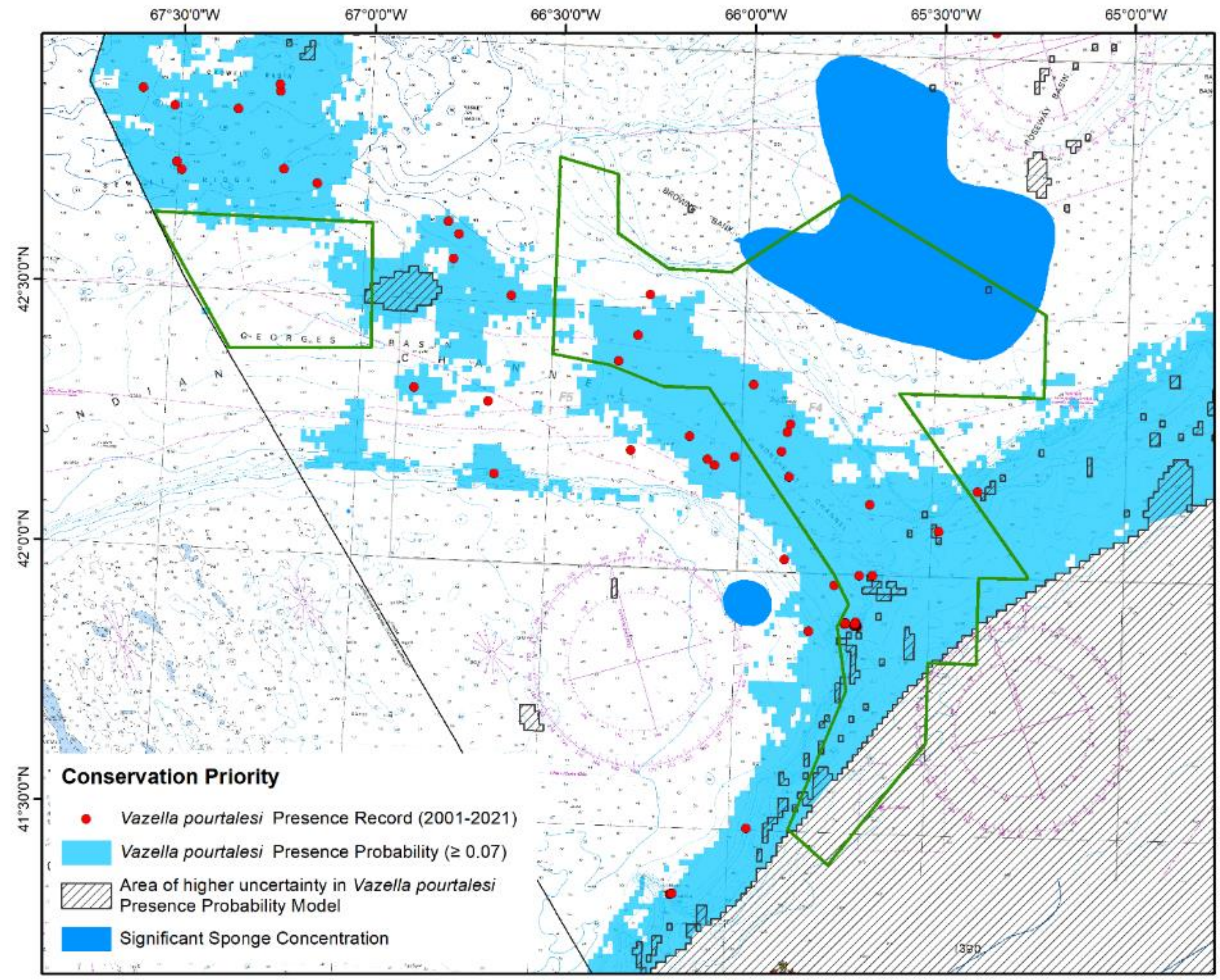



Figure 1.4.3-5. Overlap of areas of significant sponge concentrations (adapted from Kenchington et al. 2016), along with presence records and predicted suitable habitat (≥7% presence probability) for Russian Hat Sponge (*Vazella pourtalesi*; adapted from Beazley et al. 2018). within the Fundian Channel-Browns Bank AOI (green polygon). Note that the hatching indicates areas of higher uncertainty in the *V. pourtalesi* presence probability model, so habitat predictions are less certain in those areas.

*Groundfish*

<u>Persistent habitat for juvenile Atlantic Halibut</u>

Atlantic Halibut (*Hippoglossus hippoglossus*) are commonly found in deep-water channels between banks along the edge of the continental shelf at depths of 200-500 m (DFO 2020*a*). Small halibut primarily feed on invertebrates with the diet shifting predominantly towards fish as size increases (DFO 2006). While halibut spawning areas are not known for the Northwest Atlantic, the AOI has been identified as one of two distinct areas of juvenile halibut abundance in the Scotian Shelf Bioregion (Shackell et al. 2016; Boudreau et al. 2017). These two hotspots, which overlap the Fundian Channel-Browns Bank AOI and the Gully MPA, have been consistently observed over more than three decades despite fluctuations in overall Atlantic Halibut stock abundance, suggesting these areas are persistent and resilient juvenile halibut refugia.

For the purpose of this assessment, the extent of the area of high juvenile Halibut abundance that overlaps the AOI was determined using the outputs of a Bayesian hierarchical spatiotemporal model employed by Boudreau et al. (2017), using halibut catch data from fishery-independent research trawl surveys collected from 2004-2013, and a threshold log abundance of 0.7 (Figure 1.4.3-6).

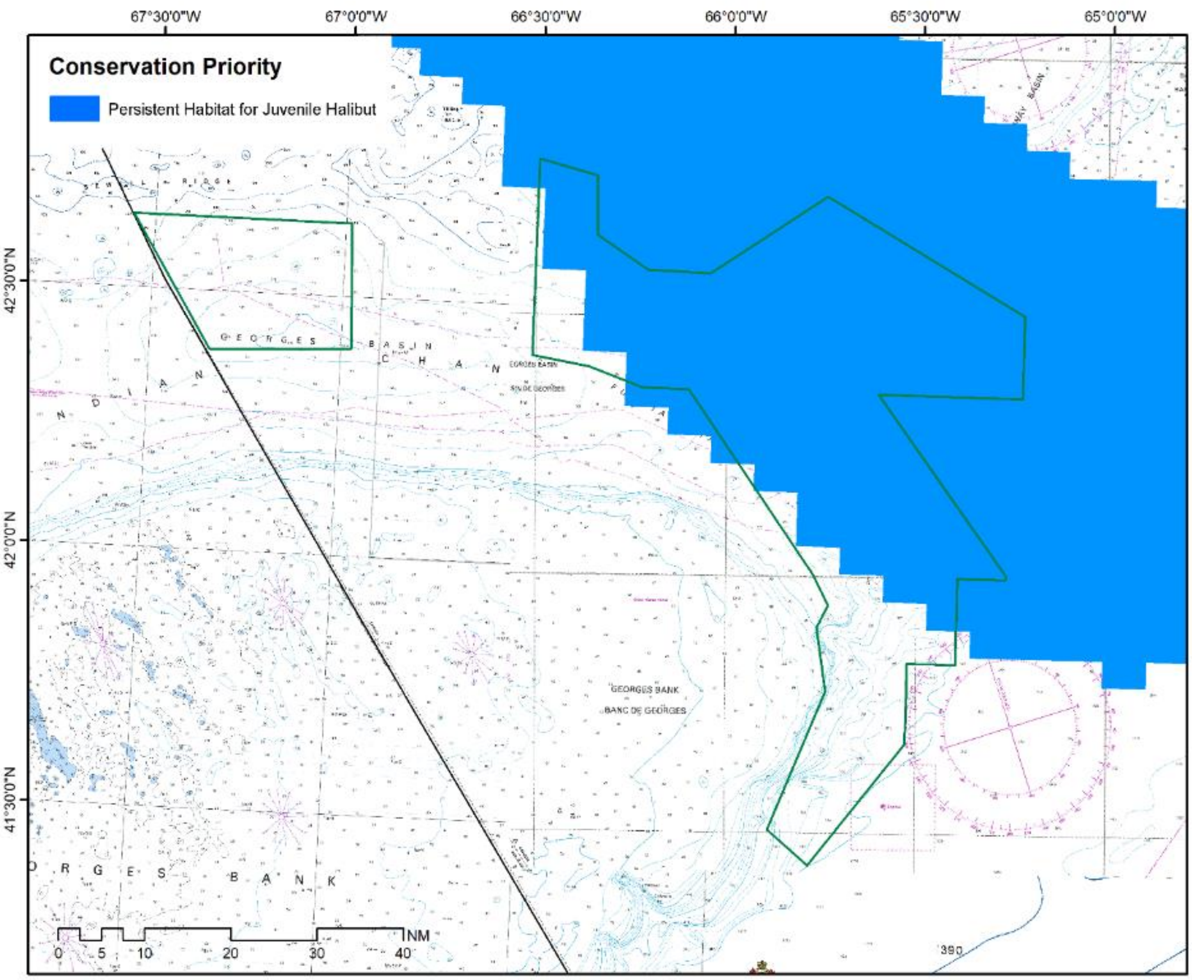



Figure 1.4.3-6. Area of persistent high abundance for juvenile Atlantic Halibut that overlaps the Fundian Channel-Browns Bank AOI (green polygon) (adapted from Boudreau et al. 2017).

Representative habitat for Atlantic Cod

Atlantic Cod (*Gadus morhua*) are bottom-dwelling fish found from Georges Bank to northern Labrador in Atlantic Canada. COSEWIC (2010) assessed the Southern population of Atlantic Cod as Endangered, and it is currently under consideration for SARA listing. The Southern Designatable Unit (DU) is currently assessed as two separate cod stocks (5Zjm and 4X5Yb), with the AOI located primarily in the 4X5Y management unit. Populations in this DU have declined by 64% in the past 3 generations. The 4X5Yb Atlantic Cod stock has been in the Critical Zone since 2011, with biomass and recruitment remaining low since then (DFO 2018). Most life history characteristics, such as age and size at maturity, differ markedly amongst populations, as do other behaviours such as movement and dispersal (COSEWIC 2010). In the southern portion of their range, including the AOI, cod reach maturity at 2-3 years of age. Juvenile cod prefer structurally complex, heterogeneous habitats, including cobble and boulder substrates that provide shelter from predators (Tupper and Boutilier 1995; Laurel et al. 2003; COSEWIC 2010). Offshore, juvenile cod have been observed amongst deep-sea corals. As cod age, the primary factors affecting distribution and habitat may be water temperature and food supply (COSEWIC 2010).

Adult cod feed on a wide variety of prey and preferences change with life stage. Larval cod feed on zooplankton (McLaren and Avendaño 1995), young cod (<37 cm in length) feed on invertebrates (i.e., krill and shrimp) and small fish such as sand lance, while adult cod (≥37 cm in length) feed primarily on crabs, and fish such as herring and Silver Hake (Andrushchenko et al. 2022). Spring spawning is broadly distributed both geographically and seasonally in the Southern DU, but both Browns Bank and nearby Georges Bank are considered major spring spawning grounds. Peak concentrations of cod eggs are found on Georges Bank in January/February and on Browns Bank in March/April (Frank et al. 1994).

For the purpose of this assessment, representative habitat for Atlantic Cod was determined using the statistical approach outlined in Horsman and Shackell (2009) and Serdynska et al. (2021). Briefly, total cod weight per tow data from the DFO summer RV survey (1970-2016) for NAFO division 4X were divided into 5 time periods, interpolated to create a continuous surface, and classified into 10 percentile classes, ranked 1-10 (i.e., a rank of 1 represents the bottom 10% of lowest reported catch weights, and a rank of 10 represents the top 10% of highest reported catch weights). The ranked maps were then summed across all time periods. Representative Atlantic Cod habitat is shown as areas with the top 20% and top 40% of ranked values across time periods (Figure 1.4.3-7).

The calculation of representative habitat for Atlantic Cod on Georges Bank (i.e., the 5Zjm stock) would require incorporation of data from the DFO spring RV survey; this was not done for the current assessment as this area is primarily outside of the AOI.

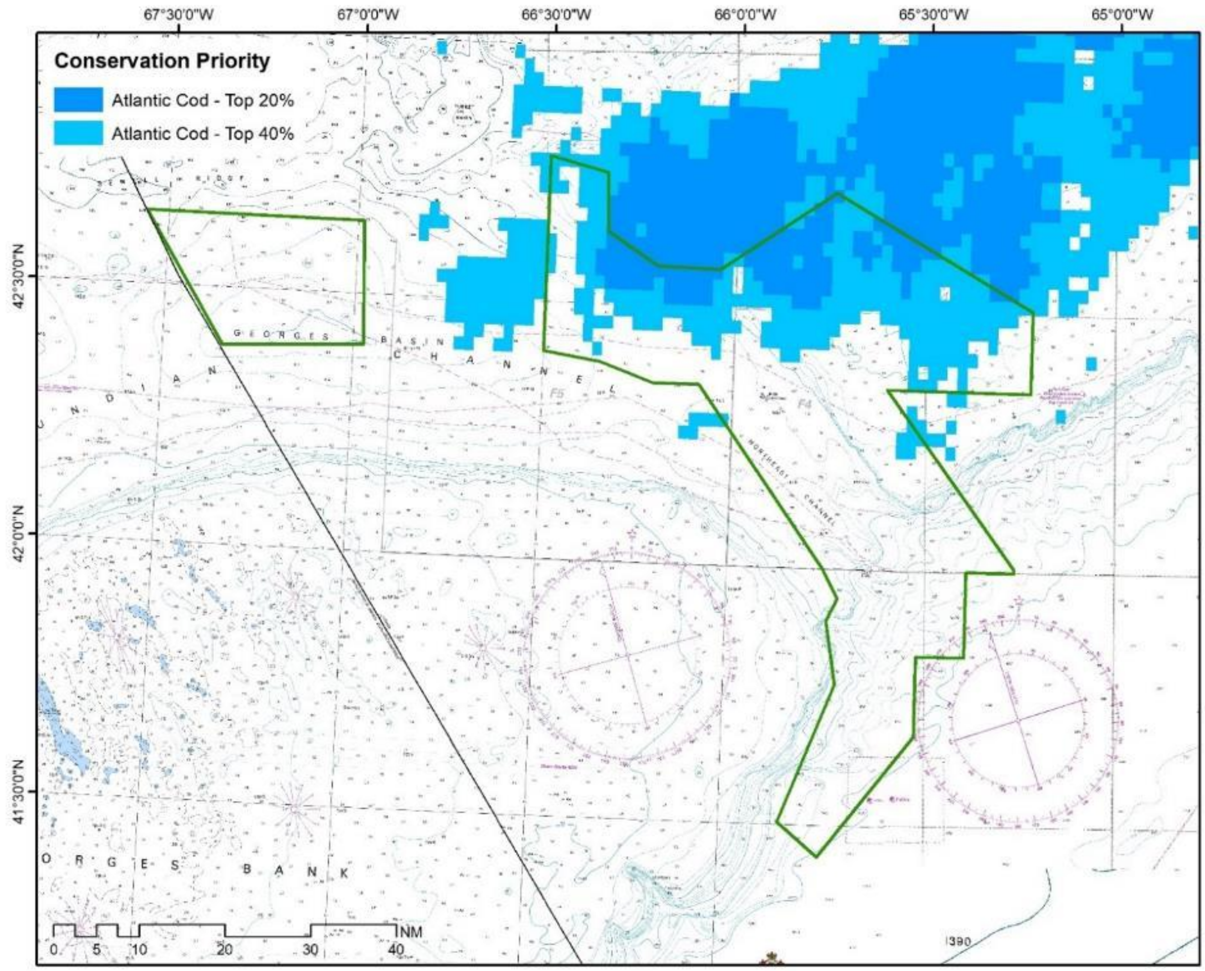



Figure 1.4.3-7. Representative habitat for Atlantic Cod that overlaps the Fundian Channel-Browns Bank AOI (green polygon). The light and dark blue polygons show the top 20% and top 40% of ranked values across time periods for cod biomass caught in the DFO Summer RV Survey in 4X from 1970-2016 (see methods in: Horsman and Shackell 2009; Serdynska et al. 2021). Representative habitat for the Georges Bank population is not shown.

Representative habitat for Atlantic Wolffish

Atlantic Wolffish (*Anarhichas lupus*) are large-bodied, bottom-dwelling fish (COSEWIC 2012*b*). The species is listed as Special Concern under SARA. On the Scotian Shelf, Atlantic Wolffish are most abundant in the eastern region (NAFO Division 4V), in the Bay of Fundy, and on Roseway, LaHave, and Brown's Banks (Ward-Paige and Bundy 2016), but their distribution has undergone a substantial reduction in the past several generations (Collins et al. 2015). They are found both inshore and offshore, and prefer temperatures between 0.5-3 °C and depths between 100-500 m (DFO 2020*a*). Atlantic Wolffish can be found on various substrate types including sand, gravel, large rocks, and boulders (Novaczek et al. 2017). Atlantic Wolffish grow to be 150 cm in length and feed primarily on brittle stars, sea urchins, crabs, and shrimp. Adult Atlantic Wolffish are not generally considered far-ranging, as mark recapture work showed fish moved an average of just 8 km over several years (Templeman 1984*a*). Atlantic Wolffish deposit their eggs on the bottom and larvae tend to stay close to the nest, leading to little dispersal potential (Scott and Scott 1988; O'Dea and Haedrich 2001). Wolffish dens are predicted to be associated with relatively shallow depths and in areas of suitable rocky substrate (Novaczek et al. 2017).

For the purpose of this assessment, representative habitat for Atlantic Wolffish was determined using the statistical approach outlined in Horsman and Shackell (2009) and Serdynska et al. (2021). Briefly, total Atlantic Wolffish weight per tow data from the DFO summer RV survey (1970-2016) for NAFO division 4X were divided into 5 time periods, interpolated to create a continuous surface, and classified into 10 percentile classes, ranked 1-10 (i.e., a rank of 1 represents the bottom 10% of lowest reported catch weights, and a rank of 10 represents the top 10% highest reported catch weights). The ranked maps were then summed across all time periods. Representative Atlantic Wolffish habitat is shown as areas with the top 20% and top 40% of ranked values across time periods (Figure 1.4.3-8)

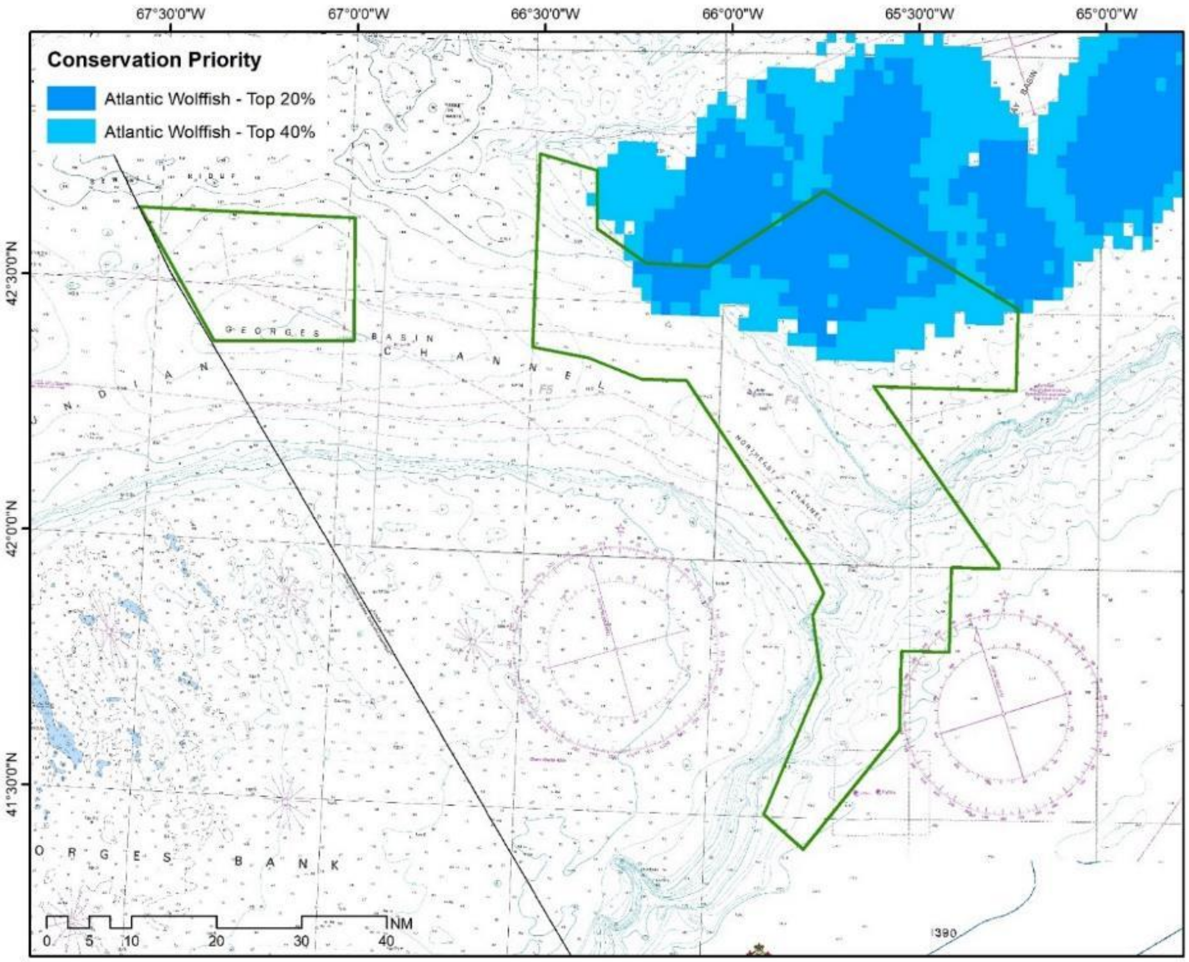



Figure 1.4.3-8. Representative habitat for Atlantic Wolffish that overlaps the Fundian Channel-Browns Bank AOI (green polygon). The light and dark blue polygons show the top 20% and top 40% of ranked values across time periods for Atlantic Wolffish biomass caught in the DFO

Summer RV Survey in 4X from 1970-2016 (see methods in: Horsman and Shackell 2009; Serdynska et al. 2021).

Representative habitat for Winter Skate

Winter Skate (*Leucoraja ocellata*) are bottom-dwelling cartilaginous fish that are endemic to the Northwest Atlantic, with a considerable portion of their range consisting of three distinct Canadian populations (COSEWIC 2015). The Western Scotian Shelf – Georges Bank Designatable Unit (DU) was re-assessed as Not At Risk by COSEWIC (2015). COSEWIC determined this population to be Not at Risk given the population size and distribution has remained stable since the 1970s. Winter Skate have a long generation time (18 years), high age at maturity (~13 years), and low fecundity, making them vulnerable to population declines. They are typically found on sand and gravel at depths less than 150 m – though they have been recorded to a depth of 371 m – and the majority are found on the Scotian Shelf in waters ranging from 5-9 °C (Collette and Klein-MacPhee 2002; COSEWIC 2015). Individuals <40 cm in length feed primarily on shrimp (*Crangon septemspinosa*) and gammarid amphipods, while those >40 cm in length feed on large Rock Crab (*Cancer irroratus*) and fishes (Kelly and Hanson 2013).

For the purpose of this assessment, representative habitat for Winter Skate was determined using the statistical approach outlined in Horsman and Shackell (2009) and Serdynska et al. (2021). Briefly, total Winter Skate weight per tow data from the DFO summer RV survey (1970-2016) for NAFO division 4X were divided into 5 time periods, interpolated to create a continuous surface, and classified into 10 percentile classes, ranked 1-10 (i.e., a rank of 1 represents the bottom 10% of lowest reported catch weights, and a rank of 10 represents the top 10% highest reported catch weights). The ranked maps were then summed across all time periods. Representative Winter Skate habitat is shown as areas with the top 20% and top 40% of ranked values across time periods (Figure 1.4.3-9).

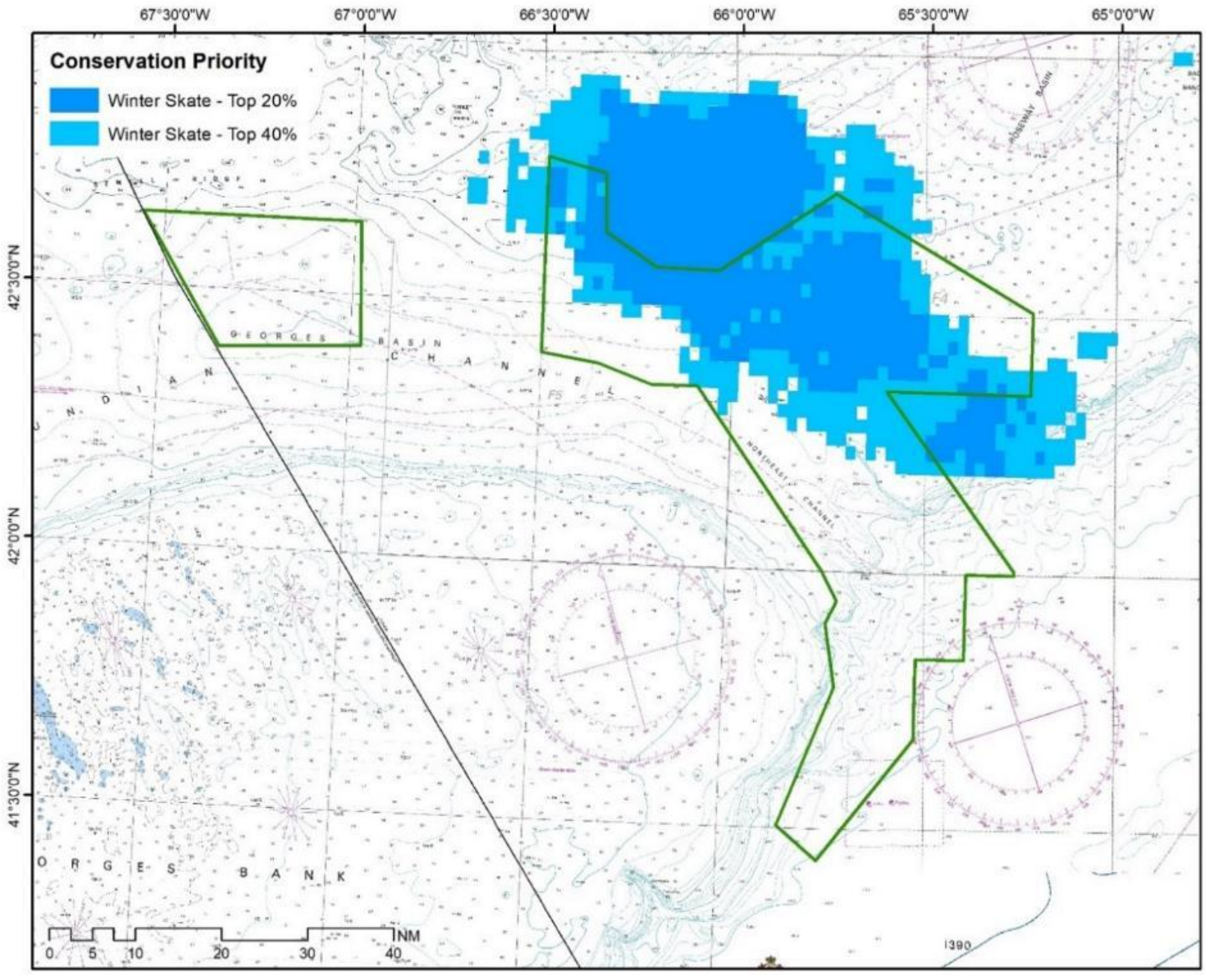



Figure 1.4.3-9. Representative habitat for Winter Skate that overlaps the Fundian Channel-Browns Bank AOI (green polygon). The light and dark blue polygons show the top 20% and top 40% of ranked values across time periods for Winter Skate biomass caught in the DFO Summer RV Survey in 4X from 1970-2016 (see methods in: Horsman and Shackell 2009; Serdynska et al. 2021).

Representative habitat for Thorny Skate

Thorny Skate (*Amblyraja radiata*) are large cartilaginous fish found across the northern Atlantic. In Canada, they are defined as a single Designatable Unit (DU) that spans from Baffin Bay to Georges Bank, though population declines over the southern extent of their historic distribution has led to some contraction in range (COSEWIC 2012*c*). This species was assessed as Special Concern by COSEWIC and is currently under consideration for addition to Schedule 1 of SARA. The Georges Basin portion of the AOI includes an area of persistent top quintile habitat for Thorny Skate (Horsman and Shackell 2009). Thorny Skate have low growth rates and reach maturity at a late age, limiting population resilience (COSEWIC 2012*c*). This species lives on a variety of substrates on much of the continental shelf, including sand, gravel, and mud bottoms at depths of 18-1200 m, generally in water temperatures of 0-10 °C. Although spawning occurs year-round, peak spawning activity is thought to occur in the fall and winter (Templeman 1987;

del Río and Junquera 2002). Thorny Skate reach maturity at age 11 and lay just 6-40 eggs per year (COSEWIC 2012*c*). Tagging studies and benthic egg cases suggest limited adult and egg dispersal potential respectively, though migration across their range is unknown (Templeman 1984*b*; COSEWIC 2012*c*). Thorny Skate have a varied diet, including fish, molluscs, crustaceans, and polychaetes (COSEWIC 2012*c*).

For the purpose of this assessment, representative habitat for Thorny Skate was determined using the statistical approach outlined in Horsman and Shackell (2009) and Serdynska et al. (2021). Briefly, total Thorny Skate weight per tow data from the DFO summer RV survey (1970-2016) for NAFO division 4X were divided into 5 time periods, interpolated to create a continuous surface, and classified into 10 percentile classes, ranked 1-10 (i.e., a rank of 1 represents the bottom 10% of lowest reported catch weights, and a rank of 10 represents the top 10% highest reported catch weights). The ranked maps were then summed across all time periods. Representative Thorny Skate habitat is shown as areas with the top 20% and top 40% of ranked values across time periods (Figure 1.4.3-10).

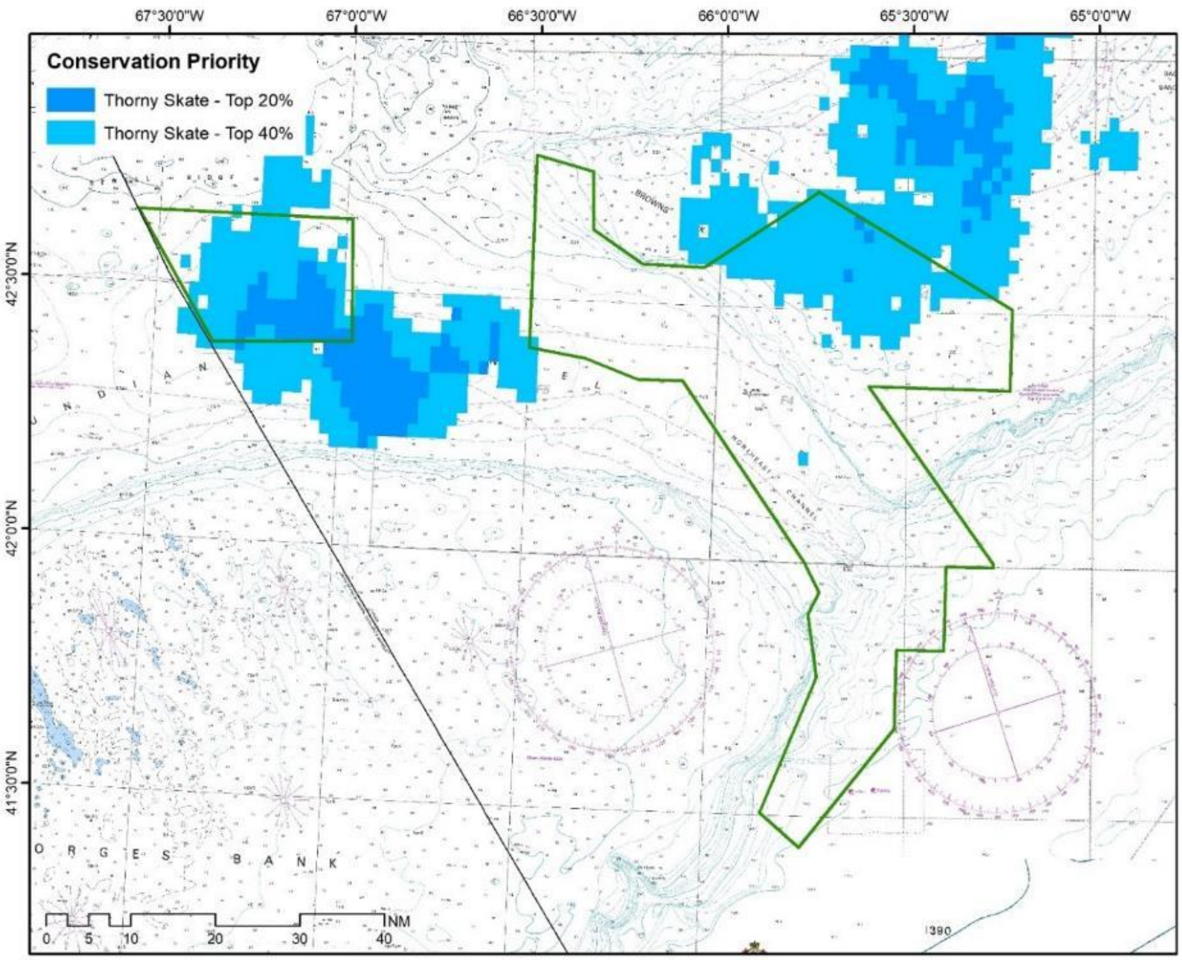



Figure 1.4.3-10. Representative habitat for Thorny Skate that overlaps the Fundian Channel-Browns Bank AOI (green polygon). The light and dark blue polygons show the top 20% and top 40% of ranked values across time periods for Thorny Skate biomass caught in the DFO Summer RV Survey in 4X from 1970-2016 (see methods in: Horsman and Shackell 2009; Serdynska et al. 2021).

Representative habitat for White Hake

White Hake (*Urophycis tenuis;* COSEWIC – Threatened) are demersal fish found from North Carolina to Labrador, with the highest abundances in the Gulf of Maine and on Georges Bank, including the western portion of the AOI (COSEWIC 2013). The AOI is part of the Atlantic and Northern Gulf of St. Lawrence Designatable Unit (DU), which was assessed as Threatened and is currently under consideration for addition to Schedule 1 of SARA. COSEWIC assessed the DU as Threatened in 2013 due to a decline in adults by approximately 70% over the past three generations. Much of this decline took place in the mid-1990s and the population has remained stable since 2004. On the Scotian Shelf, White Hake are found in high abundance in the Bay of Fundy and in the deep waters along the shelf break (Horsman and Shackell 2009). Adult White Hake are most commonly found on fine substrates, such as mud at the bottom of basins on the Scotian Shelf. This species is found over a wide range of depths (50-325 m) but prefer warmer, more saline waters with a temperature range of 5-9 °C (COSEWIC 2013). In the southern portion of their range, individuals move towards shallower water in warmer months and disperse to deep water in colder months (Musick 1974; Chang et al. 1999). Crustaceans and fish are the dominant prey for this species, with the proportion of fish in the diet increasing with age (Chang et al. 1999).

For the purpose of this assessment, representative habitat for White Hake was determined using the statistical approach outlined in Horsman and Shackell (2009) and Serdynska et al. (2021). Briefly, total White Hake weight per tow data from the DFO summer RV survey (1970-2016) for NAFO division 4X were divided into 5 time periods, interpolated to create a continuous surface, and classified into 10 percentile classes, ranked 1-10 (i.e., a rank of 1 represents the bottom 10% of lowest reported catch weights, and a rank of 10 represents the top 10% highest reported catch weights). The ranked maps were then summed across all time periods. Representative White Hake habitat is shown as areas with the top 20% and top 40% of ranked values across time periods (Figure 1.4.3-11).

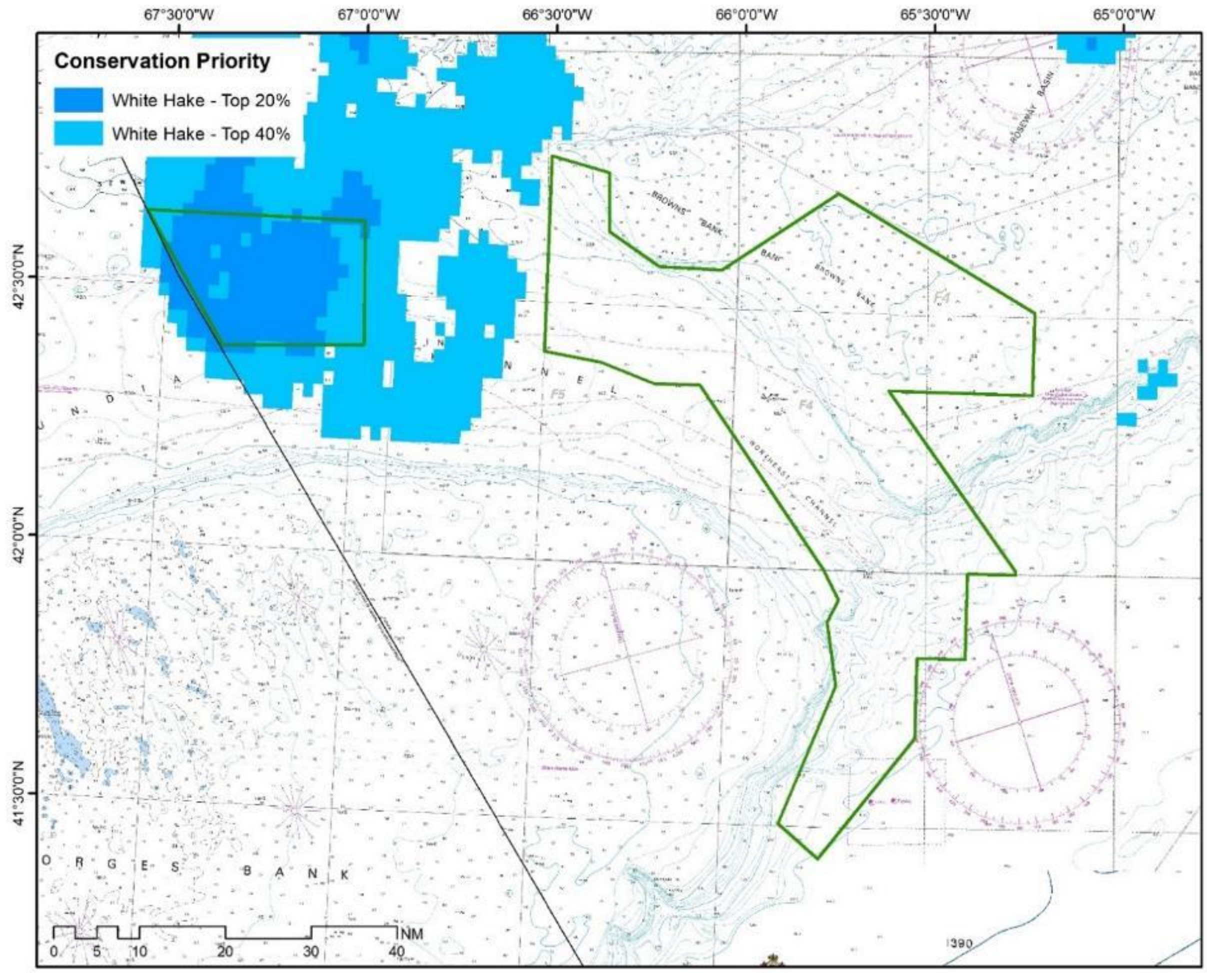



Figure 1.4.3-11. Representative habitat for White Hake that overlaps the Fundian Channel-Browns Bank AOI (green polygon). The light and dark blue polygons show the top 20% and top 40% of ranked values across time periods for White Hake biomass caught in the DFO Summer RV Survey in 4X from 1970-2016 (see methods in: Horsman and Shackell 2009; Serdynska et al. 2021).

Highly suitable habitat for Cusk

Cusk (*Brosme brosme*) are sedentary, slow-moving, cod-like benthic fish that range across the northern Atlantic. Cusk found in North American waters is considered one Designatable Unit (DU), which has lost 85% of mature individuals over the past three generations; this population was assessed as Endangered by COSEWIC (2012*d*) and is currently under consideration for addition to Schedule 1 of SARA. Of note, a recent Science Response that analyzed the status of Cusk in NAFO divisions 4VWX5Z reports that the Cusk biomass index remains above the Limit Reference Point (DFO 2021), placing Cusk in the cautious zone. Furthermore, analyses using data from the Halibut Industry Survey suggests that the population abundance has been stable since 1999 (DFO 2014). For this assessment, sensitivity analyses will consider the status of the local Cusk population, as informed by DFO science advice.

Cusk are generally found on rough rocky substrates in relatively warm water ranging from 2-12 °C, and more specifically between 6-10 °C in the Gulf of Maine (Scott 1982; Scott and Scott 1988). Cusk can be found from 20-1100 m (Andriyashev 1964; Cohen et al. 1990; Hareide and Garnes 2001). For waters off Nova Scotia and Newfoundland, Cusk caught in the Halibut Industry Survey are most frequently caught at depths of 400-600 m but have been caught at depths up to 1185 m (Harris et al. 2018).

Cusk are notably fecund, as a single adult may release between 100,000 to 4,000,000 eggs (Oldham 1972). Spawning occurs over banks and the season lasts from May to August with a peak in June. Cusk do not appear to undergo extensive local, seasonal, or spawning migrations (COSEWIC 2012*d*). This species feeds primarily on crustaceans and other fish.

For the purpose of this assessment, the area of highly suitable habitat for Cusk was determined using the outputs of a habitat suitability model (predicted presence) for Cusk for the Maritimes Region predicted using a Random Forest method (Harris et al. 2018), with a threshold of 70% presence probability (Figure 1.4.3-12).

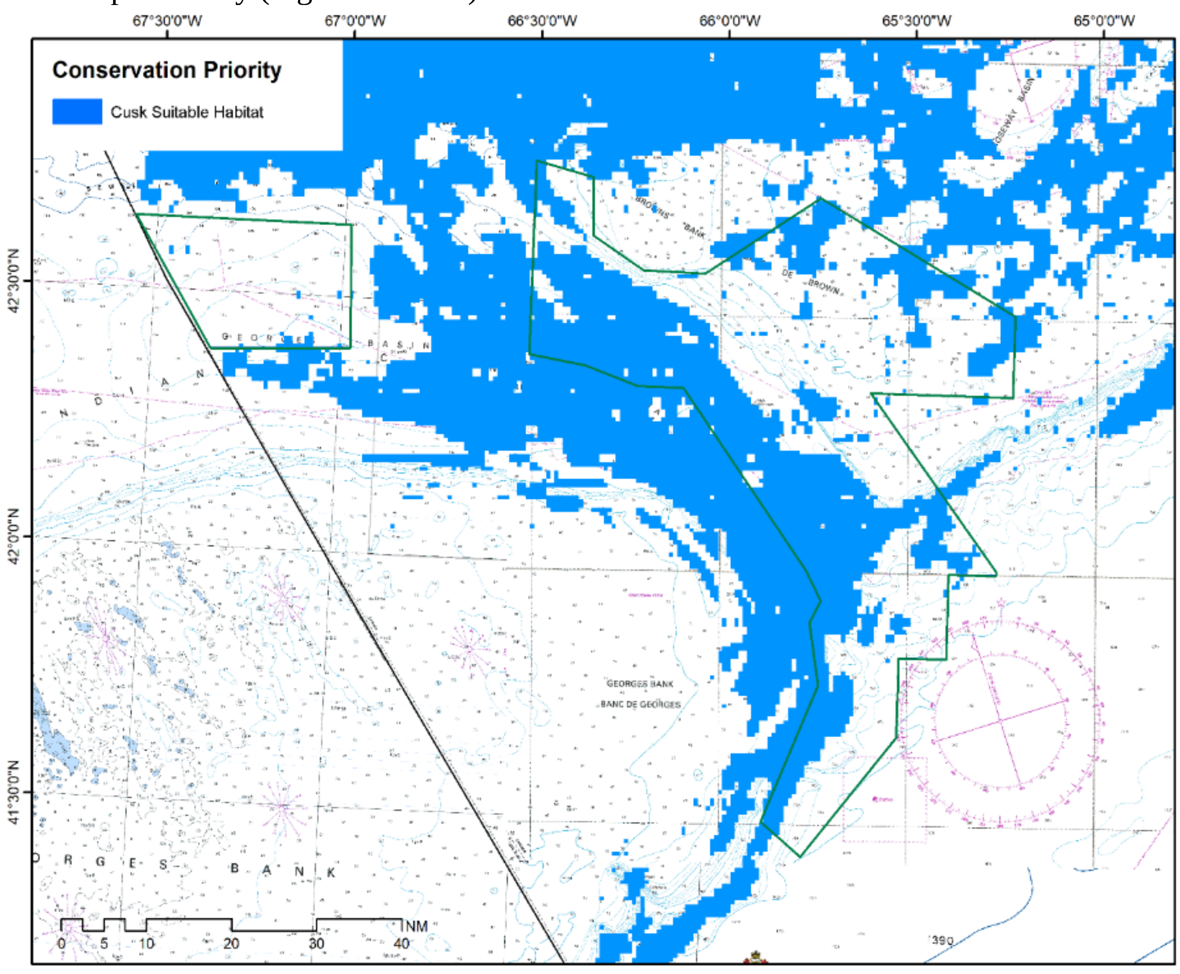



Figure 1.4.3-12. Overlap of suitable habitat for Cusk (adapted from Harris et al. 2018) with the Fundian Channel-Browns Bank AOI (green polygon).

*Birds*

Foraging habitat for most functional guilds of marine birds

The AOI encompasses certain offshore habitat features that support a diversity of seabirds, including bank, deep-water channel and basin habitats, and oceanographic conditions that support an area of high primary productivity (DFO 2020*a*) and enhance the relative availability of prey. Relatively persistent congregation of seabirds from multiple functional guilds is indicative of a reliably abundant, varied and available prey base (Barrett et al. 2006). The area is known to support aggregations of a diversity of marine bird prey species, including zooplankton, squid, and fish.

Birds that are known to occur in significant numbers within the AOI can be grouped into functional foraging guilds. DFO (2020*a*) provides a detailed description of data sources used to characterize the abundance patterns for each guild within the AOI, including from the *Programme intégré de recherche sur les oiseaux pélagiques* (PIROP), a historic at-sea survey program active from 1965 to 1992, and Eastern Canada Seabirds at-Sea (ECSAS), a more recent survey program initiated in 2006 and ongoing. Functional foraging guilds commonly occurring within the AOI are described briefly below.

Shallow-diving pursuit generalists (shearwaters)

This group is composed of five species of shearwater: Great Shearwater (*Puffinus gravis*), Sooty Shearwater (*Puffinus griseus*), Cory's Shearwater (*Calonectris diomedea*), Manx Shearwater (*Puffinus puffinus*), and Audubon's Shearwater (*Puffinus lherminieri*), with the former two dominating abundance patterns within the AOI (DFO 2020*a*). Non-breeding shearwaters visit offshore northwest Atlantic waters in summer to forage in flocks during the day, capturing squid, Capelin, and other small fish, where available (Brown et al. 1981). Available PIROP and ECSAS data indicate shearwaters are present in the Scotian Shelf Bioregion in the largest numbers from May through November. Shearwaters can dive from the air to hunt but more often begin pursuit from the surface of the water and are known to aggregate around fishing vessels to feed on discards and offal (Godfrey 1986). Although many shearwaters conduct shallow (1-5 m) dives for foraging purposes, some studies have recorded dive depths of >50 m (Ronconi et al. 2010). These animals forage predominantly during the day, with peak foraging activities reported to occur at dawn and dusk for both Great and Sooty Shearwaters (Raymond et al. 2010; Ronconi et al. 2010). Available data indicate that these birds forage predominantly in the eastern portion of the AOI in water over bank and channel habitats (DFO 2020*a*).

For the purpose of this assessment, important foraging areas for shallow-diving pursuit generalists (shearwaters) were defined as the summed top-quintile classes (top 20% of values for the Scotian Shelf Bioregion) from effort-corrected kernel density plots using available bioregion-wide data from PIROP and ECSAS for each species that make up the guild (adapted from DFO 2020*a*; Figure 1.4.3-13).

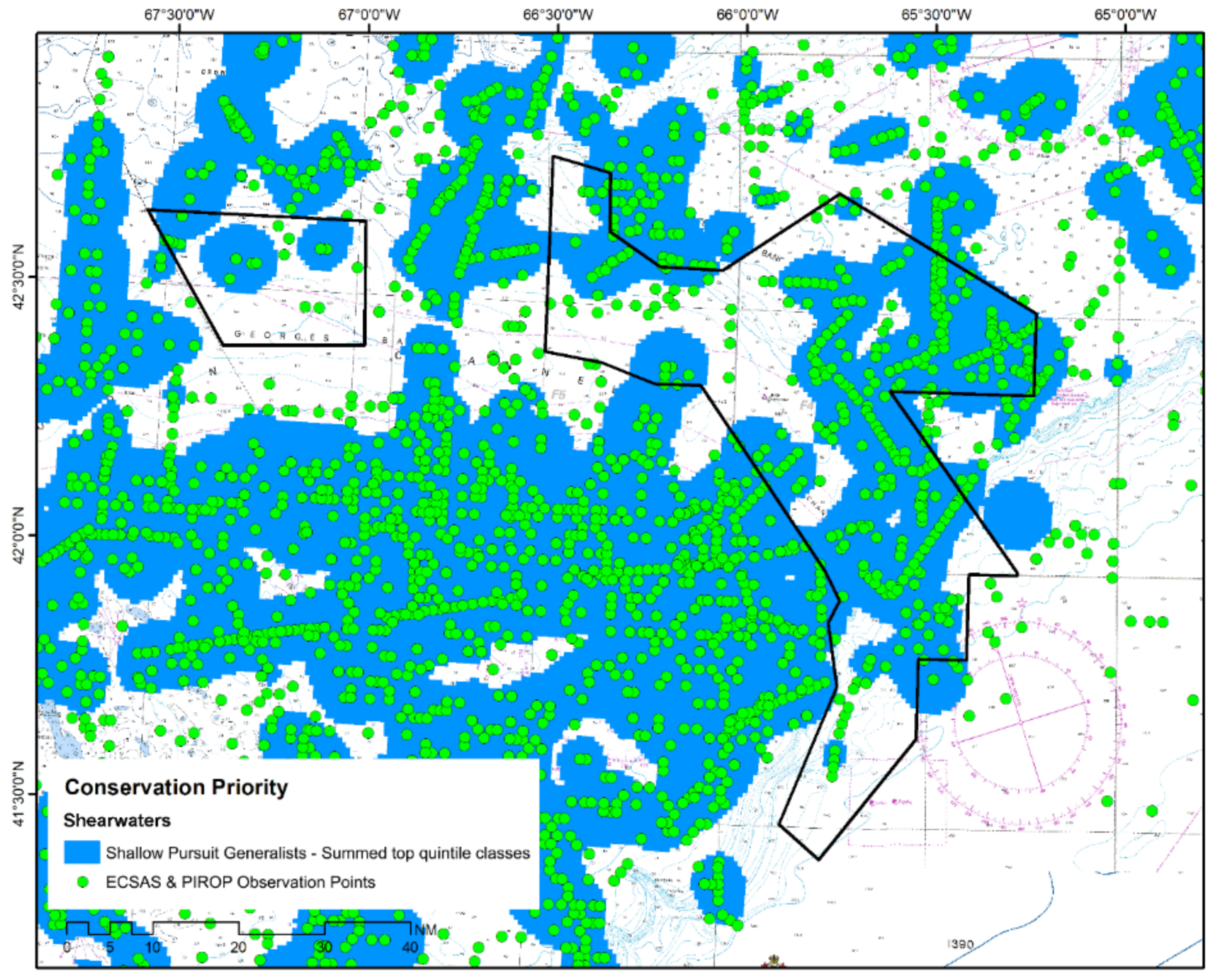



Figure 1.4.3-13. Overlap of top quintile foraging areas (blue polygons) for shallow-diving pursuit generalist (shearwaters) with the Fundian Channel-Browns Bank AOI (black polygon). All observed locations for shallow-diving pursuit generalists in the ECSAS and PIROP databases from May through November are shown as green points.

Surface-seizing planktivores/piscivores (phalaropes and storm-petrels)

This group consists of storm-petrels and phalaropes, including Leach's Storm-petrel (*Oceanodroma leucorhoa;* COSEWIC – Threatened), Wilson's Storm-petrel (*Oceanites oceanicus*), Red-necked Phalarope (*Phalaropus lobatus*), and Red Phalarope (*Phalaropus fulicarius*). Northern storm-petrels are small seabirds ranging from 14-23 cm in length (Alsop 2005). Storm-petrels are highly pelagic, approaching coastlines primarily to access terrestrial breeding habitats, predominantly small islands. They feed on small fish, crustaceans, and squid, primarily by hovering or gliding over the surface of the water (Hedd et al. 2009). Wilson's Storm-petrels are known to follow vessels to feed on plankton stirred up by propellers and boat movement.

Like the storm-petrels, phalaropes are considered pelagic species outside their breeding season (Alsop 2005). Both the Red-necked and Red Phalaropes breed in the Arctic and winter in more tropical waters. The presence of phalaropes in the AOI corresponds to migration to and from breeding grounds farther north. These animals prey on small marine invertebrates (Mercier and Gaskin 1985) and can enhance their foraging by swimming in small, rapid circles and skimming zooplankton that rise to the surface in the resultant vortex.

Available PIROP and ECSAS data indicate storm-petrels are present in the Scotian Shelf Bioregion in the largest numbers from May through September, and phalaropes are present in the largest numbers during May-June and August-October.

For the purpose of this assessment, important foraging areas for surface-seizing planktivores/piscivores (phalaropes and storm-petrels) was defined as the summed top-quintile classes (top 20% of values for the Scotian Shelf Bioregion) from effort-corrected kernel density plots using available bioregion-wide data from PIROP and ECSAS for each species that make up the guild (adapted from DFO 2020*a*; Figure 1.4.3-14).

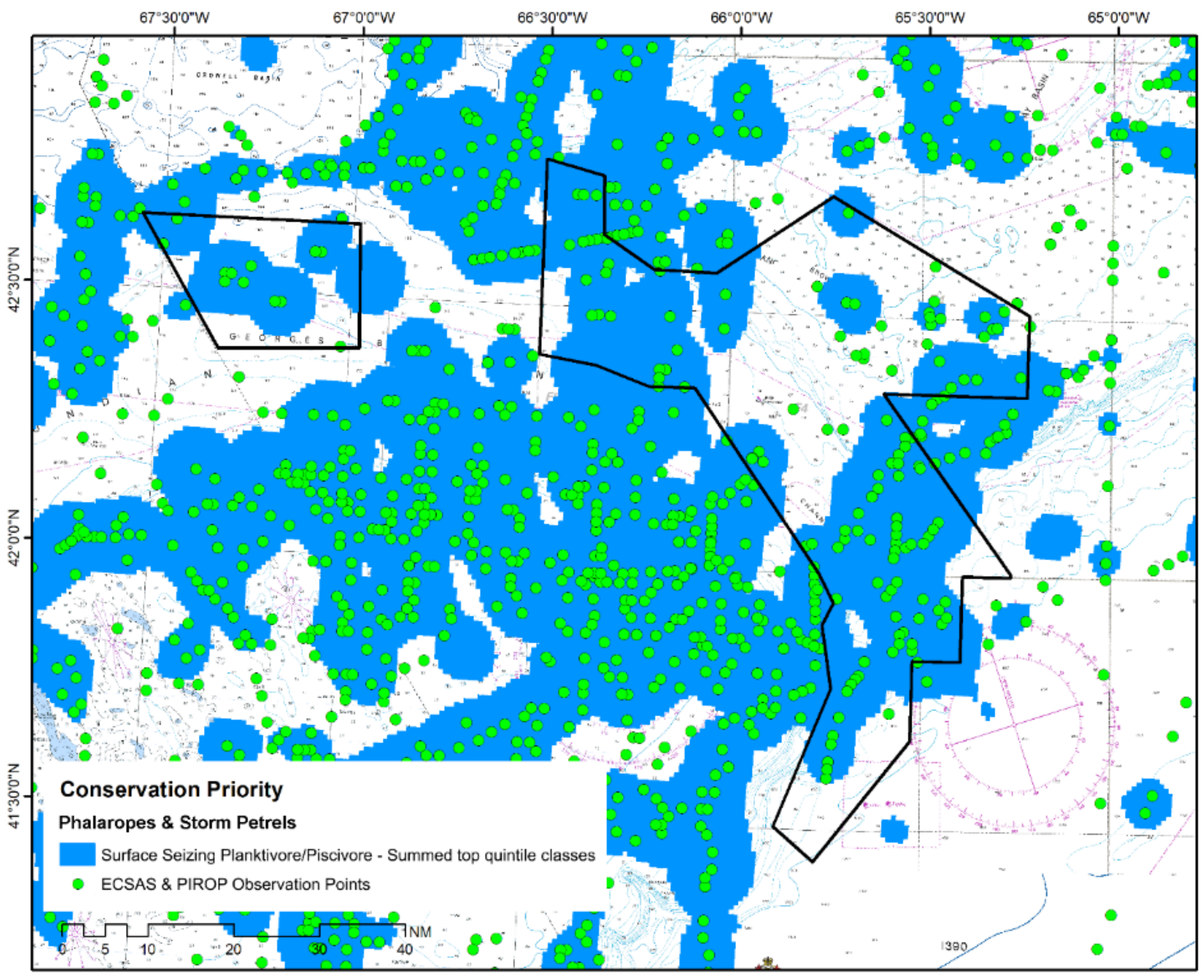



Figure 1.4.3-14. Overlap of top quintile foraging areas (blue polygons) for surface-seizing planktivores/piscivores (phalaropes and storm-petrels) with the Fundian Channel-Browns Bank AOI (black polygon). All observed locations for surface-seizing planktivores/piscivores in the ECSAS and PIROP databases from May through October are shown as green points.

Surface shallow-diving piscivores (gulls, terns, and skuas)

Large gulls commonly found in the AOI include the Herring Gull (*Larus argentatus*), Great Black-backed Gull (*Larus marinus*), Glaucous Gull (*Larus hyperboreus*), and Iceland Gull (*Larus glaucoides*). Black-legged Kittiwake (*Rissa tridactyla*) is also included. Terns in this guild include Common Tern (*Sterna hirundo*), Arctic Tern (*Sterna paradisaea*), and possibly the Roseate Tern (*Sterna dougallii*) (SARA – Endangered) as the AOI spans the line connecting breeding areas and known migratory staging areas in New England (DFO 2020*a*). The guild also includes skuas and jaegers, specifically South Polar Skua (*Stercorarius maccormicki*), Great Skua (*Stercorarius skua*), Parasitic Jaeger (*Stercorarius parasiticus*), Pomarine Jaeger (*Stercorarius pomarinus*), and Long-tailed Jaeger (*Stercorarius longicaudus*).

This functional group includes a diversity of seabirds that demonstrate a variety of feeding strategies and dietary preferences, including feeding on fish by diving from flight (Alsop 2005). Many species in this group are known to follow fishing vessels, and small gulls, terns, and kittiwakes often aggregate in highly productive areas where predatory fish or whales drive prey to the surface while feeding. While some species are highly migratory and pass through the region on their way to nesting or overwintering grounds, others are present year-round.

For the purpose of this assessment, important foraging areas for surface shallow-diving piscivores (gulls, terns, and skuas) was defined as the summed top-quintile classes (top 20% of values for the Scotian Shelf Bioregion) from effort-corrected kernel density plots using available bioregion-wide data from PIROP and ECSAS for each species that makes up the guild (adapted from DFO 2020*a*; Figure 1.4.3-15).

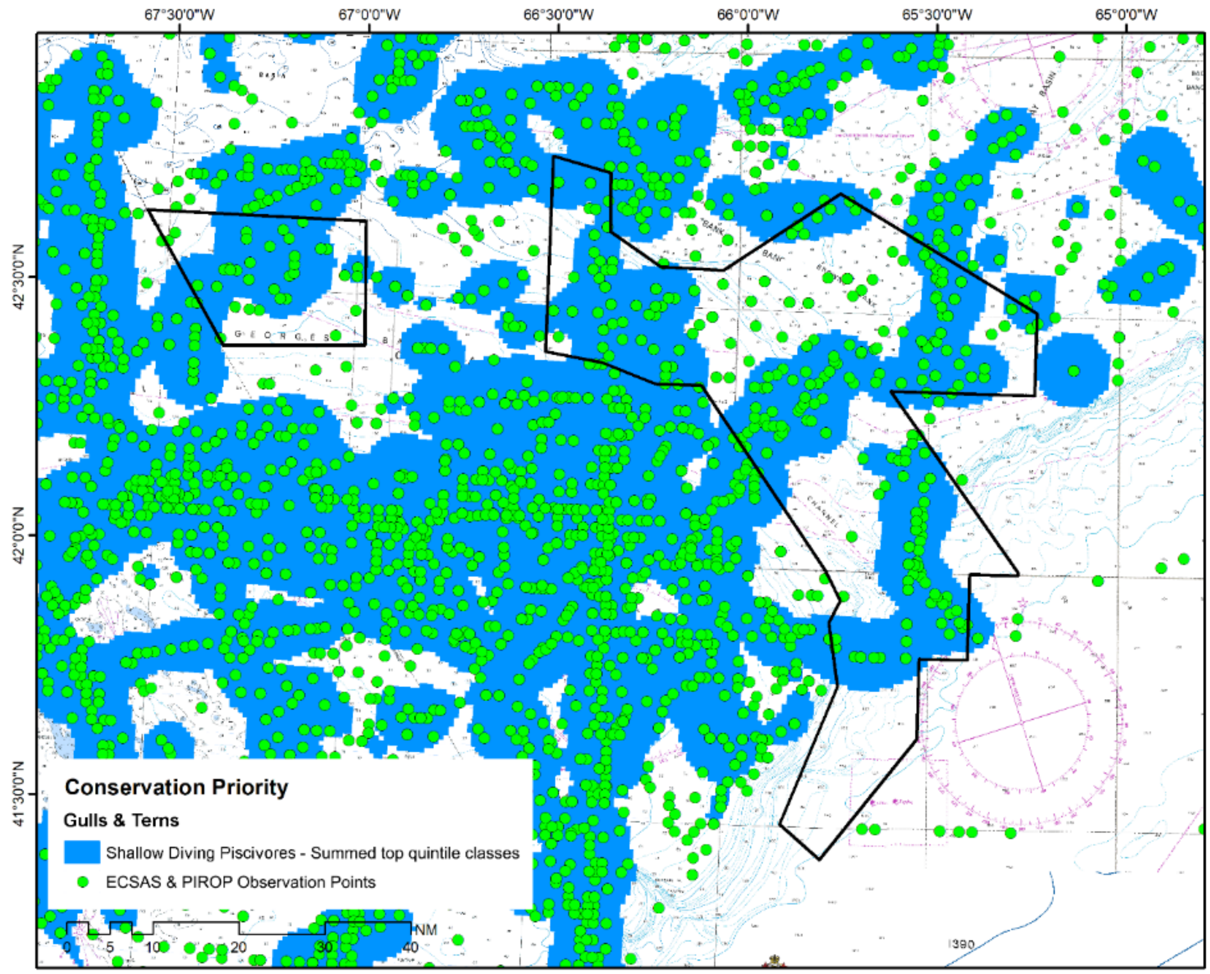



Figure 1.4.3-15. Overlap of top quintile foraging areas (blue polygons) for surface shallow-diving piscivores (gulls, terns, and skuas) with the Fundian Channel-Browns Bank AOI (black polygon). All observed locations for surface shallow-diving piscivores in the ECSAS and PIROP databases are shown as green points.

Pursuit-diving piscivores (alcids)

Pursuit-diving piscivores include the Thick-billed Murre (*Uria lomvia*), Common Murre (*Uria aalge*), Razorbill (*Alca torda*), and Atlantic Puffin (*Fratercula arctica*). This group of seabirds is characterized by stout bodies, short wings, black and white counter-shaded plumage, and expert swimming and diving capabilities (Godfrey 1986; Gaston and Jones 1998). They occur in offshore north Atlantic waters primarily during the winter, feeding on small fishes and marine invertebrates that they are able to pursue while swimming underwater (Gaston and Jones 1998; Gaston and Hipfner 2000). These birds are gregarious and aggregate in large flocks (Alsop 2005). Foraging dives range in depth amongst the different species in this functional group. Razorbill commonly forage between 1.5-6 m below the surface, though depths can reach up to 100 m (Piatt and Nettleship 1985; Jury 1986; Paredes et al. 2008). Atlantic Puffin commonly forage within 18 m of the surface though they are known to dive as deep as 68 m (Burger and Simpson 1986; National Audubon Society n.d.). Murres typically forage the deepest; for example, the Thick-billed Murre commonly forages at depths ranging from 21-46 m, with a maximum recorded depth of 210 m (Croll et al. 1992).

Available data suggest large alcids are consistently abundant within the AOI, though more recent survey data show a broader distribution across the Scotian Shelf (DFO 2020*a*). While a recent tracking study involving overwintering Atlantic Puffin individuals originating from three Gulf of Maine colonies indicates year-round use of the Gulf of Maine area, including the AOI (Baran 2019). Available PIROP and ECSAS data indicate alcids are present in the Scotian Shelf Bioregion primarily from October to June.

For the purpose of this assessment, important foraging areas for pursuit-diving piscivores (alcids) was defined as the summed top-quintile classes (top 20% of values for the Scotian Shelf Bioregion) from effort-corrected kernel density plots using available bioregion-wide data from PIROP and ECSAS for each species that make up the guild (adapted from DFO 2020*a*; Figure 1.4.3-16).

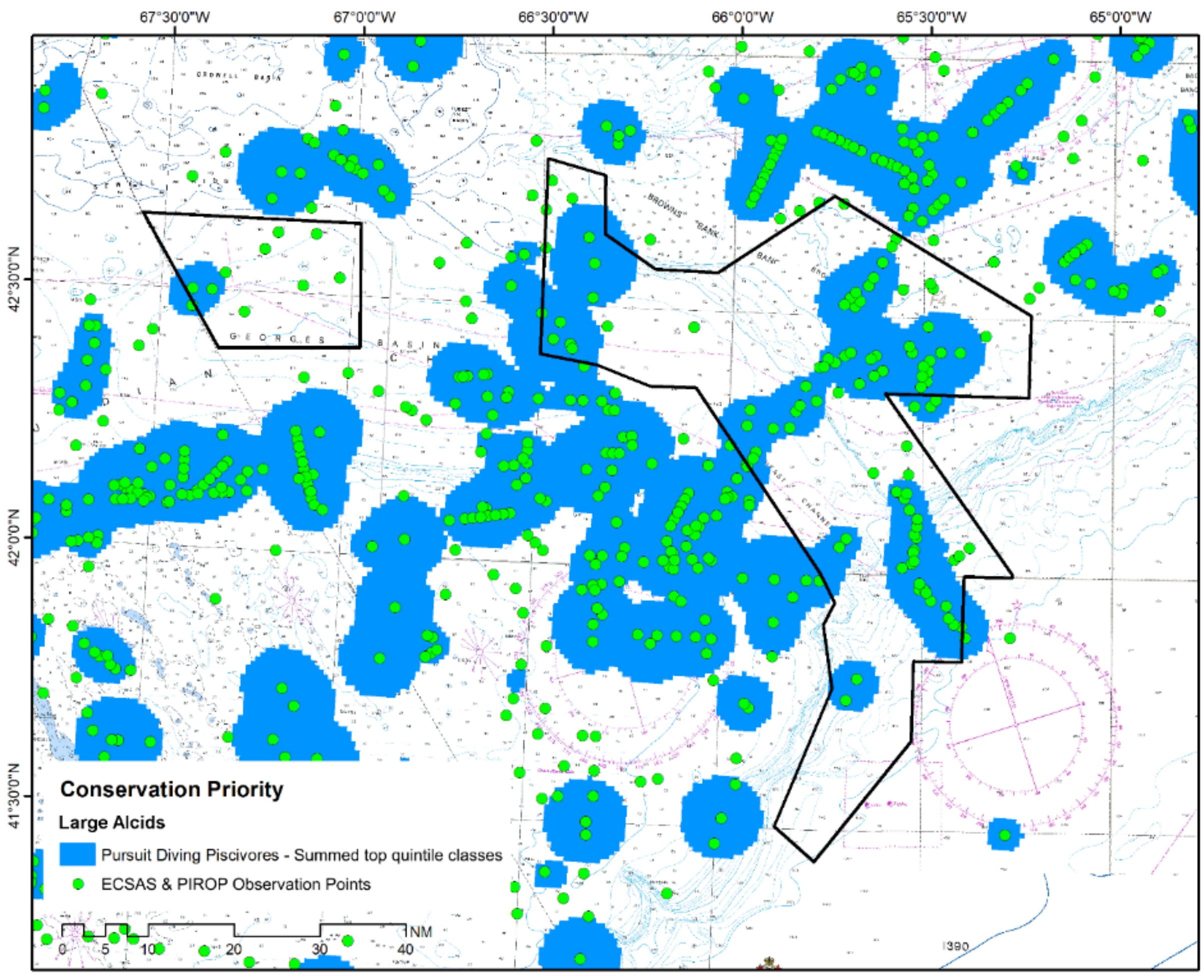



Figure 1.4.3-16. Overlap of top quintile foraging areas (blue polygons) for pursuit-diving piscivores (alcids) with the Fundian Channel-Browns Bank AOI (black polygon). All observed locations for pursuit-diving piscivores in the ECSAS and PIROP databases from October to June are shown as green points.

Pursuit-diving planktivores (Dovekie)

This guild includes a single species, Dovekie (*Alle alle*), thought to be the only Atlantic seabird that feeds predominantly on plankton (Montevecchi and Stenhouse 2002). While Evans (1981) found that during breeding Dovekie fed exclusively on copepods and amphipods and ranged only 2.5 km from the nesting colony, recent work in Newfoundland suggests a diet shift to larger zooplankton and small fish during non-breeding (Fife et al. 2015). Dovekie breed in the high Arctic, predominantly in large colonies in Greenland with occasional occurrence in the eastern Canadian Arctic, and over-winter in offshore marine habitats and along the coast of northeast North America (Montevecchi and Stenhouse 2002), including the AOI. Available PIROP and ECSAS data indicates Dovekie are present in the Scotian Shelf Bioregion from November through May. Available historic survey data indicated some areas of Georges and Browns Bank were important for Dovekie (DFO 2020*a*). More recent surveys provide evidence of a large scale shift in distribution for this species from the western to the eastern Scotian Shelf, with important areas remaining in the eastern portion of the site.

For the purpose of this assessment, important foraging areas for pursuit-diving planktivores (Dovekie) was defined as the summed top-quintile classes (top 20% of values for the Scotian Shelf Bioregion) from effort-corrected kernel density plots using available bioregion-wide data from PIROP and ECSAS for each species that make up the guild (adapted from DFO 2020*a*; Figure 1.4.3-17).

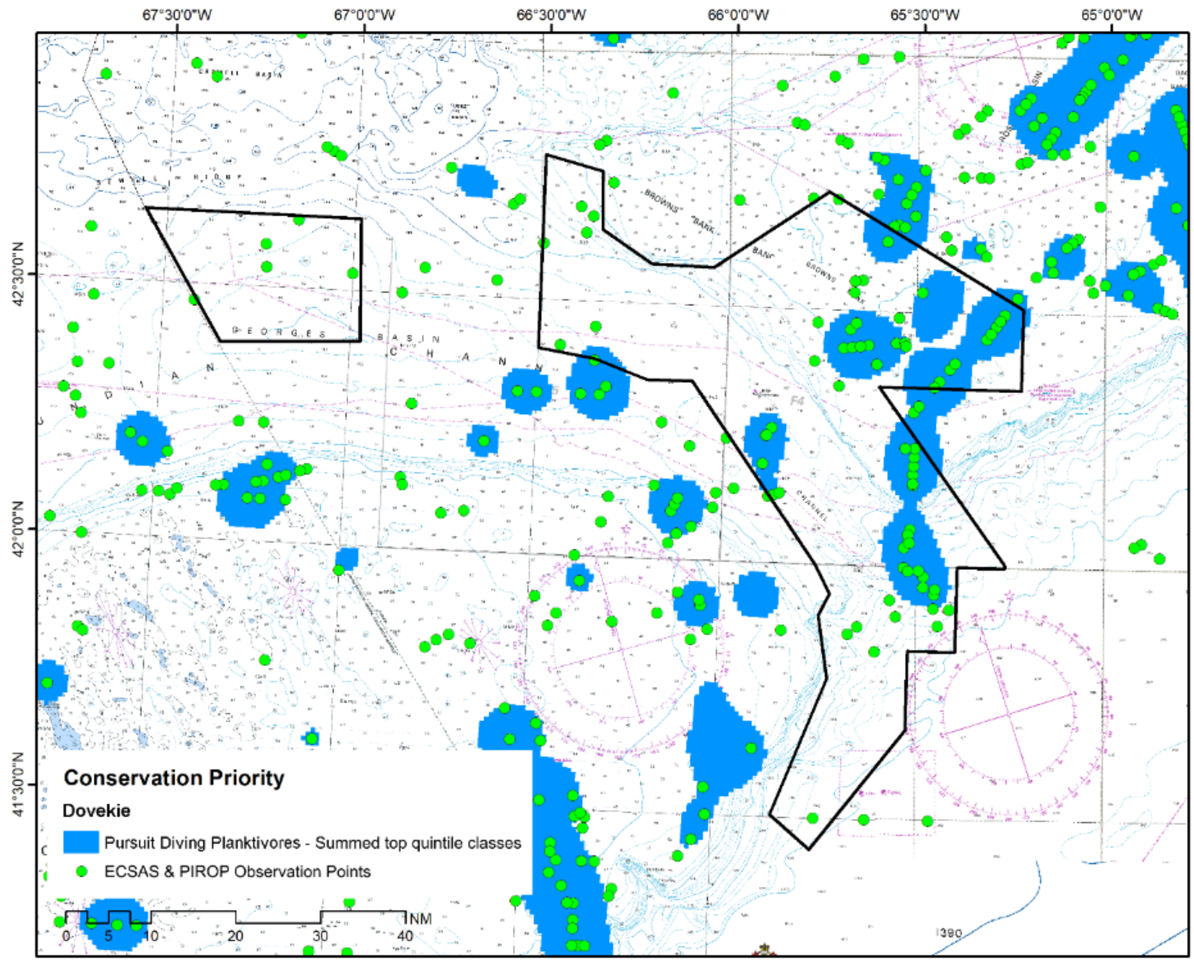



Figure 1.4.3-17. Overlap of top quintile foraging areas (blue polygons) for pursuit-diving planktivores (Dovekie) with the Fundian Channel-Browns Bank AOI (black polygon). All observed locations for pursuit-diving planktivores in the ECSAS and PIROP databases from November through May are shown as green points.

Plunge-diving piscivores (Northern Gannet)

This functional guild includes a single species, Northern Gannet (*Morus bassanus*): a large marine bird that nests on rocky coastal cliffs during the winter and spends the rest of its time foraging at sea (Godfrey 1986). Available PIROP and ECSAS data indicates Northern Gannet are present in the Scotian Shelf Bioregion primarily from April through November (spanning spring northward and fall southward migrations). The Northern Gannet feeds mainly on shoaling fish, including Mackerel, Capelin, and Herring, as well as squid, via plunge diving from heights of 30 m, often up to hundreds of kilometers from nesting sites (Godfrey 1986; Montevecchi et al. 1988; Mowbray 2002; Garthe et al. 2014). Garthe et al. (2000) demonstrated that Gannets occasionally dive to depths of 22 m in pursuit of prey, but generally undertake shorter, more shallow dives (90% of dives occurring to <10 m depth). Although the North American population of Northern Gannets is not in decline, it is restricted to six established breeding sites: three in Newfoundland and three in the Gulf of St. Lawrence (Mowbray 2002). Available historic data showed that Northern Gannets were common across the AOI in shallow bank and deeper channel habitat (DFO 2020*a*). More recent data indicate a preference for the eastern portion of the AOI, though persistence of use within the AOI is less clear than for other species.

For the purpose of this assessment, important foraging areas for plunge-diving piscivores (Northern Gannet) was defined as the summed top-quintile classes (top 20% of values for the Scotian Shelf Bioregion) from effort-corrected kernel density plots using available bioregion-wide data from PIROP and ECSAS for each species that make up the guild (adapted from DFO 2020*a*; Figure 1.4.3-18).

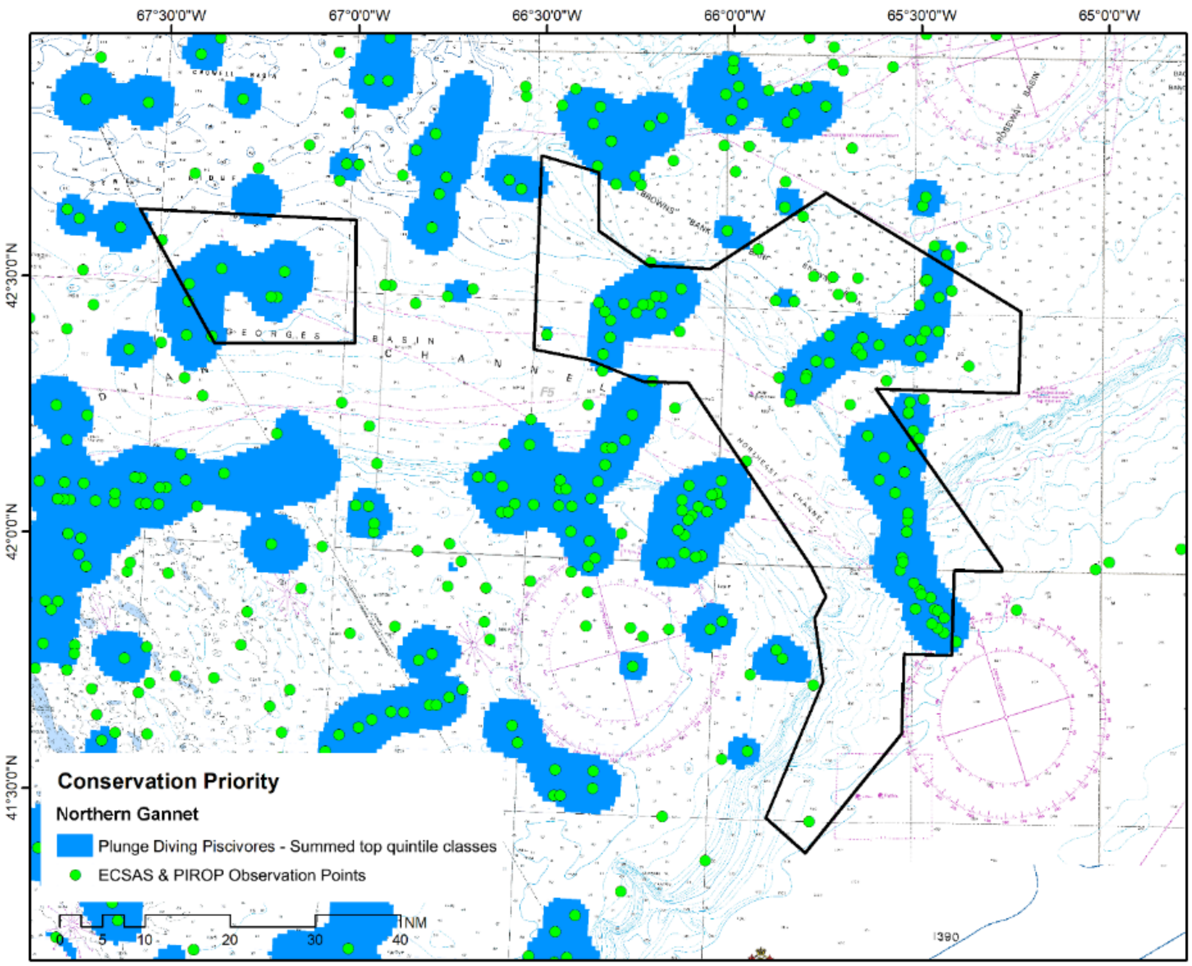



Figure 1.4.3-18. Overlap of top quintile foraging areas (blue polygons) for plunge-diving piscivore (Northern Gannet) with the Fundian Channel-Browns Bank AOI (black polygon). All observed locations for plunge-diving piscivores in the ECSAS and PIROP databases from April through November are shown as green points.

Area of high productivity

The mouth (i.e., south-eastern extent) of the Fundian Channel is an area of relatively high productivity in the Scotian Shelf, owing to a combination of oceanographic processes including a persistent clockwise gyre over Browns Bank, areas of upwelling, the occasional presence of Gulf

Stream current and warm-core rings, and internal waves that concentrate plankton. These features attract species at all trophic levels, including large and small pelagic fishes, sea turtles, seabirds, and cetaceans.

For the purpose of the risk assessment, areas of high productivity in and around the AOI were defined as areas of persistent high (top quintile) annual phytoplankton biomass in the Western and Slope subdivisions of the Scotian Shelf Bioregion, as determined by Fuentes-Yaco et al. (2015). Productivity is highest in the period of September to April, which encompasses the bloom in late fall, higher productivity in winter, and March/April spring bloom (Johnson et al. 2017) (Figure 1.4.3-19).

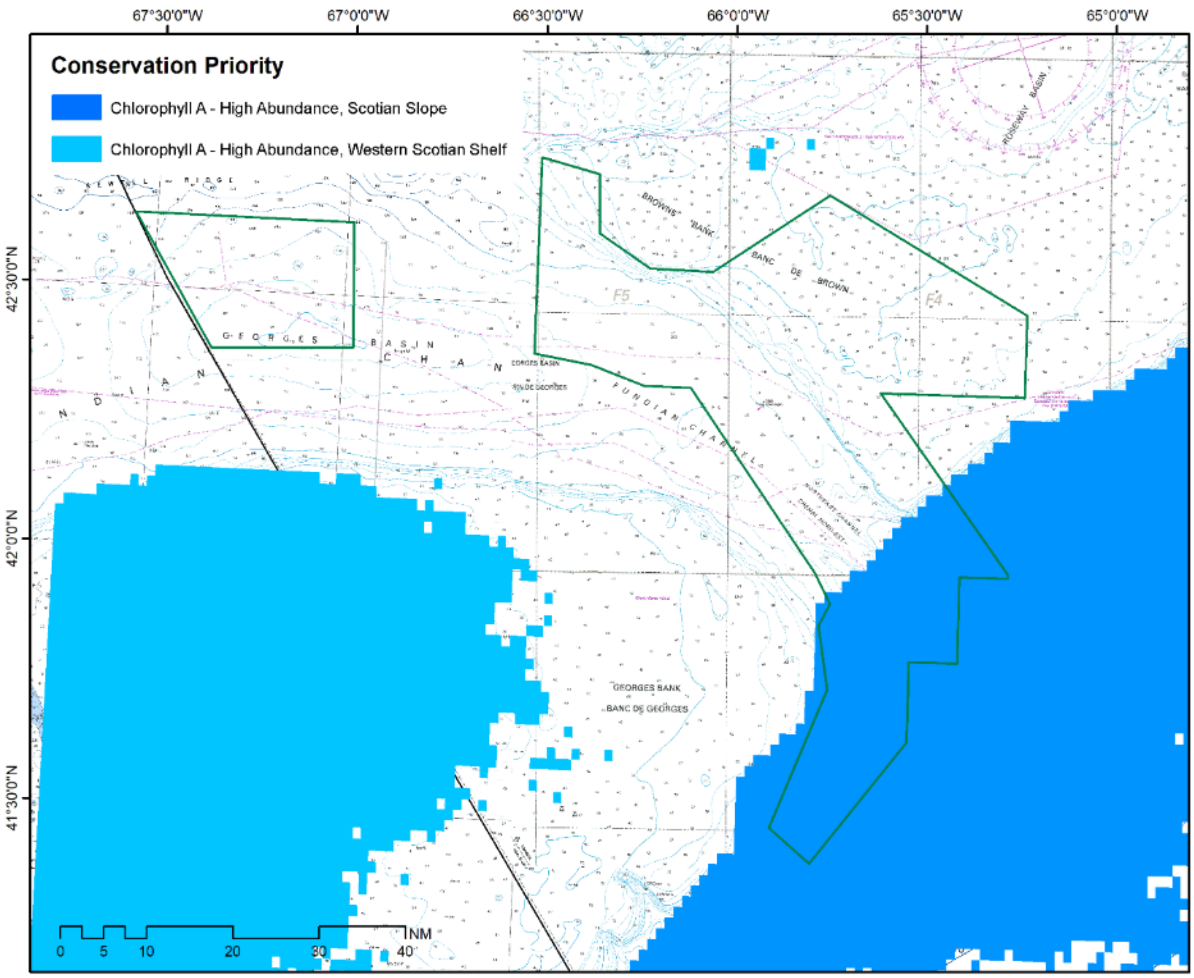



Figure 1.4.3-19. Overlap of areas of high and persistent annual phytoplankton biomass (adapted from Fuentes-Yaco et al. 2015) with the Fundian Channel-Browns Bank AOI (green polygon).

*Other Conservation Priorities*

Certain conservation priorities proposed by DFO (2020*a*) for the Fundian Channel-Browns Bank AOI are not well-suited for risk assessment. These are briefly described along with the rationale for their exclusion in Table 1.4.3-2.

Table 1.4.3-2. Conservation priorities recommended by DFO (2020*a*) that will not be subject to this ecological risk assessment.

| Conservation priority | Rationale for scoping out of the risk assessment |
|---|---|
| Diverse representation of habitat types, including basin, bank, deep-water slope and channel habitats, and their associated fish and invertebrate communities. | While the complexity of habitats and substrates found within the AOI provides a strong rationale for marine conservation based on the uniqueness of the area and the biodiversity it supports, it is difficult to assess how the human activities scoped into the risk assessment could perceptibly impact this feature as a whole. |

### 1.4.4 Human Activities

In 2018, the Minister of Fisheries, Oceans and the Canadian Coast Guard launched a National Advisory Panel on MPA Protection Standards to gather perspectives and offer recommendations on protection standards for federal MPAs (DFO 2019, DFO 2023). On April 25, 2019, the Government of Canada responded to the Panel's final report. In regard to the designation of new MPAs, oil and gas exploration and exploitation, mining, dumping, and bottom trawling will be prohibited in all sites going forward. The prohibition on bottom trawling applies to mobile bottom-contacting gear used for commercial and recreational purposes including otter trawls, beam trawls, shrimp trawls, hydraulic clam dredges, and scallop dredges. These activities were not considered as part of the current risk assessment.

Human activities to be considered in the Fundian Channel-Browns Bank AOI risk assessment were identified through available data and information about human uses of the site, including a marine harvest profile (DFO Policy and Economics 2021). Pressures associated with the following human activities will be assessed:

- Fisheries
  - Pot/trap
  - Pelagic and bottom longline
  - Buoy gear
  - Gillnet
  - Midwater trawl
- Marine Transportation
  - Vessel transits
  - Vessel-sourced spills
- Submarine Cables
  - Installation (surface and buried)

Each of these activities will be further described as part of the introduction to the sector-specific risk assessments (see Chapters 2-4).

In addition to activities addressed by the new protection standards for federal MPAs (described above), other activities that will not be considered in the Fundian Channel-Browns Bank AOI ecological risk assessment include activities that have either never occurred in the area or are not currently being planned for the area (e.g., renewable energy generation, offshore aquaculture).

Certain extremely low impact fisheries will also not be assessed for the sake of efficiency. Specifically, hand-gear (angling/hook and line, harpoon), are highly selective, with limited to no bycatch, and do not impact the substrate. Likewise, food, social, and ceremonial fisheries remove only small amounts of biomass from the environment.

Activities associated with public safety, national defence, national security, law enforcement or emergency response will also not be assessed, as these activities are allowed to occur in all *Oceans Act* MPAs. Other activities, such as scientific research and commercial tourism, will be evaluated on a case-by-case basis through an activity application if a Fundian Channel-Browns Bank MPA is designated.

## 1.5 POTENTIAL FOR INTERACTION

Once the activities and ecosystem components to be considered in the assessment have been identified, the next step in the risk assessment process is to evaluate the potential for interaction to determine which interactions merit analysis. For this assessment, the potential for interaction was determined by consulting pathways of effects models (where available), along with supplemental information from relevant literature. Interaction, as used here, means that an exposure pathway exists and there is potential for negative impacts to occur. The potential for interaction between activities (and their associated pressures) and the conservation priorities for the Fundian Channel-Browns Bank AOI was evaluated as part of each sector-specific risk assessment (see Chapters 2-4). For each activity, a risk analysis was conducted only for those conservation priorities where a potential for negative impacts exists (e.g., spatial and temporal overlap of pressure and conservation priority). To simplify the analysis, risks for each activity/pressure were analyzed against the most vulnerable aspect of each conservation priority. Where multiple species within an assemblage of conservation priorities (e.g., groundfish) had a potential for negative impacts from a specified pressure, the risk assessment analyzed the interaction only for the most sensitive species or ecosystem component of the group, as determined by expert opinion or review of the literature. That assessment may then be used as a proxy for others in the assemblage.

## 1.6 RISK STATEMENT

For each risk analysis, a risk statement was developed to help frame the scenario under assessment, with consideration for the nature and magnitude of the activity and the characteristics of the area. The scenario under assessment may be a situation that is likely to occur as a result of a particular human activity (e.g., a certain level of fishing bycatch) or it may be a rare event (e.g., a large accidental oil spill), but in all cases it should be a realistic scenario.

Each risk statement was set up using the following format:

"There is a risk that *pressure x* from *activity y* will lead to a *perturbation in conservation priority z* within the AOI."

For example, to assess the interaction between pressures associated with the offshore lobster fishery and significant sponge concentrations, a risk statement could be:

"There is a risk that *bottom disturbance* from *lobster pots* will lead to *negative impacts on deep-water coral communities* within the AOI".

## 1.7 RISK ANALYSIS

The risk analysis approach used for the ecological risk assessment for the Fundian Channel-Browns Bank AOI assessed the consequence of an interaction between activity/pressure and ecological component by estimating the magnitude of the interaction (i.e., exposure based on the expected level of human activity) and the potential sensitivity of the ecological component to the pressure within the AOI. Once the consequence level was determined, it was then combined with the likelihood (i.e., probability) of the interaction to assign a level of risk using the heat map shown in Figure 1.7.3-1. Please note that the scope of this assessment is to determine risk specifically within the FC-BB AOI, hence the results of these assessments may not be reflective of the level of sensitivity, likelihood, or overall risk from activities/pressures experienced in other parts of the region. The method for deriving consequence, likelihood, and the overall risk level is described further below.

### 1.7.1 Consequence

This method defines the potential consequence of an interaction between an ecological component and a given activity/pressure as a function of Exposure and Sensitivity, as follows:

$Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$

Where:

$Q_{Exposure}$ is the magnitude of interaction between the activity/pressure and the ecosystem component as determined by three factors (Table 1.7.1-1):

1) Intensity of the interaction as scored from 1-3
2) Temporal scale of the interaction as scored from 1-4
3) Spatial scale of the interaction as scored from 1-3

Intensity provides a measure of density (e.g., effort, number of events, amount) or persistence of the pressure in the environment (e.g., persistence of oil after a spill event), and is determined based on characteristics of the activity being assessed.

Temporal scale is used to score the frequency of the potential interaction on an annual basis, rather than the duration of a single event. This factor allows the evaluator to adjust exposure for seasonal activities (e.g., seasonal fishery) versus those activities that have the potential to occur and interact with the conservation priority year-round. For conservation priorities that are only present within the AOI during certain seasons, an estimate of frequency per year is still used, as the pressures associated with a given interaction would only act on the conservation priority while it is present within the site.

Spatial scale is the amount of spatial overlap of the pressure with the conservation priority within the AOI. For fisheries interactions this would be the extent of overlap of the fisheries footprint with the spatial extent of the conservation priority within the AOI. For pressures such as oil spills or noise, the spatial scale would consider the overlap of the predicted zone of influence with the spatial extent of the conservation priority.

Scores used in calculating exposure are determined with consideration for existing preventative management measures (seasonal and gear type restrictions, industry best practices, etc.) based on available human-use data and/or expert advice for cases where data were lacking.

Table 1.7.1-1. Definitions for scoring $Q_{Exposure}$ variables (adapted from Murray et al. 2016)

| | | |
|---|---|---|
| ***Intensity*** | | |
| *Score* | *Effect* | *Definition*[2] |
| 1 | Low | Low density or persistence |
| 2 | Moderate | Moderate density or persistence |
| 3 | High | High density or persistence |
| ***Temporal Scale*** | | |
| *Score* | *Effect* | *Definition*[3] |
| 1 | Rare | Potential to occur but not every year |
| 2 | Sporadic/Occasional | Potential to occur quarterly to annually; or potential for continuous seasonal use up to 3 months of the year |
| 3 | Frequent | Potential to occur weekly to monthly; or potential daily occurrences for 4 to 8 months of the year |
| 4 | Continuous | Potential to occur daily; or potential for continuous use for 9 months of the year or more |
| ***Spatial Scale*** | | |
| *Score* | *Effect* | *Definition*[4] |
| 1 | Few restricted locations | <10% spatial overlap between the pressure and conservation priority within the AOI |
| 2 | Localized | 10-49% spatial overlap between the pressure and conservation priority within the AOI |
| 3 | Widespread | >50% spatial overlap between the pressure and conservation priority within the AOI |

These three scores are then multiplied to derive a raw $Q_{Exposure}$ score ranging from 1 to 36 and the raw $Q_{Exposure}$ score is then binned to a scale of 1-5 (Table 1.7.1-2).

[2] See each sector-specific chapter for further details on how intensity is assessed for a given pressure.

[3] The definitions for the temporal frequency scores were expanded from those used in Murray et al. 2016 to provide more direction for scoring potential continuous use of limited duration, such as seasonal activities.

[4] The % spatial overlap used for each of the spatial scale scores was taken from Aker et al. 2014.

Table 1.7.1-2. Scoring Rubric for $Q_{Exposure}$ (adapted from O et al. 2015).

| ***Description*** | | | ***Raw Score*** | ***Binned Score*** |
|---|---|---|---|---|
| *Intensity* | *Temporal Scale* | *Spatial Scale* | | |
| 1 (Low) | 1 (Rare) | 1 (Few restricted locations) | 1 | 1 |
| 1 (Low) | 1 (Rare) | 2 (Localized) | 2 | 1 |
| 1 (Low) | 2 (Sporadic/Occasional) | 1 (Few restricted locations) | 2 | 1 |
| 2 (Moderate) | 1 (Rare) | 1 (Few restricted locations) | 2 | 1 |
| 1 (Low) | 1 (Rare) | 3 (Widespread) | 3 | 1 |
| 1 (Low) | 3 (Frequent) | 1 (Few restricted locations) | 3 | 1 |
| 3 (High) | 1 (Rare) | 1 (Few restricted locations) | 3 | 1 |
| 1 (Low) | 2 (Sporadic/Occasional) | 2 (Localized) | 4 | 2 |
| 1 (Low) | 4 (Continuous) | 1 (Few restricted locations) | 4 | 2 |
| 2 (Moderate) | 1 (Rare) | 2 (Localized) | 4 | 2 |
| 2 (Moderate) | 2 (Sporadic/Occasional) | 1 (Few restricted locations) | 4 | 2 |
| 1 (Low) | 2 (Sporadic/Occasional) | 3 (Widespread) | 6 | 2 |
| 1 (Low) | 3 (Frequent) | 2 (Localized) | 6 | 2 |
| 2 (Moderate) | 1 (Rare) | 3 (Widespread) | 6 | 2 |
| 2 (Moderate) | 3 (Frequent) | 1 (Few restricted locations) | 6 | 2 |
| 3 (High) | 1 (Rare) | 2 (Localized) | 6 | 2 |
| 3 (High) | 2 (Sporadic/Occasional) | 1 (Few restricted locations) | 6 | 2 |
| 1 (Low) | 4 (Continuous) | 2 (Localized) | 8 | 3 |
| 2 (Moderate) | 2 (Sporadic/Occasional) | 2 (Localized) | 8 | 3 |
| 2 (Moderate) | 4 (Continuous) | 1 (Few restricted locations) | 8 | 3 |
| 1 (Low) | 3 (Frequent) | 3 (Widespread) | 9 | 3 |
| 3 (High) | 1 (Rare) | 3 (Widespread) | 9 | 3 |
| 3 (High) | 3 (Frequent) | 1 (Few restricted locations) | 9 | 3 |
| 1 (Low) | 4 (Continuous) | 3 (Widespread) | 12 | 4 |
| 2 (Moderate) | 2 (Sporadic/Occasional) | 3 (Widespread) | 12 | 4 |
| 2 (Moderate) | 3 (Frequent) | 2 (Localized) | 12 | 4 |
| 3 (High) | 2 (Sporadic/Occasional) | 2 (Localized) | 12 | 4 |
| 3 (High) | 4 (Continuous) | 1 (Few restricted locations) | 12 | 4 |
| 2 (Moderate) | 4 (Continuous) | 2 (Localized) | 16 | 4 |
| 2 (Moderate) | 3 (Frequent) | 3 (Widespread) | 18 | 5 |
| 3 (High) | 2 (Sporadic/Occasional) | 3 (Widespread) | 18 | 5 |
| 3 (High) | 3 (Frequent) | 2 (Localized) | 18 | 5 |
| 2 (Moderate) | 4 (Continuous) | 3 (Widespread) | 24 | 5 |
| 3 (High) | 4 (Continuous) | 2 (Localized) | 24 | 5 |
| 3 (High) | 3 (Frequent) | 3 (Widespread) | 27 | 5 |
| 3 (High) | 4 (Continuous) | 3 (Widespread) | 36 | 5 |

The binned $Q_{Exposure}$ score is then combined with $Q_{Sensitivity}$ to derive $Q_{Consequence}$.

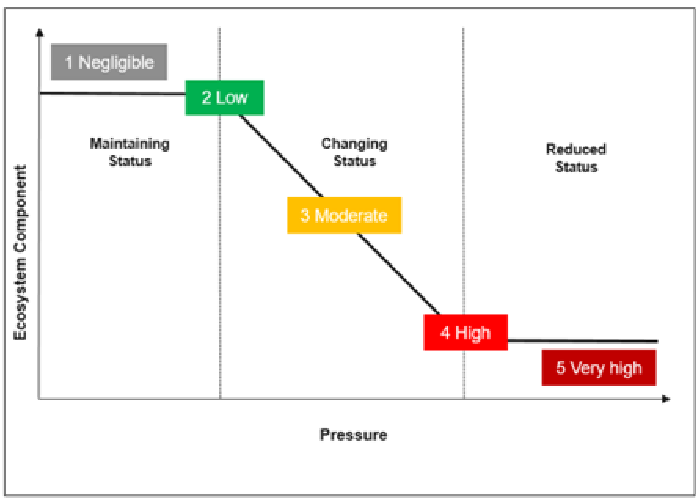
$Q_{Sensitivity}$

Sensitivity represents the potential for long-term harm to an ecosystem component as a result of interaction with the pressure based on the scenario under assessment, as defined by the risk statement. Sensitivity was determined with consideration for existing management measures based on available data, expert advice, and/or with reference to relevant peer-reviewed literature.

Resistance to change, as well as the ability to recover, was considered as part of the assignment of sensitivity level for each conservation priority. Sensitivity criteria were developed for three categories of ecological components relevant for the AOI: species, habitat, and community/ecosystem properties (Figure 1.7.1-1, Table 1.7.1-3); the most appropriate categorization was applied based on the nature of the conservation priority and the interaction with the pressure. For the purpose of this risk assessment, conservation priorities for the Fundian Channel-Browns Bank AOI were classified as follows:

- Concentrations of large mature female lobster: **SPECIES**
- Cetaceans: **SPECIES**
- Sensitive benthic species (corals and sponges): **HABITAT**
- Groundfish: **SPECIES**
- Foraging areas for seabirds: **SPECIES**
- Area of high productivity: **COMMUNITY / ECOSYSTEM PROPERTIES**

A score from 1 to 5 was assigned to the descriptive sensitivity criteria to allow for incorporation into the $Q_{Consequence}$ calculation.




| Negligible | Low | Moderate | High | Very High |
|---|---|---|---|---|
| **1. Maintaining Status:** The ecosystem component resists or rapidly compensates in the face of perturbation. | **2. just past inflection** | **3. Changing Status:** The ecosystem component changes with perturbation. Recovery is expected after a period of altered status | **4. approaching inflection** | **5. Reduced Status:** The ecosystem component has been degraded to a status where recovery is no longer secure |

Figure 1.7.1-1. The relationship between the sensitivity of ecosystem components and potential pressures.

Table 1.7.1-3. Definitions for sensitivity categories (adapted from O et al. 2015).

| | **1. Maintaining Status:** The ecosystem component resists or rapidly compensates in the face of perturbation. | **2. Just past inflection** | **3. Changing Status**: The ecosystem component changes with perturbation. Recovery is expected after a period of altered status | **4. Approaching inflection** | **5. Reduced Status:** The ecosystem component has been degraded to a status where recovery is no longer secure |
|---|---|---|---|---|---|
| **Species** | Insignificant or undetectable change. Unlikely to be detectable against background variability for this population. | Possible detectable change in population size / geographic range / genetic structure / population structure / reproductive capacity / behaviour but minimal or no impact on population dynamics. For behavioral changes, time to return to original behaviour / movement is days to weeks. | Detectable change in population size / geographic range / genetic structure / population structure / reproductive capacity / behaviour. Impacts on population dynamics at maximum sustainable level. Long-term recruitment dynamics are not adversely damaged. For behavioral changes, time to return to original behaviour / movement is weeks to months. | Major source of mortality. Detectable change in population size / geographic range / genetic structure / population structure / reproductive capacity / behaviour. Long-term recruitment dynamics are adversely affected. Time to recovery up to 5 generations free from impact. For behavioral changes, time to return to original behaviour / movement is months to years. | Local extinctions are imminent/immediate. Significant change in population size / geographic range / genetic structure / population structure / reproductive capacity / behaviour. Long-term recruitment dynamics are adversely affected. Time to recovery >5 generations free from impact. For behavioral changes, time to return to original behaviour / movement is years to decades, or change is permanent. |

| | **1. Maintaining Status:** The ecosystem component resists or rapidly compensates in the face of perturbation. | **2. Just past inflection** | **3. Changing Status**: The ecosystem component changes with perturbation. Recovery is expected after a period of altered status | **4. Approaching inflection** | **5. Reduced Status:** The ecosystem component has been degraded to a status where recovery is no longer secure |
|---|---|---|---|---|---|
| **Habitat** | Insignificant or undetectable change to habitat distribution or structure and function. Time to recover to pre-disturbed state is hours to days | Detectable impacts to habitat distribution (spatial extent) or structure and function. For impacts to habitat distribution, time to recover from local impacts is days to weeks, or days to months for larger spatial scales. For impacts to habitat structure / function, recovery (regardless of spatial scale) takes days to months. | Moderate impacts that reduce habitat distribution (spatial extent) or structure and function. For impacts to habitat distribution, time to recover from local impacts is weeks to months, or months to <1 year for larger spatial scales. For impacts to habitat structure/function, recovery (regardless of spatial scale) takes months to <1 year. | Major impacts. The level of reduction of habitat spatial extent and/or internal dynamics of habitat may threaten the ability to recover adequately, or it will cause strong downstream effects from loss of function. Recovery from impacts to habitat distribution/ structure/function takes 1 to 10 years. | The dynamics of the entire habitat is in danger of catastrophic change. If reversible, recovery may take decades to centuries. |
| **Community /ecosystem properties** | Insignificant or undetectable change. Unlikely to be detectable against natural variation. | Possible detectable change but minimal impact on species composition / relative abundance / functional group constituents / geographic range / trophic level / size structure / community dynamics. | Detectable change with some impact on species composition/relative abundance / functional group constituents / geographic range / trophic level / size structure / community dynamics. Recovery is weeks to months. | Major change to ecosystem function as species composition / relative abundance / functional group constituents / geographic range / trophic level / size structure / community dynamics is altered measurably. Recovery is months to years. | Total collapse of ecosystem function. Long term recovery period required on the scale of decades to centuries. |

Finally, recall that $Q_{Consequence}$ was calculated as follows:

$Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$

This calculation resulted in raw values between 1 and 25, which were then binned into 5 descriptive categories ranging from negligible to very high (Table 1.7.1-4). The binned category breaks were determined using quantiles and adjusted so that raw scores with the same value fell into the same category. In addition, the "negligible" and "low" categories were further adjusted based on expert opinion.

Table 1.7.1-4. Scoring Rubric for $Q_{Consequence}$.

| $Q_{Exposure}$ | $Q_{Sensitivity}$ | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$ | Binned Consequence Category |
|---|---|---|---|
| 1 | 1 | 1 | Negligible |
| 1 | 2 | 2 | Negligible |
| 2 | 1 | 2 | Negligible |
| 1 | 3 | 3 | Low |
| 3 | 1 | 3 | Low |
| 1 | 4 | 4 | Low |
| 2 | 2 | 4 | Low |
| 4 | 1 | 4 | Low |
| 1 | 5 | 5 | Moderate |
| 5 | 1 | 5 | Moderate |
| 2 | 3 | 6 | Moderate |
| 3 | 2 | 6 | Moderate |
| 2 | 4 | 8 | Moderate |
| 4 | 2 | 8 | Moderate |
| 3 | 3 | 9 | Moderate |
| 2 | 5 | 10 | High |
| 5 | 2 | 10 | High |
| 3 | 4 | 12 | High |
| 4 | 3 | 12 | High |
| 3 | 5 | 15 | High |
| 5 | 3 | 15 | High |
| 4 | 4 | 16 | Very High |
| 4 | 5 | 20 | Very High |
| 5 | 4 | 20 | Very High |
| 5 | 5 | 25 | Very High |

### 1.7.2 Likelihood

The likelihood was determined by considering the probability of the pressure interacting negatively with the conservation priority based on existing data (where available), consideration for existing management measures, references to the literature, and/or expert opinion. Likelihood levels were categorized using a five point scale based on commonly used expressions: rare, unlikely, moderate, likely, and almost certain (Table 1.7.2-1). For unplanned events, such as spills or other accidents, the likelihood score would be lower than the likelihood of interactions resulting from planned activities/normal operations (e.g., a bottom contacting fishery that will interact with the bottom on every gear deployment).

Table 1.7.2-1. Likelihood scores.

| Likelihood | % Probability | Experience/Observed Frequency |
|---|---|---|
| Almost Certain | More than 95% | Interaction will occur (or is occurring) |
| Likely | 76 - 95% | Interaction will occur in most circumstances |
| Moderate | 25 - 75% | Interaction may occur in some but not all circumstances |
| Unlikely | 5 - 24% | Interaction is unlikely |
| Rare | Less than 5% | Interaction may occur only in exceptional circumstances or almost never happens |

### 1.7.3 Risk Determination

Once the consequence and likelihood of the interaction were determined, the final risk level for the interaction was determined using a risk matrix (Figure 1.7.3-1; Table 1.7.3-1).

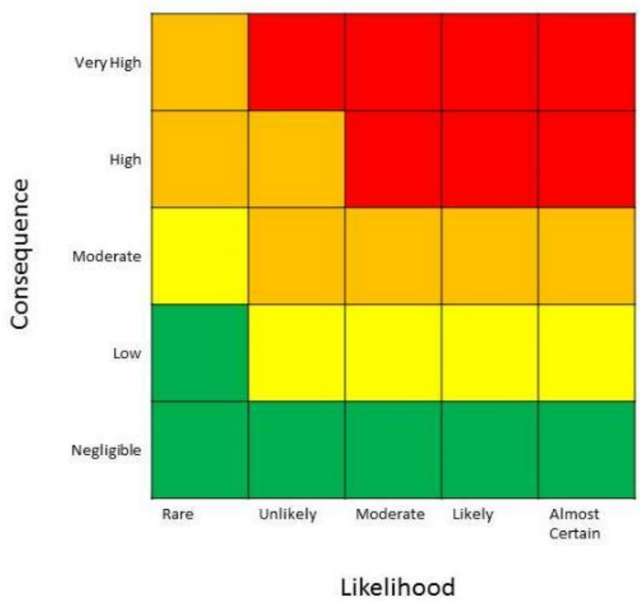



Figure 1.7.3-1. Low tolerance risk matrix (risk level descriptions are provided in Table 1.7.3-1).

This risk matrix assigns a moderately high or high risk-level to all interactions involving moderate, high, or very high consequence regardless of likelihood – with the exception of interactions determined to have moderate consequences with a rare likelihood of occurrence (see Table 1.7.3-1 for descriptions and associated management recommendations for each risk level).

This is a low tolerance risk matrix, and is used here due to the need for precautionary and conservation-focused decision-making in an MPA context. It is important to reiterate that DFO's tolerance for risk is lower within an MPA than elsewhere in the ocean; similar interactions occurring outside an MPA setting may be assessed using a higher tolerance risk matrix, and thus risk levels may come out differently.

Table 1.7.3-1. Risk level descriptions.

| Risk Level | Description | Management Recommendation |
|---|---|---|
| **High** | A risk where:<br>• there is potential, even if unlikely, for a severe long-term impact to an ecosystem component to occur<br>• it is likely that a significant or detectable moderate impact will occur | Additional management measures[5] required to ensure adequate protection of ecosystem component. |
| **Moderately High** | A risk where:<br>• it is likely that a detectable moderate impact to an ecosystem component will occur<br>• a significant or severe long-term impact could occur, but it is unlikely or rare | In general, additional management measures should be considered (where feasible) based on the nature of the risk. |
| **Moderate** | A risk where:<br>• it is likely that a detectable but minimal impact to an ecosystem component will occur<br>• a detectable moderate impact could occur, but it is rare | In general, additional management measures may or may not be considered, based on the nature of the risk. |
| **Low** | A risk where:<br>• a negligible or non-detectable impact to an ecosystem component could occur<br>• a detectable but minimal impact could occur, but it is rare | No additional management measures need to be considered. |

The management recommendations for each risk level provide the starting point for exploring feasible management options for mitigating risks to conservation priorities in the future MPA. Risk results do not represent final decisions about how activities will be managed in the future MPA. Factors such as social and economic considerations, feedback from consultations, and the application of the precautionary approach are taken into account to determine proposed design and management measures for the future MPA.

### 1.7.4 Uncertainty

Due to the considerable level of uncertainty involved with risk assessment, risk scores were assigned a relative level of uncertainty (low, moderate, high) based on the criteria in Table 1.7.4-

[5] For example: spatial or temporal restrictions, gear or equipment restrictions, or complete exclusion from the MPA. This does not preclude the need for monitoring/data collection for activities that are allowed to continue in the site.

1. The level of uncertainty was dependent on available data and the need for assumptions (ISO 2009).

Table 1.7.4-1. Criteria for assigning a level of uncertainty.

| **Uncertainty Level** | **Description** |
|---|---|
| Low Uncertainty | Widely accepted information supported by peer-reviewed science-based literature, Indigenous knowledge holders, and/or local knowledge holders. No or minimal additional data collection needed. |
| Moderate Uncertainty | Science-based evidence, Indigenous knowledge, and/or local knowledge available but potentially requiring updating or validation for specific location or time frame. |
| High Uncertainty | Little to no peer-reviewed literature, science-based data, Indigenous knowledge, and/or local knowledge available. Some general knowledge and/or data may exist but would require validation. |

The risk assessment for Fundian Channel-Browns Bank AOI was conducted with consideration for the precautionary principle. This means that the evaluator erred on the side of caution when assigning consequence and likelihood scores.

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# 2.0 FISHERIES

## 2.1 SECTOR OVERVIEW

From 2015-2019, the landed value of all fish species caught in the Fundian Channel-Browns Bank AOI averaged $5.4 million per year representing an averaged landed weight of 645,000 kg per year (DFO Policy and Economics 2021). Swordfish, tuna, and shark represent approximately 56% of the annual total; lobster, scallop, and other shellfish represent 37% of the annual total; and groundfish represent the remaining ~7% of the annual total. While 186 licence holders have landings from the AOI within this five year timespan, there was an average of 76 active licence holders per year (range of 59-100 licence holders during the assessment period).

The impacts from fishing activity varies depending on the nature of the fishery and ecological component under assessment. For example, pelagic gears may not impact benthic communities but may, like any fixed gear with rope in the water, pose entanglement risk to marine mammals and other species. Likewise, fixed bottom-contacting gears (e.g., lobster pots) have relatively less impact on sensitive benthos overall compared to mobile bottom-contacting gears (e.g., trawls). Some gear types (e.g., hagfish pots) may be very selective for the directed species while others (e.g., demersal longline) may catch a variety of non-target (bycatch) species.

<u>Existing management measures</u>

Commercial fisheries are managed by DFO in accordance with subsection 7(1) of the *Fisheries Act* through Integrated Fisheries Management Plans (IFMP), variation orders, regulations, and licence conditions. Controls and mitigation measures used to reduce ecological impacts from fishing activities may include seasonal and area restrictions, quotas, incidental catch (i.e., bycatch) restrictions, gear specifications, and monitoring (e.g., at-sea observers, dockside monitoring, Vessel Monitoring System [VMS]) and reporting (e.g., hail out/in, logbook records) requirements.

Strategies used across the Department to address bycatch in fisheries are outlined in the guidance on implementation of the *Policy on Managing Bycatch* (DFO 2013*a*). Some important general measures include the mandatory release of most species other than the target species in a manner that causes the least amount of harm (Section 33 of the *Fishery General Regulations*). For fisheries where some retention of bycatch is allowed, bycatch rules and limits are outlined in the IFMP and/or Conservation Harvesting Plan for that fishery. Related to bycatch is the issue of fisheries discards, including fish offal, which can have the effect of attracting and altering the foraging behaviour of marine species, particularly marine birds (Real et al. 2018; Sherley et al. 2020). While this issue is being addressed in other areas, such as the European Union fisheries discards ban, similar measures are not in place for fisheries operating in Canadian waters.

The *Marine Mammal Regulations* under the *Fisheries Act*, updated in 2018, prohibit the disturbance of marine mammals and outline mandatory reporting requirements for all accidental contact with marine mammals. Additionally, the *Species at Risk Act* (SARA) prohibits killing, harming, harassing or capturing any species that is listed as extirpated, endangered, or threatened. Under certain circumstances, detailed in section 73 of the *Species at Risk Act*, the minister may issue a permit to authorize activities that incidentally affect a listed species or its critical habitat.

In recognition of the important ecological role played by benthic ecosystems, the *Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas* is a component of the Sustainable Fisheries Framework and describes DFO's strategy for minimizing impacts of fishing in sensitive benthic areas. This national policy outlines a process for determining the extent and location of benthic habitat types, features, communities, and species in relation to existing or proposed fishing activity, then uses an Ecological Risk Analysis Framework to assess the risk that the activity is likely to cause harm (including serious and irreversible harm) to the sensitive benthic areas. Mitigation and management decisions are made in consideration of the precautionary principle, the ecosystem and socio-economic benefits of the fishery. The Northeast Channel Coral Conservation Area, which is one of several spatial fisheries management measures that overlap with the AOI (Figure 2.1-1), is currently managed under this policy.

The Northeast Channel Coral Conservation Area, established in 2002, was designated to protect high densities of intact octocorals and is divided into two zones (Breeze and Fenton 2007). The restricted bottom fisheries zone is closed to all bottom fishing gear used for groundfish or invertebrate fisheries. The limited bottom fisheries zone is closed to all bottom fishing gear with the exception of groundfish longline when an at-sea observer is on board.

Additionally, two seasonal groundfish spawning closures overlap with the AOI (Figure 2.1-1). These spawning areas are closed to groundfish fisheries from February 1 to June 15 for the Browns Bank spawning closure, and from the end of the 5$^{th}$ week of the year to May 31 for the Georges Bank spawning closure.

Another spatial management measure located within the AOI boundaries is a pelagic longline gear closure known as the Hell Hole (Figure 2.1-1). The Hell Hole is closed to pelagic longline gear annually from July 1 to November 30 to reduce levels of Bluefin Tuna bycatch (Breeze and Horsman 2005; DFO 2013*b*).

The AOI boundary also overlaps with Lobster Fishing Area (LFA) 40 (Figure 2.1-1). LFA 40, which includes all parts of Browns Bank shallower than 50 fathoms (91.4 m), was closed to lobster fishing in 1979 to protect lobster brood stock (DFO 2020*a*). This closure is a conservation measure for both the inshore and offshore lobster fisheries and does not affect other fishing gears.

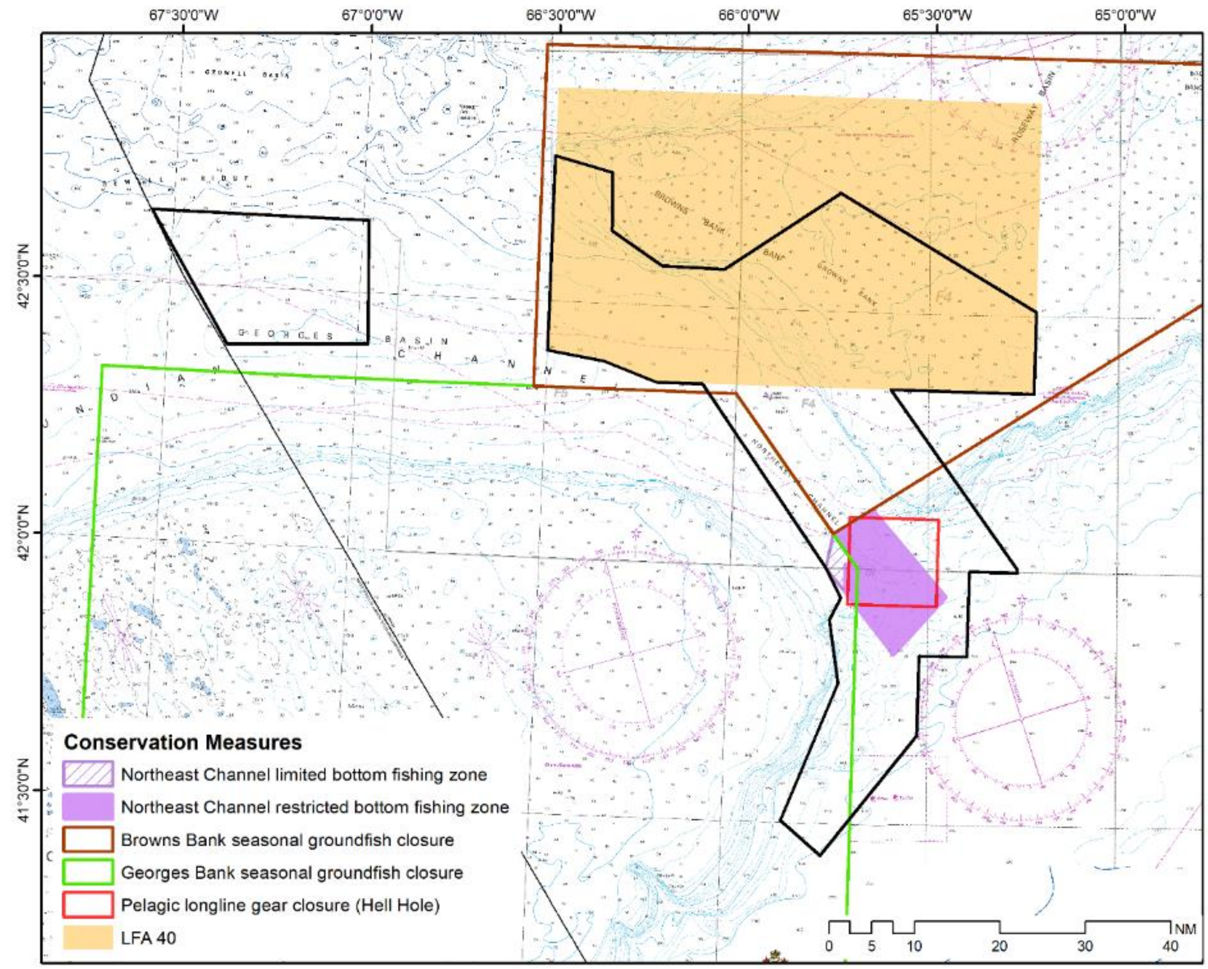


Figure 2.1-1. Existing fisheries closures within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent).

## 2.2 SCOPE OF THE FISHERIES RISK ASSESSMENT

The fisheries that were considered for assessment include those that are currently occurring within the assessment area of the AOI. These are: pot/trap for lobster and hagfish; gillnet for groundfish; pelagic and groundfish longline, and buoy gear for swordfish. As well, while there is no midwater trawl fishery currently operating within the AOI, the potential use of this gear type as an alternative groundfish gear is an area of active exploration; discussions have occurred with fisheries management staff, and there has been recent industry investment in new technology to support expanded use of this gear type; thus this potential fishery was also assessed. As mentioned in Section 1.4.4, the Government of Canada's response to the National Advisory Panel on MPA Standards final report (DFO 2023) prohibits commercial bottom trawling from occurring in all future MPAs. Scallop dredge and flatfish, groundfish, redfish and Silver Hake bottom trawl fisheries were not considered further in this assessment.

Fisheries that have not been conducted in the AOI since 2002 (based on available logbook data and expert knowledge), and some sporadically occurring fisheries were not considered for purposes of efficiency. Instead, assessments of predominant fisheries will be used to support decision-making for less common fisheries that use similar gear types (e.g., impacts from the crab fisheries can be inferred using results from the assessment of the lobster fishery).

Sporadic and/or primarily adjacent fisheries not assessed:

- Rock crab fishery
- Red crab trap fishery
- Jonah Crab trap fishery

In addition, certain low impact fisheries were also not assessed for the sake of efficiency. Specifically, hand-gear (angling/rod and reel, harpoon), are highly selective, allow for no bycatch and do not impact the substrate. Likewise, food social and ceremonial fisheries remove only small amounts of biomass from the environment.

Potential for Interaction

The potential for interactions between each of the fisheries and the conservation priorities are identified in Table 2.2-1. Briefly, bottom-contacting gears (i.e., pots/traps, bottom longline) were considered to have the potential to interact with conservation priorities associated with the benthos. Gear types that were not expected to contact the bottom (e.g., pelagic longline) would not be expected to interact with strictly benthic organisms, but may interact with fish, marine mammals, and foraging birds in other parts of the water column. Pressures associated with fishing activity include bottom disturbance and bycatch/entanglement. Potential impacts from fisheries discards to marine birds are considered within the bird/bycatch assessments.

Table 2.2-1. Potential for interaction between fishing activities and conservation priorities for the Fundian Channel-Browns Bank AOI. Dark blue shading indicates that an exposure pathway exists and effects are known to occur, light blue indicates that an exposure pathway exists and effects may occur, and white indicates a lack of interaction. An asterisk identifies interactions selected to undergo the risk assessment.

| Conservation Priority | Lobster pot | | Hagfish trap | | Groundfish longline | | Groundfish gillnet | | Pelagic longline | | Buoy gear | | Midwater trawl | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bycatch/ Entanglement | Bottom disturbance | Bycatch/ Entanglement | Bottom disturbance | Bycatch/ Entanglement | Bottom disturbance | Bycatch/ Entanglement | Bottom disturbance | Bycatch/ Entanglement | Bottom disturbance | Bycatch/ Entanglement | Bottom disturbance | Bycatch/ Entanglement | Bottom Disturbance |
| Large mature female lobster | | | | | * | | * | | | | | | * | |
| Cetaceans: Beaked whale habitat | | | | | * | | * | | * | | * | | * | |
| Cetaceans: Blue Whale foraging area | * | | * | | | | | | | | | | | |
| Sensitive benthic sp: Deep water corals | | * | | * | | * | | * | | | | | | * |
| Sensitive benthic sp: Significant sponge concentrations | | | | | | * | | | | | | | | * |
| Groundfish: Juvenile Atlantic Halibut habitat | | | | | | | | | | | | | | |
| Groundfish: Atlantic Cod habitat | | | | | | | | | | | | | | |
| Groundfish: Atlantic Wolffish habitat | | | | | | | | | | | | | | |
| Groundfish: Winter Skate habitat | | | | | | | | | | | | | | |
| Groundfish: Thorny Skate habitat | | | | | | | | | | | | | | |
| Groundfish: White Hake habitat | | | | | | | | | | | | | | |
| Groundfish: Cusk habitat | * | | | | * | | * | | | | | | * | |
| Marine birds: Shallow-diving pursuit generalists | | | | | * | | * | | * | | | | | |
| Marine birds: Surface seizing planktivore/piscivores | | | | | | | | | | | | | * | |
| Marine birds: Surface shallow-diving piscivores | | | | | | | | | | | | | | |
| Marine birds: Pursuit-diving piscivores | | | | | | | | | | | | | | |
| Marine birds: Pursuit-diving planktivores | | | | | | | | | | | | | | |
| Marine birds: Plunge-diving piscivores | | | | | | | | | | | | | | |
| Area of high productivity | | | | | | | | | | | | | | |

*Lobster pot fishery*: The lobster pot/trap is by its design a bottom contacting gear therefore there is the potential for interaction with all bottom features and habitats. Trap fisheries can impact biogenic habitat, such as corals and sponges, through crushing, entanglement with lines, and scouring if traps are dragged during retrieval or periods of strong currents (DFO 2010*a*). Due to spatial overlap, bottom disturbance of corals was assessed for the lobster fishery.

Whales can become entangled in the ground lines and buoy lines associated with trap fishing gear (DFO 2010*a*). There is greater spatial overlap between the fishery footprint and the Blue Whale foraging area than the suitable beaked whale habitat thus potential risks to the Blue Whale foraging habitat was selected to undergo the risk assessment.

The non-retained lobsters in LFA 41 are primarily berried females and larger lobsters (Pezzack et al. 2015). Based on lobster tagging studies, it is assumed that returned berried females will hatch their eggs and large lobsters will continue to reproduce post-release, therefore the impact on large female lobsters was not assessed.

Although lobster traps are designed to contact the benthos, bottom disturbance of groundfish habitat is not expected to be significant from this gear type. Furthermore, the species most frequently caught as bycatch in LFA 41 include several groundfish conservation priorities, such as Cusk and Atlantic Cod (DFO 2021*a*). Cusk was selected for assessment due to its high post-release mortality rate (COSEWIC 2012*a*).

While there are records of cormorants caught in traps and associated lines, it is a rare occurrence (DFO 2010*a*). The vast majority of seabird bycatch occurs in longline, gillnet, and otter trawl fisheries (Chuenpagdee et al. 2003; Sullivan et al. 2006; Zydelis et al. 2009; Anderson et al. 2011; Croxall et al. 2012); therefore this interaction was not assessed.

*Hagfish trap fishery*: Hagfish traps contact the bottom therefore there is the potential for interaction with all bottom features and habitats. As there was no spatial overlap with important sponge areas, bottom disturbance of corals was assessed for this fishery.

Bottom disturbance of groundfish habitat is not expected to be significant from this gear type. As well, hagfish traps are very selective and result in almost no bycatch (DFO 2009*a*). Only two kg of Atlantic Cod and one kg of White Hake were recorded in all At-Sea Observer Program records for this fishery within DFO Maritimes Region. These levels were considered too low to warrant assessment of bycatch impacts to the groundfish conservation priorities.

Whales can become entangled in the ground lines and buoy lines associated with trap fishing gear (DFO 2010*a*). There was no overlap with this activity and the suitable beaked whale habitat, therefore the potential risks to the Blue Whale foraging habitat was selected to undergo a risk assessment.

*Groundfish longline fishery:* This fishery uses a bottom-contacting gear, therefore there is the potential for interaction with bottom features and habitats. Benthic longlines are anchored to the seafloor and baited, causing a risk of bycatch of benthic organisms. Therefore, lobsters were selected for assessment. Demersal longline gear can displace or remove features on the sea floor during setting and retrieval, resulting in benthic disturbance to habitats such as deep water corals and sponges. Deep-water corals and sponges are very long lived and susceptible to damage (DFO 2010*a*), therefore due to sensitivity and overlap, both corals and sponges were selected for assessment.

Longlines can be kilometers long, with thousands of baited hooks attached to the mainline, posing a risk of entanglement to whales. While it is well known that entanglement in fishing gear is a threat to whales (DFO 2022), the source of entanglement is not well understood. Beaked whales forage at the seafloor where they may be susceptible to interacting with groundfish longlines (COSEWIC 2019). Entanglement of Blue Whales in longlines may also occur, but information on this interaction is lacking, and entanglement is considered a lower risk threat for the Northwest Atlantic population of Blue Whale (Beauchamp et al. 2009). Consequently, beaked whales were selected for assessment. The results from the beaked whale assessment can be used as a proxy for Blue Whales during site design.

The groundfish longline fishery is a multi-species fishery and can catch a variety of groundfish species. Groundfish that are not targeted by the fishery but are commonly caught as bycatch include Cusk, skates, White Hake, and wolffish (DFO 2018*a*). Cusk was selected for assessment due to its high bycatch rate compared to other groundfish species and its high post-release mortality rate (COSEWIC 2012*a*). Bottom disturbance of groundfish habitat is not expected to be significant from this gear type.

Groundfish longline has the potential for interaction with most functional guilds of seabirds. Seabirds are attracted to fishing vessels due to bait and fish waste, and are at risk of being caught on the lines largely during setting and hauling (Anderson et al. 2011), or through collision or entanglement with lines (Løkkeborg 2008; Cortés and González-Solís 2018). In an analysis of observer data in the Maritimes region, shearwaters were identified as the most common seabird bycatch in groundfish longlines in the region (Hedd et al. 2015), therefore shallow-diving pursuit generalists (e.g., shearwaters, petrels) were selected for assessment.

*Groundfish gillnet fishery*: Groundfish gillnets are anchored to the seafloor, therefore there is the potential for interaction with all bottom features and habitats. Due to spatial overlap, bottom disturbance of corals was assessed for this fishery.

This fishery results in high levels of bycatch (Clark et al. 2015). At-Sea Observer Program records for this fishery within the AOI assessment area show bycatch of all of the groundfish conservation priorities. However, within the AOI itself, there is very little spatial overlap between the activity and groundfish conservation priorities, with the exception of Cusk. Cusk were therefore selected to undergo assessment. Lobster are also caught as bycatch in this fishery and therefore large female lobster were selected for assessment.

Entanglement of marine mammals, seabirds, and other animals can also occur in groundfish gillnet fisheries (Pingguo 2006; Baer et al. 2010). As there was no spatial overlap with this fishery and the Blue Whale foraging area, beaked whales were selected for assessment. The only bird species recorded in the groundfish gillnet bycatch data within the AOI assessment area was Great Shearwater, therefore shallow pursuit-diving generalists (shearwaters) were selected for assessment.

*Pelagic longline fishery*: This fishery does not come into contact with the benthos, therefore no bottom disturbance interactions were assessed. Risks from this fishery are related to bycatch and entanglement of non-target species. Cetaceans are generally susceptible to entanglement in fishing gear, and there have been reports of entangled beaked whales in pelagic longline gear on the Scotian Shelf (DFO 2017*a*; DFO 2022). Entanglement of Blue Whales in longlines may also occur, but information on this interaction is lacking, and entanglement is considered a lower risk threat for the Northwest Atlantic population of Blue Whale (Beauchamp et al. 2009).

Considering also that the suitable beaked whale habitat has greater spatial overlap with this activity, beaked whales were selected from the two cetacean conservation priorities to undergo assessment. The results from the beaked whale assessment can be used as a proxy for Blue Whales during site design.

During the setting and retrieval of longline gear, seabirds may attack the baited hooks and become hooked or entangled, resulting in drowning when the longline sinks (DFO 2007*a*). The most susceptible seabirds to bycatch in longline fisheries globally are petrels, albatrosses, and shearwaters (Anderson et al. 2011). Northern Gannet and Great Shearwater are the only recorded seabird bycatch species within the AOI assessment area for this fishery, but interactions with pelagic longline gear and other seabird species is possible. Only a small portion of the plunge-diving piscivores (Northern Gannet) footprint had spatial overlap with this fishery, therefore shallow-diving pursuit generalists (shearwaters) were selected for assessment.

*Buoy gear:* This gear type does not come into contact with the benthos; therefore, no bottom disturbance interactions were assessed. Risks from buoy gear are related to bycatch and entanglement of non-target species. As this gear type is new within Canada and is being used in DFO Maritimes Region as of 2021, bycatch/entanglement data are not yet available for the region. However, information on potential interactions and bycatch is available for this gear type from the United States. The National Oceanic and Atmospheric Administration (NOAA) has conducted environmental assessments that indicate that buoy gear operation has the potential to affect various marine mammals, including beaked whales and Blue Whales, but available data show limited interaction with at-risk species overall (NOAA 2018; NOAA 2021). As the suitable beaked whale habitat has greater spatial overlap with the predicted extent of this activity, beaked whales were selected from the two cetacean conservation priorities to undergo assessment. The results from the beaked whale assessment can be used as a proxy for Blue Whales during site design.

Although there may be some potential for seabird interaction with buoy gear based on known interactions with pelagic longlines, assessment of available bycatch data from the United States buoy gear fisheries indicate limited interaction with seabirds (Bayse and Kerstetter 2010; Oceana 2015). Both the California and Atlantic fisheries bycatch data did not include records of any seabirds killed or seriously injured via buoy gear operations in these fisheries. Therefore, interaction is anticipated to be minimal, and no seabird interactions were assessed for this activity.

*Midwater Trawl:* Although midwater trawl gear is designed to operate above the seafloor, this gear type has been documented to make contact with benthic structures (NOAA 2014; Chosid and Pol 2020). Therefore, there is the potential for this fishery to interact with bottom features and habitats. Deep-water corals and sponges are very long lived and susceptible to damage (DFO 2010*a*), therefore due to sensitivity and overlap, both corals and sponges were selected for assessment.

Bycatch rates in midwater trawls are generally considered low based on available data, as midwater trawls often target schooling fish (DFO 2010*a*). Groundfish that are not expected to be targeted by this fishery, but that were present in observer bycatch tables, include Atlantic Wolffish, Cusk, Thorny Skate, and White Hake (Table 2.4.7-1, 2). Cusk was selected for assessment due to its high post-release mortality rate (COSEWIC 2012*a*). Lobster are also caught as bycatch in this fishery and therefore large female lobster were selected for assessment.

Entanglement of whales and seabirds can occur in midwater trawl gear (Harris et al. 2013; Hedd et al. 2015; Feyrer et al. 2021). Cetaceans are generally susceptible to entanglement in fishing gear, and there are documented cases of beaked whales entangled in trawls within Atlantic Canada (Harris et al. 2013; Feyrer et al. 2021). Hence, beaked whales were selected for assessment. From Hedd et al. (2015), the highest amount of seabird bycatch from midwater trawl fisheries operating in Atlantic Canada from 1998 to 2011 were shearwaters. Therefore, shallow pursuit-diving generalists (shearwaters) were selected for assessment.

## 2.3 METHODS

Consequence

$Q_{Exposure}$

For most fisheries, $Q_{Exposure}$ was calculated using data from fisheries logbooks reported between 2008 and 2017. These data included catch locations, dates, and landed weight of species caught for each record. For analyses using logbook data, the spatial footprint of each fishery was determined by mapping the number of sets recorded in each three $km^2$ hexagonal grid cell within the AOI. For the purpose of this analysis, a ‘set’ was defined as a fishing logbook entry that includes information for all species caught within a reporting interval assigned to a single geographic location. Depending on the fishery, a set might be a summary of fishing activity for a full day, for a single gear deployment/retrieval, or for another reporting interval. Unless otherwise specified, grid cells where more than one set was reported between 2008 and 2017 were considered part of the footprint for the fishery. Cells containing only one record were not included in the intensity classification or calculation of spatial overlap with conservation priorities. Given the limitations in data resolution (i.e., geographic accuracy and reporting frequency) this approach to determining the spatial extent of each fishery should be considered an approximation only.

Pelagic longline has a much larger spatial footprint than other gear types used in the area due to the length of the gear (ranging from approximately 30-90 km), so fisheries logbook information, including catch locations and landed weights, are not considered an accurate proxy to use for the $Q_{Exposure}$ calculations. Instead, using a method described in Butler et al. (2019), vessel tracking information was used to capture the footprint of the pelagic longline fishing fleet. Specifically, VMS data from 2003-2018 were filtered to select data for vessels presumed to be engaged in pelagic longline fishing, and operating at fishing-like speeds (i.e., travelling between 0.5 and 4.5 knots). The filtered VMS data were then analyzed to produce a heat map of pelagic longline fishing vessel density (vessel minutes/$km^2$). A small amount of effort from vessels using other gear types under a pelagic longline licence, such as rod and reel, is likely present in the data. To account for this, effort within the Hell Hole closure was removed as it was presumed to indicate trolling activity, since pelagic longline fishing is prohibited in this area.

As pelagic buoy gear is a new gear type within DFO Maritimes Region, no data are available to indicate the spatial footprint of vessels fishing with this gear. The pelagic longline licence spatial footprint (including the Hell Hole) was used as a proxy to indicate where this gear may be used, although it is acknowledged that the true spatial extent for buoy gear is anticipated to be smaller based on the lower number of licence holders using the gear and smaller gear footprint.

Groundfish midwater trawls do not currently operate within the AOI, and few fisheries logbook records for this gear type are available for the area. For $Q_{Exposure}$ calculations, the spatial footprint for a potential pelagic trawl fishery for Silver Hake was developed using Silver Hake weight per tow data from the DFO summer RV survey for 4VWX+5Z. Briefly, data from 1970-2020 were divided into 6 time periods, interpolated to create a continuous surface, and classified into 10 percentile classes, ranked 1-10 (i.e., a rank of 1 represents the bottom 10% of lowest reported catch weights, and a rank of 10 represents the top 10% highest reported catch weights). The ranked maps were then summed across all time periods. The midwater trawl spatial footprint includes areas with the top 40% of ranked values for Silver Hake across time periods.

For all fisheries analyses, the conservation priority and fisheries datasets were clipped to an area corresponding to the map extent, i.e., the AOI assessment area (refer to Figure 2.1-1). This was done so that when calculating fishing intensity, the data were representative of an area broader than the AOI boundary itself, but not so large as to include unrelated effort by fleets operating in different management areas across the bioregion.

To calculate $Q_{Exposure}$, the spatial scale of the interaction between each fishery and conservation priority was determined based on the amount of overlap between the fishery footprint and the spatial extent of the conservation priority. The temporal scale of the interaction was determined by considering the overlap of the fishing season with the presence of the conservation priority within the AOI. For cases where the temporal overlap between the activity and conservation priority included overlap with a seasonal closure, the temporal score was adjusted to reflect the reduced potential for temporal interaction resulting from the closure(s). For most fisheries, the intensity score was determined by considering the average number of fishing sets recorded per grid cell in the area where the fishery and conservation priority overlap within the AOI, where the number of sets was classified into low (1), medium (2) or high (3) intensity categories based on quantile breaks. For the pelagic longline fishery, the intensity score was calculated as the average VMS intensity in the area of overlap with the conservation priority, where the VMS data was ranked into intensity classes using a Log10 scale (i.e., Intensity 1 = 0-100 vessel minutes/km$^2$, Intensity 2 = 100-1000 vessel minutes/km$^2$, Intensity 3 = >1000 vessel minutes/km$^2$). For the new pelagic buoy gear fishery, no data were available. Based on an anticipated number of licence holders, and the nature of gear configuration and deployment, intensity was uniformly classified as low. For the midwater trawl fishery, which does not currently operate within the AOI, the median intensity score, moderate, was assigned as a reasonable estimate.

$Q_{Sensitivity}$

The sensitivity level for interactions within the AOI between the various fishing pressures and the conservation priorities was determined based on a review of available literature and expert opinion.

<u>Likelihood</u>

The likelihood was determined by considering the probability of the fishing pressure interacting negatively with the conservation priority based on existing data (where available), references to the literature, or expert opinion. For assessments of bottom disturbance, the likelihood of gear disturbing the bottom was assessed based on how the gear is designed to be fished. For example, the likelihood scores for gear types that target bottom-dwelling species would be higher for bottom disturbance interactions compared to gear that may only contact the bottom infrequently or accidentally. For assessments of bycatch or entanglement, the probability of a species being caught/entangled was determined by reviewing available data from At-Sea Observer Program reports, stock assessment reports, peer-reviewed literature, and/or expert opinion.

## 2.4 RISK ASSESSMENT FOR COMMERCIAL FISHERIES IN THE FUNDIAN CHANNEL-ROWNS BANK AOI

### 2.4.1 Lobster Pot Fishery

The offshore lobster fishery is authorized to occur in Lobster Fishing Area (LFA) 41 which starts 50 nautical miles offshore of Nova Scotia and extends to the edge of the continental slope but fishing is restricted to 4X and 5Zc and historically only occurs in 5 areas: Georges Bank, Georges Basin, Crowell Basin, Southeast Brown's Bank and West Browns (DFO 2020*a*). Fishing generally occurs in depths of 100 to 320 m.

There are eight commercial licences for offshore lobster, all of which are enterprise allocations (DFO 2020*a*). The eight licences are held by two licence holders. The total allowable catch (TAC) is set annually and runs from January 1 to December 31. An annual TAC of 720t was established in 1985 based on historical landings, and has remained at this level ever since (DFO 2021*a*). While fishing is limited from July to September for quality reasons, fishing does occur year-round (V. Docherty, DFO Resource Management, personal communication, 2020).

There is no pot/trap limit or limit on the dimensions of the trap associated with this fishery, although traps used are similar in design and size to those used in the inshore lobster fishery (DFO 2020*a*). The traps are set in strings (also known as trawls) of approximately 100 traps connected by a ground line (C. Boyd, Clearwater Seafoods, personal communication, 2021). The strings are anchored at each end and as per regulatory requirements, lines from each end of the trawl are attached to buoys at the surface. Figure 2.4.1-1 illustrates the offshore lobster fishery footprint within the AOI assessment area.

Groundfish, including Cusk, are common bycatch species in the offshore lobster fishery (DFO 2018*b*). Entanglement of marine mammals in the vertical lines is also known to occur (Donaldson et al. 2010). Habitat damage associated with this gear type depends on the construction of the trap, hauling depth and speed, environmental conditions, and number of traps. Traps can damage coral by scraping, fragmenting, dislodging or entanglement.

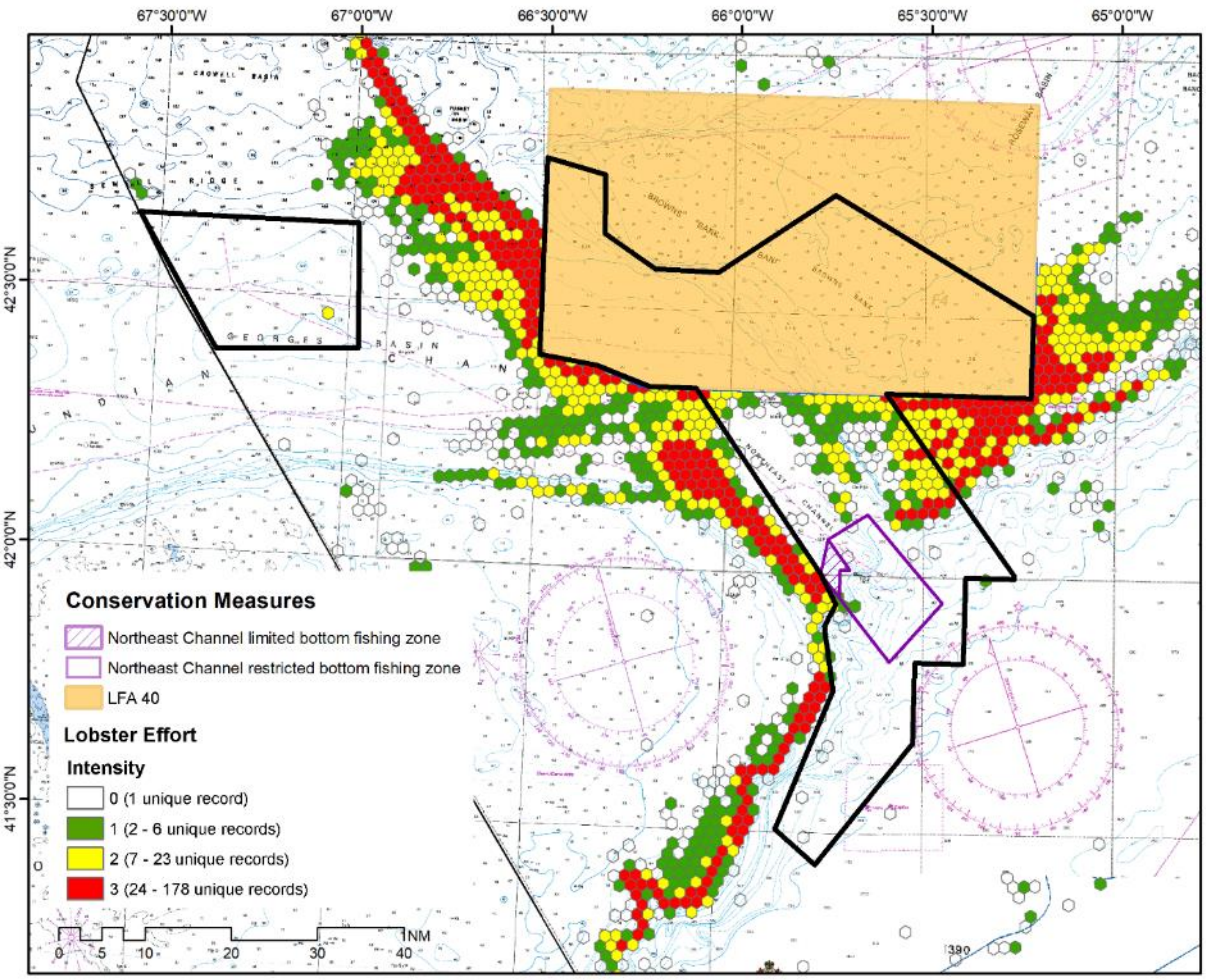


Figure 2.4.1-1. Map of offshore lobster fishing effort from 2008 to 2017 within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Intensity for the fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets hauled during the 2008-2017 period in the AOI assessment area. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis. The total fishing extent of the offshore lobster fishery within the AOI during this time period was approximately 526 $km^2$. Note that while a $3km^2$ grid cell was used for calculations in the risk analysis, $5km^2$ grid cells were used for the maps due to privacy concerns.

Existing management measures

The LFA 41 fishery is managed through a variety of measures including a current total allowable catch (TAC), minimum carapace length (82.5 mm), limited entry, and a prohibition on landing berried or v-notched female lobsters (DFO 2020*a*). There is no limit on the number of offshore traps authorized per licence. Traps possess biodegradable clips to prevent ghost fishing if the trap is lost at sea and also have escape vents so undersized lobsters can vacate the trap. There is a 100% dockside monitoring program for the offshore lobster fishery. LFA 40, which includes all parts of Browns Bank less than 50 fathoms was closed to fishing in 1979 to protect lobster broodstock. Figure 2.4.1-1 illustrates the location of LFA 40 relative to the Fundian Channel-

Browns Bank AOI boundary. As per the licence conditions, the release of large lobsters (greater than 6 lbs), soft lobsters, and culls (lobster with only one claw or no claws) is permitted if they are alive and released in a manner that causes the least harm. Gear deployment and configuration incorporates techniques and rope types that reduces whale entanglement risk (C. Boyd, personal communication, 2021). In particular, use of trawls (i.e., multiple traps per string) has reduced the amount of vertical buoy lines in the water column, thereby helping to mitigate cetacean entanglement risk (Vanderlaan et al. 2011; Brillant et al. 2017). The total number of traps deployed has been reduced by approximately 50% from 2013-2018 (from 204 in 2013 to 104 in 2018). Incorporating weighted rope in groundlines and buoy lines has also reduced the amount of rope in the water column. Additionally, in 2019, DFO introduced mandatory reporting of all fisheries interactions with marine mammals (DFO 2020*a*). Interaction information is reported electronically by licence holders directly to DFO.

In addition to dockside monitoring of all landings, there is also an At-Sea Observer Program that collects information on both landed and discarded lobster as well as bycatch species (DFO 2020*a*). Since 2012, At-Sea Observer Program coverage has been approximately 15% on a per-trip basis (DFO 2019*a*) and 3.8% by weight (Cook et al. 2017).

<u>Bycatch profile</u>

The species most frequently caught as bycatch in LFA 41 are: Jonah Crab, Cusk, Atlantic Cod, Red and White Hake, and Sea Raven (DFO 2018*b*). Overall, bycatch has declined from an average of 49,050 kg (2011-2013) to an average of 11,888 kg (2017-2019) and this trend includes conservation priorities for the AOI such as Cusk (averaging 11,892 kg annually in 2011-2013 to averaging 3,122 kg annually in 2017-2019) and Atlantic Cod (averaging 4,778 kg annually in 2011-2013 to averaging 2,778 kg annually in 2017-2019) (DFO 2021*a*). Table 2.4.1-1 contains bycatch data from 2009-2018 At-Sea Observer records.

Table 2.4.1-1. At-Sea Observer Program records from DFO's Industry Survey Database for the lobster fishery within the Fundian Channel-Browns Bank Area of Interest (AOI) assessment area for 2009 to 2018. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 2,558.

| **Species** | **Kept Weight (kg)** | **Discard Weight (kg)** | **# Unique Sets** | **% of Sets** |
|---|---:|---:|---:|---:|
| American Lobster | 903,096 | 127,021 | 2,551 | 99.73 |
| Jonah Crab | 922 | 16,440 | 1,036 | 40.50 |
| Cusk | 0 | 8,069 | 674 | 26.35 |
| Atlantic Cod | 6 | 4,620 | 617 | 24.12 |
| White Hake | 16 | 3,443 | 5,552 | 21.58 |
| Red Hake | 0 | 980 | 195 | 7.62 |
| Sea Raven | 10 | 645 | 145 | 5.67 |
| Haddock | 1 | 531 | 142 | 5.55 |
| Hermit Crabs | 5 | 514 | 78 | 3.05 |
| Atlantic Rock Crab | 248 | 346 | 126 | 4.93 |
| Redfish (unseparated) | 6 | 246 | 155 | 6.06 |
| Longhorn Sculpin | 65 | 154 | 100 | 3.91 |
| Groundfish (NS) | 0 | 134 | 36 | 1.41 |
| Black Belly Rosefish | 0 | 115 | 56 | 2.19 |
| Hake (NS) | 0 | 108 | 19 | 0.74 |

| | | | | |
|---|---|---|---|---|
| Whelks | 0 | 101 | 24 | 0.94 |
| Atlantic (Striped) Wolffish | 0 | 77 | 22 | 0.86 |
| Sculpins | 0 | 58 | 12 | 0.47 |
| Snails and slugs | 0 | 57 | 4 | 0.16 |
| Silver Hake | 1 | 54 | 25 | 0.98 |
| Pollock | 0 | 42 | 18 | 0.70 |
| Northern Stone Crab | 0 | 37 | 11 | 0.43 |
| Monkfish, Goosefish, Angler | 0 | 32 | 10 | 0.39 |
| Blue Crab | 0 | 20 | 3 | 0.12 |
| Sea Scallop | 0 | 19 | 3 | 0.12 |
| Shorthorn Sculpin | 0 | 15 | 6 | 0.23 |
| Foreign articles/garbage | 0 | 15 | 1 | 0.04 |
| Spiny Dogfish | 0 | 13 | 3 | 0.12 |
| Asteroidea S.C. | 0 | 12 | 9 | 0.35 |
| Offshore Hake | 0 | 11 | 4 | 0.16 |
| Sea Robins | 0 | 9 | 6 | 0.23 |
| Buccinidae F. | 0 | 8 | 6 | 0.23 |
| Mackerel (Atlantic) | 1 | 3 | 4 | 0.16 |
| Toad Crab | 0 | 3 | 3 | 0.12 |
| Other fish | 4 | 23 | 14 | 0.57 |
| Other crustaceans | 0 | 143 | 5 | 0.2 |
| Other echinoderms | 0 | 4 | 4 | 0.16 |
| Other molluscs | 0 | 2 | 2 | 0.08 |
| **Total** | **904,381** | **164,124** | **N/A** | **N/A** |

**Risk Assessment - Lobster pot fishery and Blue Whale foraging area**

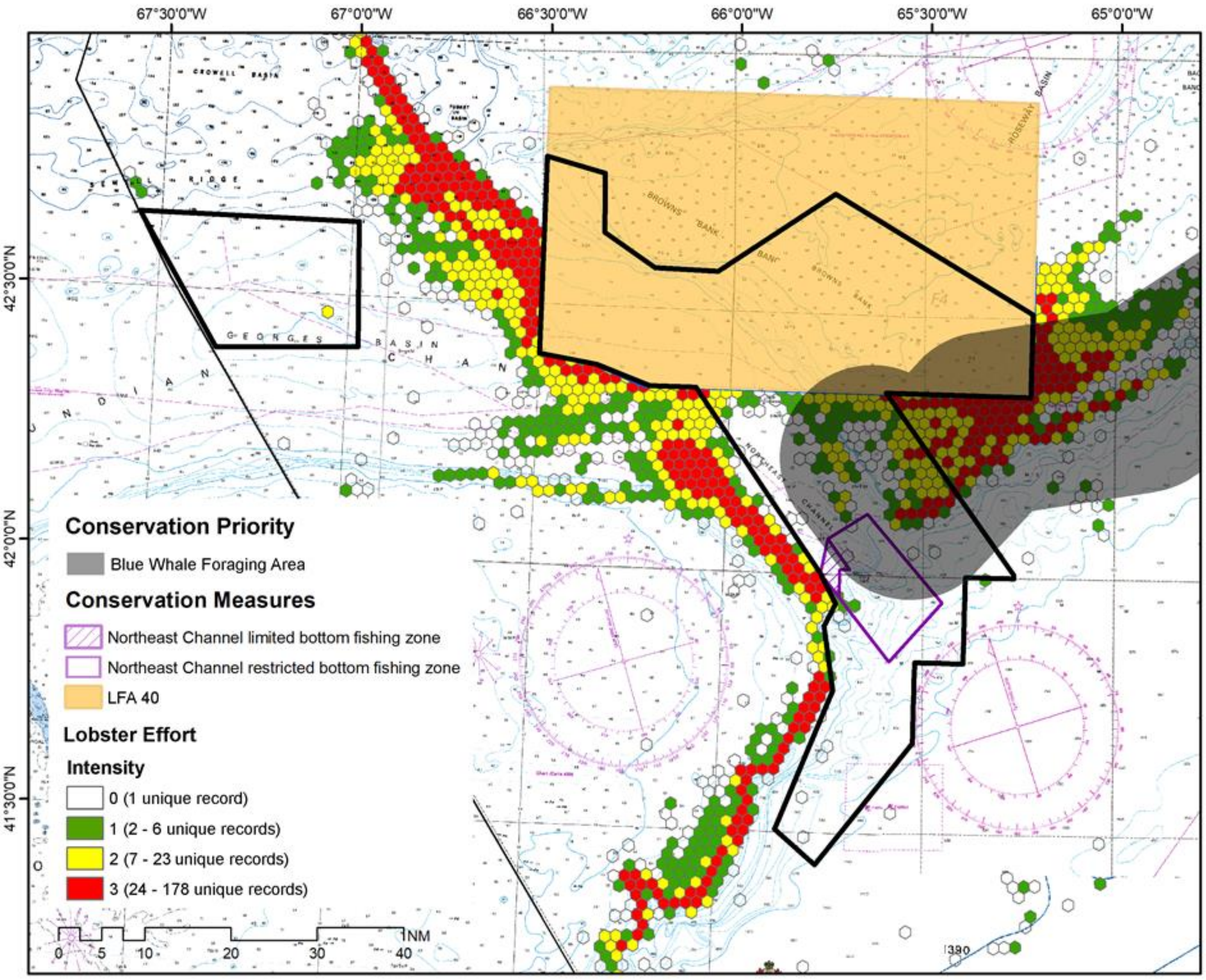


Figure 2.4.1-2. Overlap of Blue Whale foraging area with the lobster pot fishery footprint. Intensity for the fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets hauled during the 2008-2017 period in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis. Note that while a 3km$^2$ grid cell was used for the risk analysis, 5km$^2$ grid cells were used for the maps due to privacy concerns.

**Risk Statement**: There is a risk that entanglement in lobster fishing gear will lead to negative impacts on Blue Whales in an important foraging area within the AOI.

Table 2.4.1-2. Scoring for the risk posed by the lobster pot fishery to foraging Blue Whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 4 x 2<br>= 16 (raw score) |

| | | |
|---|---|---|
| Intensity | 2 | Based on available effort data for the lobster fishery in the assessment area, the average intensity of the fishery where it intersects with the extent of Blue Whale foraging habitat in the AOI is considered moderate. |
| Temporal | 4 | Blue Whales are present in Canadian waters year-round and the offshore lobster fishery is open year-round, therefore there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 2 | There is localized spatial overlap (22%) between the lobster fishery and the Blue Whale foraging habitat within the AOI. |
| $Q_{Sensitivity}$ | 3 | Large whales are susceptible to floating ground lines that are oriented horizontal to the sea floor (ALWTRT 2004 as cited in Bradt 2012) and vertical lines that attach the gear to surface buoys (Johnson et al. 2005 as cited in Bradt 2012). Groundlines can float approximately 4.6-6 m up off the seafloor and form arcs of line in the water column (Johnson et al. 2005). These components of the fishing gear can get caught in the mouth and/or wrapped around tails and flippers while feeding is occurring (Bradt 2012).<br><br>The effects of entanglement on large whales can be difficult to quantify as the impact may not be immediately evident (Reeves et al. 2013 as cited in Brown et al. 2013). In addition to direct mortality from fishing gear entanglement (COSEWIC 2012*b*), large whales are often strong enough to break free from anchored fishing gear and swim with residual gear wrapped around their appendages (Moore 2014), potentially carrying fishing gear for days to years (van der Hoop et al. 2017). This fishing gear adds drag which depletes energy reserves and can eventually result in death if the whale cannot escape the gear (Moore 2014). Due to the generic nature of this residual gear, it can be difficult to determine the specific fishery from which the fishing gear originated (Johnson et al. 2005). Entanglement of large whales can also result in drowning, emaciation, or infection/severe tissue damage (Moore and van der Hoop 2012). For whales that do survive entanglements, stress can affect health and fecundity even after the gear is no longer attached (Pettis et al. 2004).<br><br>Furthermore, the severity of entanglement impacts differ between taxonomic groups; for example, a fishing hook embedded in the head of a baleen whale is generally not lethal (NMFS 2012). The presence of loose or draped gear or an external, visible hook on the body has also been assessed as a non-serious injury to mysticetes, as long as the gear does not constrict any part of the animal or does not lead to health decline.<br><br>The Northwest Atlantic Blue Whale population was assessed as Endangered by COSEWIC and listed under SARA as Endangered (COSEWIC 2012*b*). The most recent minimum population estimate is ~402 individuals (NOAA 2020) with indications of |

| | | |
|---|---|---|
| | | low recruitment and calving rates (Beauchamp et al. 2009; COSEWIC 2012*b*). There is insufficient information to determine population trends for North Atlantic Blue Whales (NOAA 2020). The potential biological removal (PBR) (i.e., the maximum number of non-natural mortalities that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) for the Western North Atlantic population of Blue Whale was estimated at 0.8.<br><br>The DFO Recovery Strategy for this population of Blue Whales classified entanglement in fishing gear as a lower risk threat (Beauchamp et al. 2009; COSEWIC 2012*b*), and the most recent stock assessment report from NOAA (2020) notes that although the total level of human-caused mortality and serious injury is unknown, it is believed to be insignificant and approaching zero.<br><br>Due to the small size of the Blue Whale population, entanglement of even a small number of individuals can have an impact on the population's health (Beauchamp et al. 2009; DFO 2018*c*). However, there is no available data that suggests entanglement impacts within the AOI by this gear type is exceeding the maximum sustainable level nor adversely impacting long-term recruitment dynamics. Taken together, a sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 3$<br>$= 12$ (raw score) |
| Likelihood | Rare | Fishing gear entanglement is a known cause of human-induced mortality of Blue Whales in the North Atlantic, though such incidents are under-reported (COSEWIC 2012*b*). Blue Whale carcasses are negatively buoyant and initially sink upon death (Nelson et al. 2007; Cassoff et al. 2011), which makes quantifying the frequency of entanglement events challenging. This is exacerbated by the lack of onshore winds and currents in many areas and can result in offshore entanglement events not being reported or sighted (Moore 2014).<br><br>Another method of detecting fisheries interactions with this species is observing entanglement scarring. A recent study by Ramp et al. (2021) in the Gulf of St. Lawrence found 13.1% of individually photographed Blue Whales had entanglement scarring of the dorsal region. There were higher instances of scarring (up to 59.9%) when images of their tails and peduncles were analysed. Overall, this study indicates that the proportion of Blue Whales having previous interactions with fishing gear throughout their lifetime may range from 13% to 60%. It is important to note that Ramp et al. (2021) did not determine |

| | | |
|---|---|---|
| | | annual entanglement rate for Blue Whales or the extent of fishing pressure that resulted in this amount of entanglement scarring.<br><br>Though the effectiveness of neutrally buoyant lines remains unclear (Pace et al. 2014; van der Hoop et al. 2013), the offshore lobster fishery has made efforts to minimize risk of whale entanglement by employing neutrally buoyant or sinking groundlines between traps to minimize the potential for rope to float off the seafloor. As well, the LFA 41 fishery uses trawls of 100 traps to reduce vertical lines in the water column. From 2013-2018, the number of traps deployed, and thereby number of vertical buoy lines, has been reduced by approximately 50%. These existing management measures decrease the likelihood of entanglement events.<br><br>There is little to no available information to suggest a rate at which entanglement events occur within the AOI. While there is potential for Blue Whale entanglement in lobster gear within the AOI, based on existing management measures and available information, the likelihood was estimated as rare. |
| Overall risk | Moderately high | Additional management measures should be considered (where feasible) to address risks from this pressure. Examples could include gear modifications (e.g., use of Tension Line Cutters; further reduction in vertical lines) or restrictions where this fishery overlaps with the Blue Whale foraging area within the future MPA. |
| Uncertainty | High | Since 2019, amendments to the Marine Mammal Regulations have required the offshore lobster fishery to report all accidental contact with marine mammals directly to DFO (DFO 2020*a*). However, entanglement events may go unwitnessed. As well, entanglement scarring for Blue Whales does not generally provide a clear link to fishing gear type.<br><br>The potential for large animals, such as Blue Whales, to break free from the gear before being noticed and recorded by observers can further limit the comprehensiveness of this data source. As a result, observer data are limited in their ability to approximate rates of cetacean bycatch and entanglement.<br><br>Additionally, as mentioned above, mortality may not be immediate, as entangled animals may die of sublethal effects such as starvation or infection at some future date (Pettis et al. 2004; Moore and van der Hoop 2012), and some animals eventually sink when they die (Moore 2014). These factors obscure knowledge of entanglement-related mortality. |

**Risk Assessment - Lobster pot fishery and deep-water corals**

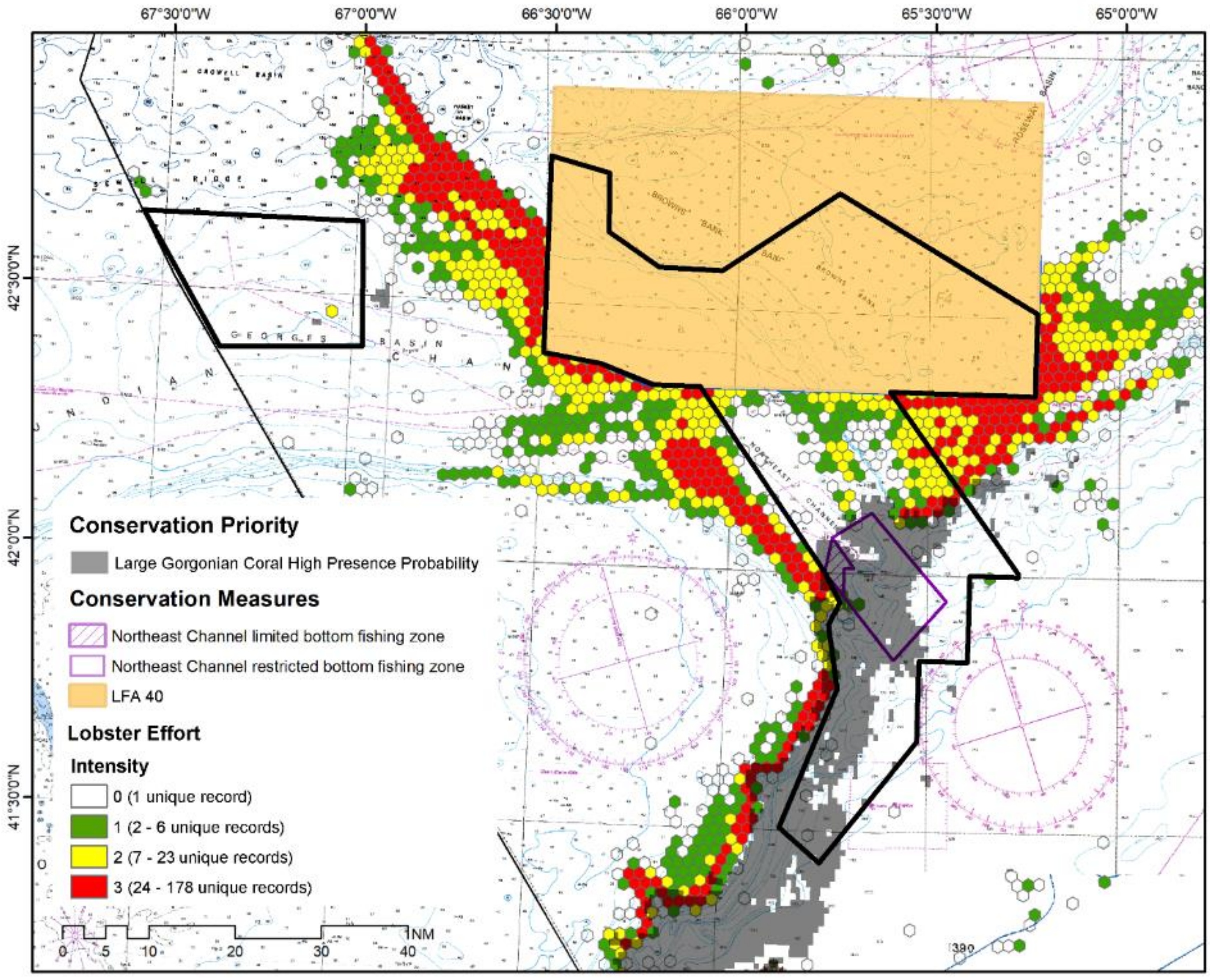


Figure 2.4.1-3. Overlap of the predicted extent of large gorgonian corals with the lobster pot fishery footprint. Intensity for the fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets hauled during the 2008-2017 period in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis. Note that while a 3km$^2$ grid cell was used for the risk analysis, 5km$^2$ grid cells were used for the maps due to privacy concerns.

**Risk Statement**: There is a risk that bottom disturbance from lobster pots will lead to negative impacts on deep-water coral communities within the AOI.

Table 2.4.1-3. Scoring for the risk posed by the lobster pot fishery to deep-water coral within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 4 x 1<br>= 8 (raw score) |

| | | |
|---|---|---|
| Intensity | 2 | Based on available effort data for the lobster fishery in the assessment area, the average intensity of the fishery where it intersects with the predicted extent of deep-water corals in the AOI is considered moderate. |
| Temporal | 4 | Deep-water corals are present year-round and the offshore lobster fishery is open year-round, therefore there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 1 | There is low spatial overlap (3.9%) between the lobster fishery and the predicted extent of large gorgonian corals within the AOI. |
| $Q_{Sensitivity}$ | 5 | Corals are susceptible to fishing from both direct (removal and/or damage) and indirect impacts (smothering) (DFO 2010*b*). The effect of fishing gear on corals is dependent on a number of factors including: morphology/skeletal composition of the coral, coral reproduction and growth rate, methods and timing of deployment of gear, and the frequency with which the location is fished.<br><br>Traps may be dropped directly on top of coral colonies or dragged along the bottom during deployment or recovery (Rooper et al. 2017). Another study found that traps reduced the abundance of gorgonian corals due to rope entanglement (Hunt and Matthews 1999 as cited in Barnette 2001). Additionally, damage from traps may include flattening of habitats, particularly the breaking of gorgonians which may result in reduced growth rates or mortality, and susceptibility to disease (Appledorn et al. 2000 as cited in Barnette 2001; Gall et al. 2020). Scraping, fragmenting, and dislodging sessile fauna are all potential impacts associated with trap fisheries (Donaldson et al. 2010).<br><br>Gorgonian corals are long-lived and slow to recover from physical damage (Witherell and Coon 2001). Growth rates and life spans of corals vary by species; studies of gorgonian corals have calculated growth rates of 5-26 mm per year and lifespans of 100 to 200 years (Roberts et al. 2006 as cited in Campbell and Simms 2009). Some of the species of deep-water corals found in Nova Scotia may take decades to centuries to recover from impacts associated with fishing activities, if they recover at all (Sherwood and Edinger 2009; DFO 2010*b*).<br><br>Due to the slow recovery time from physical damage, a sensitivity score of 5 was assigned. |
| $Q_{Consequence}$ | High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 5$<br>$= 15$ (raw score) |
| Likelihood | Almost certain | The lobster fishery occurs annually and traps contact the bottom as part of the fishery. Bottom disturbance is therefore considered almost certain. |

| | | |
|---|---|---|
| Overall risk | High | Additional management measures are required to address risks from this pressure to deep-water corals, e.g., restricting this fishery in the predicted extent of large gorgonian corals within the future MPA. |
| Uncertainty | Low | While there are fewer studies on the impacts of fixed fishing gear on corals (DFO 2018*d*), there is sufficient evidence to support spatial closure to bottom contacting gear in areas of high coral concentration (e.g., Northeast Channel Coral Conservation Area) in accordance with DFO's *Policy for Managing the Impacts of Fisheries on Sensitive Benthic Areas* (DFO 2009*b*). The presence probability map for deep-water corals within the AOI was developed using available data from different types of research surveys. The identified coral area is predictive in nature due to limited survey coverage in the deeper waters. |

**Risk Assessment - Lobster pot fishery and highly suitable habitat for Cusk**

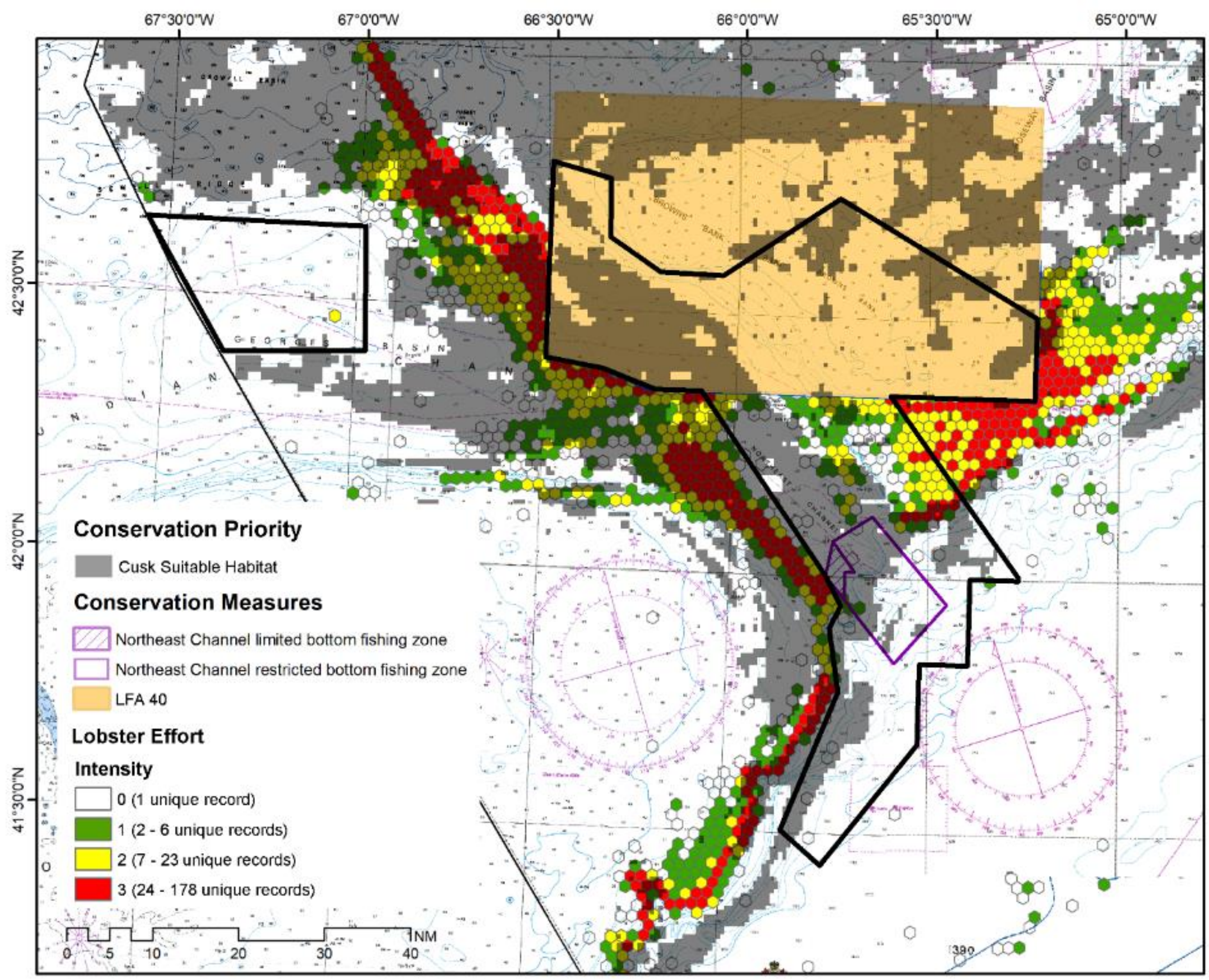


Figure 2.4.1-4. Overlap of highly suitable Cusk habitat with the lobster pot fishery footprint. Intensity for the fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets hauled during the 2008-2017 period

in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis. Note that while a 3km$^2$ grid cell was used for the risk analysis, 5km$^2$ grid cells were used for the maps due to privacy concerns.

**Risk Statement**: There is a risk that bycatch in lobster pots will lead to negative impacts on the local population of Cusk in its suitable habitat within the AOI.

Table 2.4.1-4. Scoring for the risk posed by the lobster pot fishery to Cusk within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 4 x 1<br>= 8 (raw score) |
| Intensity | 2 | Based on available effort data for the lobster fishery in the assessment area, the average intensity of the fishery where it intersects with the predicted extent of highly suitable Cusk habitat in the AOI is considered moderate. |
| Temporal | 4 | Cusk are presumed to be present year-round and the offshore lobster fishery is open year-round, therefore there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 1 | There is low spatial overlap (8.2%) between the lobster fishery and the highly suitable Cusk habitat within the AOI. |
| $Q_{Sensitivity}$ | 2 | Fish species with a physoclistous swim bladder (i.e. a swim bladder that is not attached to the esophagus), such as Cusk, are likely to possess a lower survival rate when discarded due to their physiology (Cook et al. 2017). Cusk usually experience physical trauma when brought to the surface in a trap due to the expansion of gas in their swim bladders. Physical trauma can include: overexpansion or rupture of swim bladder, stomach eversion, intestinal protrusion through the cloaca, external hemorrhaging, organ torsion, subcutaneous gas bubbles, ocular gas bubbles (Rummer and Bennet 2005; Hannah et al. 2008; Pribyl et al. 2009; Campbell et al. 2010; Rogers et al. 2011; Butcher et al. 2012 as cited in Chen and Runnebaums 2014). Additionally, Cusk are likely to remain positively buoyant when brought to the surface, which increases the probability of predation (Chen and Runnebaums 2014). Cusk are therefore less likely to survive after release (COSEWIC 2012*a*).<br><br>Fishing mortality is the only known major source of anthropogenic mortality for Cusk (Harris and Hanke 2010). Cusk is a bycatch species in the lobster fishery; retention of Cusk is prohibited thus all catch is discarded (COSEWIC 2012*a*).<br><br>It is estimated that 86% of Cusk captured in the LFA 41 lobster fishery are dead when brought to the surface (Harris and Hanke 2010). Furthermore, discarded live Cusk are likely to remain positively buoyant when brought to the surface, which increases |

| | | |
|---|---|---|
| | | the probability of predation (Chen and Runnebaums 2014). Therefore, while post-capture mortality is unknown, it is assumed to be high (COSEWIC 2012*a*).<br><br>Recent DFO science advice places local (NAFO divisions 4VWX5Z) Cusk population biomass above the Limit Reference Point (DFO 2021*b*), and analyses using data from the Halibut Industry Survey suggests that the population abundance has been stable since 1999 (DFO 2014).<br><br>Taken together, considering the predicted low survival rate of discarded bycatch alongside the stable status of the local Cusk population, the lobster fishery could cause possible detectable changes in population size, but is only expected to have minimal impact on population dynamics. Therefore, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 2$<br>$= 6$ (raw score) |
| Likelihood | Unlikely | From 2009 to 2018, 2,293 lobster fishing sets were observed by at-sea observers in the Fundian Channel-Browns Bank assessment area (Table 2.4.1-1). Of these sets, approximately 26% of sets contained Cusk. Note that bycatch of Cusk has shown a declining trend in recent years from an average of 11,892 kg annually in 2011-2013 to an average of 3,122 kg annually in 2017-2019 (DFO 2021*a*). Taking into consideration the significant decreasing trend in cusk bycatch, likelihood of Cusk bycatch was assessed as unlikely. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) to address risks from this pressure to Cusk, e.g., restricting this fishery in areas important to Cusk within the future MPA. |
| Uncertainty | Low | While the exact post-release mortality of Cusk has not been calculated, the peer-reviewed, science-based literature is clear that it is high, especially in situations where the Cusk are brought to the surface from significant depths. The area of highly suitable habitat for Cusk was determined using the outputs of a habitat suitability model and is predictive in nature. |

### 2.4.2 Hagfish Trap Fishery

There has been a directed fishery for hagfish off Nova Scotia since 1989 (DFO 2017*b*). As of 2019, there are seven limited entry, commercial hagfish licences within DFO Maritimes Region (DFO 2019*b*). These licences are a combination of commercial communal, inshore, and enterprise allocation. The traps used consist of baited barrels fitted with funnels for hagfish entry, and escape holes through which undersized hagfish can exit (DFO 2017*b*). Traps are connected to surface buoys that indicate the location and ownership of the gear and enable retrieval

(Johnston et al. 2007). Strings of 30 to 35 traps are commonly used in the Maritimes Region, and weights are placed on the groundlines between traps (DFO 2019*b*). Soak times vary from one to 48 hours with the majority of gear tended within 20 to 24 hours (DFO 2018*e*).

The majority of hagfish landings on the Scotian Shelf occur in depths from 50 m to 300 m and in temperatures between 3.5-9°C (DFO 2018*e*). Hagfish prefer waters with full salinity and soft clay or flocculent sediments (DFO 2017*b*), but they have been reported on almost all substrate types (DFO 2018*e*). Hagfish landings peaked in 2013 at 3,198 mt and since have been steadily decreasing on the Scotian Shelf, to 556 mt in 2017. This decrease has been attributed to reduced fishing effort due to market factors, rather than any notable changes in catch rates. Within the AOI, landings and effort appear to be concentrated within Georges Basin, though the relative fishing intensity is low (see Figure 2.4.2-1).

Hagfish traps are very selective and result in almost no bycatch (DFO 2009*a*). The traps by design are a bottom contacting gear therefore there is the potential for interaction with all bottom features and habitats. As well, whales can become entangled in the ground lines and buoy lines associated with trap fishing gear (DFO 2010*a*).

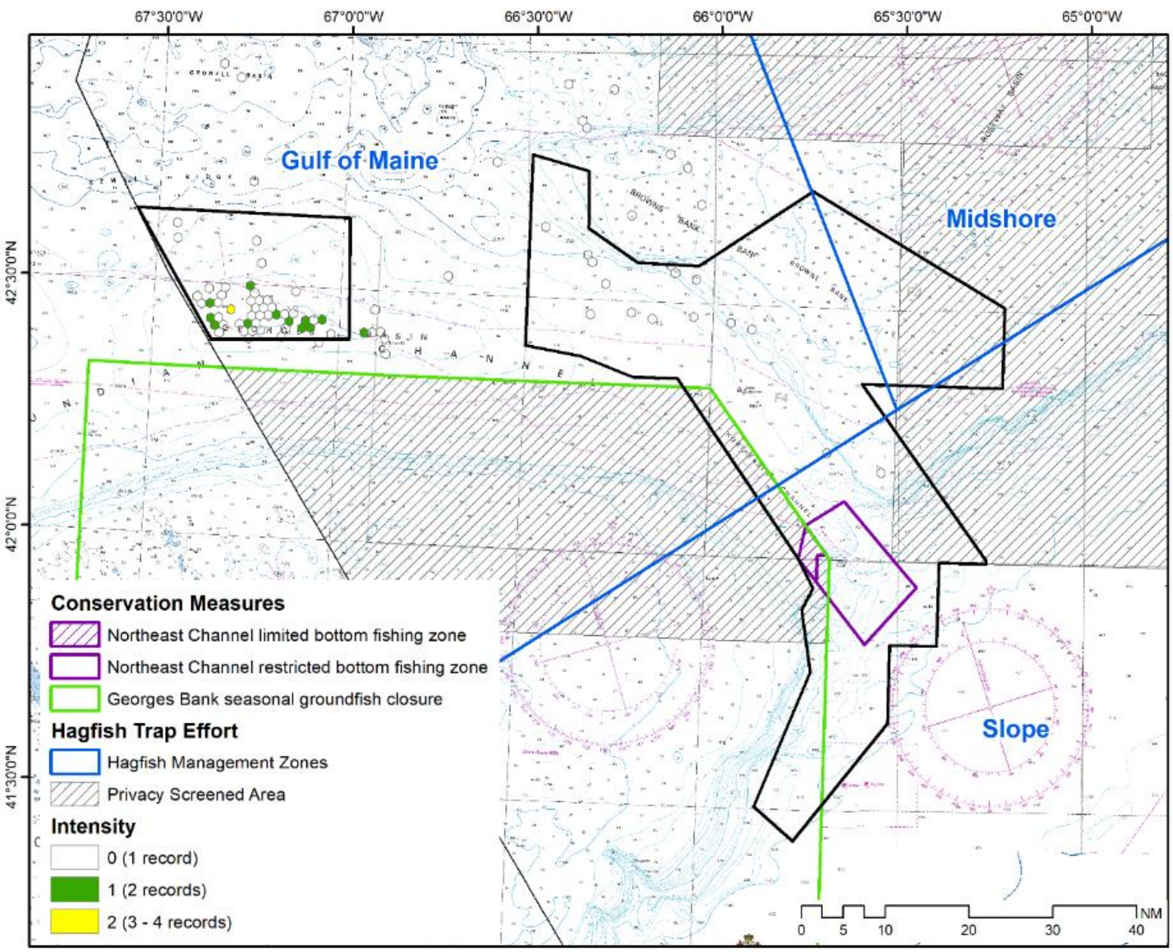


Figure 2.4.2-1. Map of hagfish fishing effort from 2008 to 2017 within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Intensity for the fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of recorded sets during the 2008-2017 period in the

AOI assessment area. Hagfish effort could not be shown in the grey hatched areas due to privacy constraints, as data within these areas did not meet the Rule of Five[6]. However, effort within the privacy screened area was considered in the analysis. The total fishing extent of the hagfish fishery within the AOI during this time period was approximately 38 $km^2$. Hagfish fishery management zones are also labeled (blue text).

Existing management measures

A sustainable harvest level and reference points have not been developed for this fishery. In the absence of these, a conservative approach to harvesting has been maintained (DFO 2019*b*). In the Maritimes Region there is a limited entry fishery occurring within a 6 month season every year (April 15th to October 15th) with a competitive overall quota for the 2019 season of 1,550 tonnes (DFO 2019*b*). Gear restrictions include a limit of 450 barrels per licence with a maximum trap size of 102.5 cm x 60.96 cm, a maximum of 4 entrance funnels, and a minimum of 36 escape holes of at least 14.3 mm in diameter. At least one of the entrance funnels must be composed of biodegradable material to prevent ghost fishing if gear is lost.

The Hagfish fishery in the Maritimes Region currently occurs in NAFO Divisions 4V, 4W, 4X, and 5Z (DFO 2018*e*). Starting in the 2019 fishing season, the broad fishing area was divided into four Hagfish Management Zones: Midshore, Gulf of Maine, 4V, and Offshore/Slope (DFO 2019*b*). The overall quota is divided up among the four management zones. The coordinates for the zones are provided in licence conditions, and licence holders are restricted to fishing within only one zone during a fishing trip. The Fundian Channel-Browns Bank AOI falls within three of the four management zones (Midshore, Gulf of Maine, and Offshore/Slope) (see Figure 2.4.2-1). The Hagfish fishery is also subject to a seasonal groundfish closure on Georges Bank (March 1st to May 31st) to protect spawning haddock (DFO 2019*b*).

Monitoring of fishing activity includes mandatory VMS, port hailing (outgoing and return), and 100% dockside monitoring coverage (DFO 2017*b*). Prior to 2019, at-sea observers collected data from two fishing sets per day, recording both hagfish length data and any bycatch (DFO 2019*b*). Difficulties in recording length data for the species while at sea have resulted in fewer observed sets in recent years. The use of weighted lines may reduce risk of entanglement with cetaceans, though the effectiveness remains unclear (Pace et al. 2014; van der Hoop et al. 2013). Additionally, amendments to the Marine Mammal Regulations in 2018 require all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018).

Bycatch profile

The construction and design of the traps used in the fishery result in very low quantities of non-target species being captured (DFO 2009*a*). To illustrate, the bycatch profile from one year of experimental fishing off of Nova Scotia is shown in Table 2.4.2-1.

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[6] The Rule of Five on data privacy states that fisheries data and data products (e.g., maps) are not to be shared without consent for fisheries where there are less than five different Fisher IDs, Licence IDs, or vessel registration numbers (VRNs) in any one geographic area during the timeframes displayed in map products.

Table 2.4.2-1. Bycatch from the experimental Hagfish fishery off of eastern Nova Scotia in the fall of 2005 from a total of 1,678 hagfish traps (Louisbourg Seafoods Limited 2006).

| Species | # Caught |
|---|---|
| Shrimp | 25 |
| Sea urchins | 5 |
| Sea stars | 3 |
| Whelk | 3 |
| Crab | 1 |
| Redfish | 1 |

In this instance, only 38 animals were caught as bycatch in 1,678 traps. Available At-Sea Observer data includes only 159 unique sets observed for the hagfish fishery in all of DFO Maritimes Region in all years of available data (see Table 2.4.2-2). Some fish species were recorded as bycatch, but in very small numbers.

Table 2.4.2-2. At-Sea Observer Program records from DFO's Industry Survey Database for the hagfish fishery within DFO Maritimes Region for 2009 to 2018. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 159.

| Species | Kept Weight (kg) | Discard Weight (kg) | # Unique Sets | % of Sets |
|---|---|---|---|---|
| Northern Hagfish | 179,984 | 540 | 159 | 100 |
| Squirrel or Red Hake | 0 | 27 | 19 | 11.95 |
| Cod (Atlantic) | 0 | 2 | 2 | 1.26 |
| Snow Crab (Queen) | 0 | 1 | 1 | 0.63 |
| White Hake | 0 | 1 | 1 | 0.63 |
| **Total** | **179,984** | **571** | **N/A** | **N/A** |

__Risk Assessment – Hagfish trap fishery and Blue Whale foraging area__

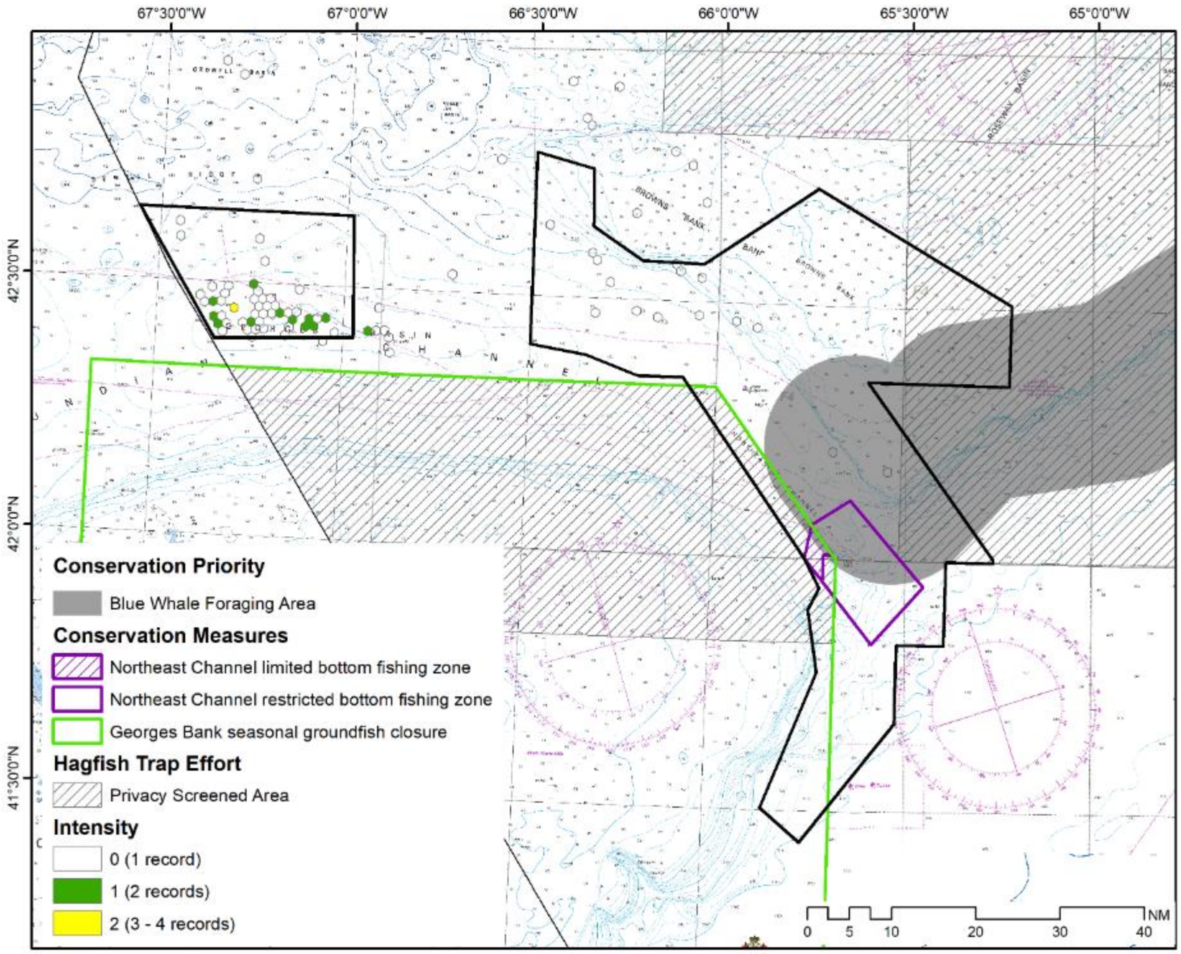


Figure 2.4.2-2. Overlap of Blue Whale foraging areas with the hagfish trap fishery footprint. Intensity for the hagfish fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of recorded sets the 2008-2017 period within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Hagfish effort could not be shown in the grey hatched areas due to privacy constraints. However, effort within the privacy screened area was considered in the analysis. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that entanglement in hagfish fishing gear will lead to negative impacts on Blue Whales in an important foraging area within the AOI.

Table 2.4.2-3. Scoring for the risk posed by the hagfish trap fishery to foraging Blue Whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 1 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 1<br>= 3 (raw score) |

| | | |
|---|---|---|
| Intensity | 1 | Based on available effort data for the hagfish fishery in the assessment area, the average intensity of the fishery where it intersects with the extent of Blue Whale foraging habitat in the AOI is considered low. |
| Temporal | 3 | Blue Whales are present in Canadian waters year-round and the hagfish fishing season is open for six months of the year from April to October (DFO 2019*b*). Therefore there is potential temporal overlap for up to six months of the year. |
| Spatial | 1 | There is minimal spatial overlap (less than 1%) between the hagfish fishery and Blue Whale foraging habitat within the AOI. |
| $Q_{Sensitivity}$ | 3 | Large whales are susceptible to floating ground lines that are oriented horizontal to the sea floor (ALWTRT 2004 as cited in Bradt 2012) and vertical lines that attach the gear to surface buoys (Johnson et al. 2005 as cited in Bradt 2012). Groundlines can float approximately 4.6-6 m up off the seafloor and form arcs of line in the water column (Johnson et al. 2005). These components of the fishing gear can get caught in the mouth and/or wrapped around tails and flippers while feeding is occurring (Bradt 2012).<br><br>The effects of entanglement on large whales can be difficult to quantify as the impact may not be immediately evident (Reeves et al. 2013 as cited in Brown et al. 2013). In addition to direct mortality from fishing gear entanglement (COSEWIC 2012*b*), large whales are often strong enough to break free from anchored fishing gear and swim with residual gear wrapped around their appendages (Moore 2014), potentially carrying fishing gear for days to years (van der Hoop et al. 2017). This fishing gear adds drag which depletes energy reserves and can eventually result in death if the whale cannot escape the gear (Moore 2014). Due to the generic nature of this residual gear, it can be difficult to determine the specific fishery from which the fishing gear originated (Johnson et al. 2005). Entanglement of large whales can also result in drowning, emaciation, or infection/severe tissue damage (Moore and van der Hoop 2012). For whales that do survive entanglements, stress can affect health and fecundity even after the gear is no longer attached (Pettis et al. 2004).<br><br>Furthermore, the severity of entanglement impacts differ between taxonomic groups; for example, a fishing hook embedded in the head of a baleen whale is generally not lethal (NMFS 2012). The presence of loose or draped gear or an external, visible hook on the body has also been assessed as a non-serious injury to mysticetes, as long as the gear does not constrict any part of the animal or does not lead to health decline (NMFS 2012).<br><br>The Northwest Atlantic Blue Whale population was assessed as Endangered by COSEWIC and listed under SARA as Endangered (COSEWIC 2012*b*). The most recent minimum population estimate |

| | | |
|---|---|---|
| | | is ~402 individuals (NOAA 2020) with indications of low recruitment and calving rates (Beauchamp et al. 2009; COSEWIC 2012*b*). There is insufficient information to determine population trends for North Atlantic Blue Whales (NOAA 2020). The potential biological removal (PBR) (i.e., the maximum number of non-natural mortalities that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) for the Western North Atlantic population of Blue Whale was estimated at 0.8.<br><br>The DFO Recovery Strategy for this population of Blue Whales classified entanglement in fishing gear as a lower risk threat (Beauchamp et al. 2009; COSEWIC 2012*b*), and the most recent stock assessment report from NOAA (2020) notes that although the total level of human-caused mortality and serious injury is unknown, it is believed to be insignificant and approaching zero.<br><br>Due to the small size of the Blue Whale population, entanglement of even a small number of individuals can have an impact on the population's health (Beauchamp et al. 2009; DFO 2018*c*). However, there is no available data that suggests entanglement impacts within the AOI by this gear type is exceeding the maximum sustainable level nor adversely impacting long-term recruitment dynamics. Taken together, a sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | Low | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 1 \times 3$<br>$= 3$ (raw score) |
| Likelihood | Rare | Fishing gear entanglement is a known cause of human-induced mortality of Blue Whales in the North Atlantic, though such incidents are under-reported (COSEWIC 2012*b*). Blue Whale carcasses are negatively buoyant and initially sink upon death (Nelson et al. 2007; Cassoff et al. 2011), which makes quantifying the frequency of entanglement events challenging. This is exacerbated by the lack of onshore winds and currents in many areas and can result in offshore entanglement events not being reported or sighted (Moore 2014).<br><br>Another method of detecting fisheries interactions with this species is observing entanglement scarring. A recent study by Ramp et al. (2021) in the Gulf of St. Lawrence found 13.1% of individually photographed Blue Whales had entanglement scarring of the dorsal region. There were higher instances of scarring (up to 59.9%) when images of their tails and peduncles were analysed. Overall, this study indicates that the proportion of Blue Whales having previous interactions with fishing gear throughout their lifetime may range from 13% to 60%. It is important to note that Ramp et al. (2021) did not determine annual entanglement rate for Blue Whales or the |

| | | |
|---|---|---|
| | | extent of fishing pressure that resulted in this amount of entanglement scarring.<br><br>Though the effectiveness of neutrally buoyant lines remains unclear (Pace et al. 2014; van der Hoop et al. 2013), the hagfish fishery used weights on the groundlines between barrels in the hagfish fishery (DFO 2019*b*) to minimize the potential for rope to float off the seafloor.<br><br>There is little to no available information to suggest a rate at which entanglement events occur within the AOI. While there is potential for Blue Whale entanglement in hagfish gear within the AOI, based on existing management measures and available information, the likelihood was estimated as rare. |
| Overall risk | Low | Risk score is low due to very low exposure score. However, given the sensitivity, gear modifications (e.g., rope diameter and break strength; and reduction in vertical lines) or restrictions could be considered where this fishery overlaps with the Blue Whale foraging area within the future MPA. |
| Uncertainty | High | Since 2018, amendments to the Marine Mammal Regulations have required all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018). However, entanglement events may go unwitnessed. As well, entanglement scarring for Blue Whales does not generally provide a clear link to fishing gear type.<br><br>The potential for large animals, such as Blue Whales, to break free from the gear before being noticed and recorded by observers can further limit the comprehensiveness of this data source. As a result, observer data are limited in their ability to approximate rates of cetacean bycatch and entanglement.<br><br>Additionally, as mentioned above, mortality may not be immediate, as entangled animals may die of sublethal effects such as starvation or infection at some future date (Pettis et al. 2004; Moore and van der Hoop 2012), and some animals eventually sink when they die (Moore 2014). These factors obscure knowledge of entanglement-related mortality. |

**Risk Assessment – Hagfish trap fishery and deep-water coral**

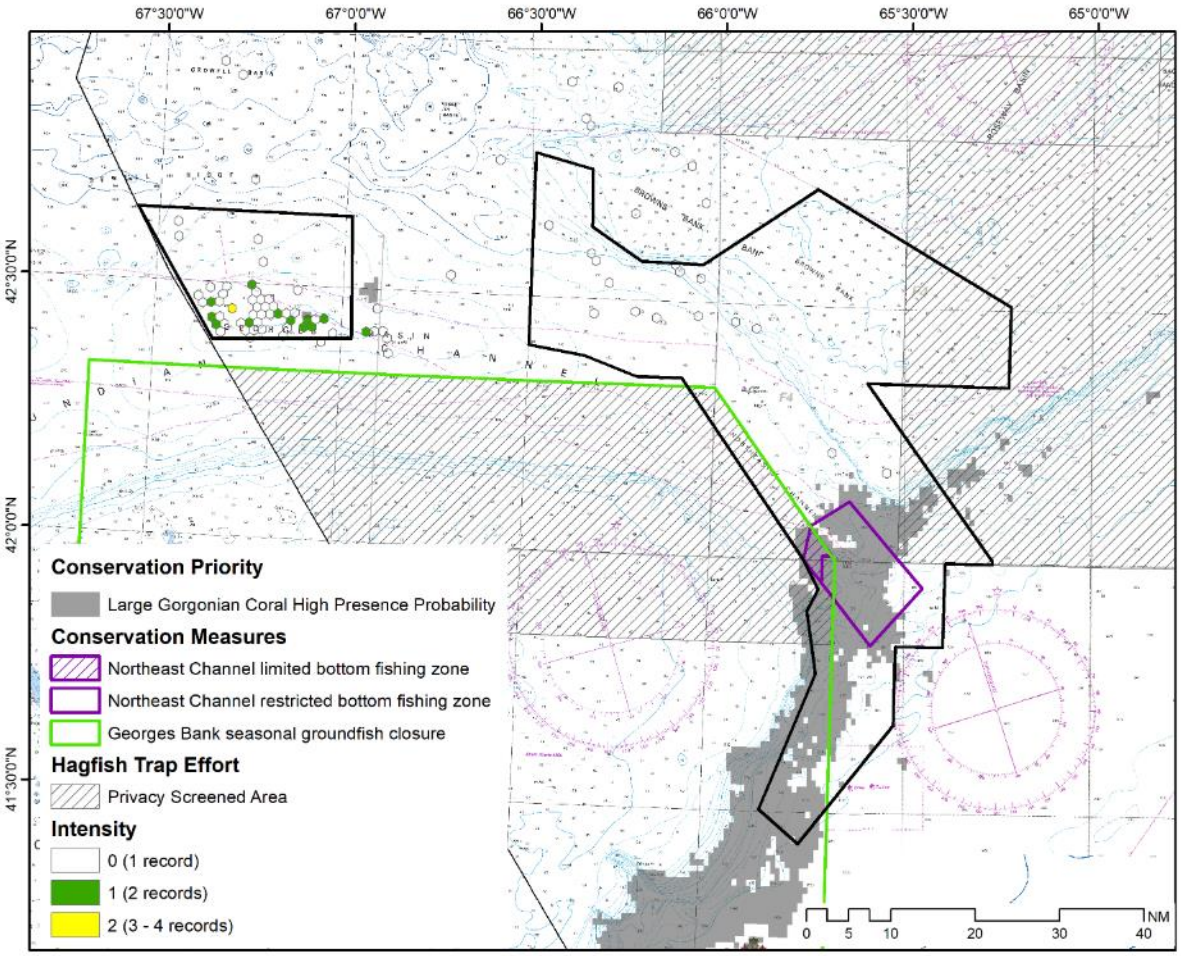


Figure 2.4.2-3. Overlap of the predicted extent of large gorgonian corals with the hagfish trap fishery footprint. Intensity for the hagfish fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of recorded sets during the 2008-2017 period within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Hagfish effort could not be shown in the grey hatched areas due to privacy constraints. However, effort within the privacy screened area was considered in the analysis. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bottom disturbance from hagfish traps will lead to negative impacts on deep-water coral communities within the AOI.

Table 2.4.2-4. Scoring for the risk posed by the hagfish trap fishery to deep-water corals within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 1 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 1<br>= 3 (raw score) |

| | | |
|---|---|---|
| Intensity | 1 | Based on available effort data for the hagfish fishery in the assessment area, the average intensity of the fishery where it intersects with the predicted extent of deep-water corals in the AOI is considered low. |
| Temporal | 3 | Deep-water corals are present year-round, and the hagfish fishing season is open for six months of the year from April to October (DFO 2019*b*). Therefore there is potential temporal overlap for up to six months of the year. |
| Spatial | 1 | There is minimal spatial overlap (less than 1%) between the hagfish fishery and the predicted extent of large gorgonian corals within the AOI. |
| $Q_{Sensitivity}$ | 5 | Corals are susceptible to fishing from both direct (removal and/or damage) and indirect impacts (smothering) (DFO 2010*b*). The effect of fishing gear on corals is dependent on a number of factors including: morphology/skeletal composition of the coral, coral reproduction and growth rate, methods and timing of deployment of gear, and the frequency with which the location is fished.<br><br>Traps, and associated gear such as groundlines, may be dropped directly on top of coral colonies or dragged along the bottom during deployment or recovery (Rooper et al. 2017). Another study found that traps reduced the abundance of gorgonian corals due to rope entanglement (Hunt and Matthews 1999 as cited in Barnette 2001). Additionally, damage from traps may include flattening of habitats, particularly the breaking of gorgonians, which may result in reduced growth rates or death (Appledorn et al. 2000 as cited in Barnette 2001). Scraping, fragmenting, and dislodging sessile fauna are all potential impacts associated with trap fisheries (Donaldson et al. 2010). Additionally, once damaged, corals are more susceptible to disease (Gall et al. 2020)<br><br>Gorgonian corals are long-lived and slow to recover from physical damage (Witherell and Coon 2001). Growth rates and life spans of corals vary by species, studies of gorgonian corals have calculated growth rates of 5-26 mm per year and lifespans of 100 to 200 years (Roberts et al. 2006 as cited in Campbell and Simms 2009). Some of the species of deep-water corals found in Nova Scotia may take decades to centuries to recover from impacts associated with fishing activities, if they recover at all (DFO 2010*b*).<br><br>Due to the sensitivity of these corals to physical disturbance and the extremely slow recovery time, a sensitivity score of 5 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 1 \times 5$<br>$= 5$ (raw score) |

| | | |
|---|---|---|
| Likelihood | Almost certain | The hagfish fishery occurs annually and traps contact the bottom as part of the fishery. Bottom disturbance was therefore considered almost certain. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) to address risks from this pressure to deep-water corals, e.g., restricting this fishery in the predicted extent of large gorgonian corals within the future MPA. |
| Uncertainty | Low | While there are fewer studies on the impacts of fixed fishing gear on corals compared to mobile gears (DFO 2018*d*), there is sufficient evidence to support spatial closure to bottom contacting gear in areas of high coral concentration (e.g., Northeast Channel Coral Conservation Area) in accordance with DFO's *Policy for Managing the Impacts of Fisheries on Sensitive Benthic Areas* (DFO 2009*b*). The presence probability map for deep-water corals within the AOI was developed using available data from research surveys. The identified coral area is predictive in nature due to limited survey coverage in the deeper waters. |

### 2.4.3 Groundfish Gillnet Fishery

Groundfish are harvested as a multi-species groundfish fishery by multiple mobile and fixed gear fleets. Within DFO Maritimes Region, only the inshore fixed gear (FG) groundfish fleets (<45' and 45'-65') are authorized to fish with gillnets (DFO 2018*a*). The gillnet landings within the AOI between 2008 and 2017 are all attributed to the FG <45' fleet. This fishery is open year-round, though there is relatively little groundfish gillnet activity within the Fundian Channel-Browns Bank AOI (see Figure 2.4.3-1).

The groundfish gillnet fishery uses demersal gillnets, which are stationary nets set on the seafloor. The net has a weighted rope at the bottom of the panel that is also anchored in place at either end, and the top of the panel is kept buoyant with a line of floats (DFO 2010*a*). The net works by intercepting fish as they move naturally through their environment. Ideally the fish will swim though the net and get caught with the mesh behind the gill cover, or will be wedged in the mesh at the largest part of the body (Pingguo 2006). In these cases, capture is based on fish and mesh size, which increases the size selectivity of the gear. Other types of fish capture in gillnets such as snagging or entanglement can decrease selectivity, and the frequency of these types of captures can be influenced by the webbing material used, among other factors.

While size selectivity can be high using gillnets, species selectivity is low, resulting in high levels of bycatch (Clark et al. 2015). Entanglement of marine mammals, seabirds and other animals can also occur (Pingguo 2006; Baer et al. 2010; Hedd et al. 2015). As this gear anchors to the bottom, the main concern for benthic habitats is through crushing or entanglement of cold-water coral and sponge communities (Baer et al. 2010).

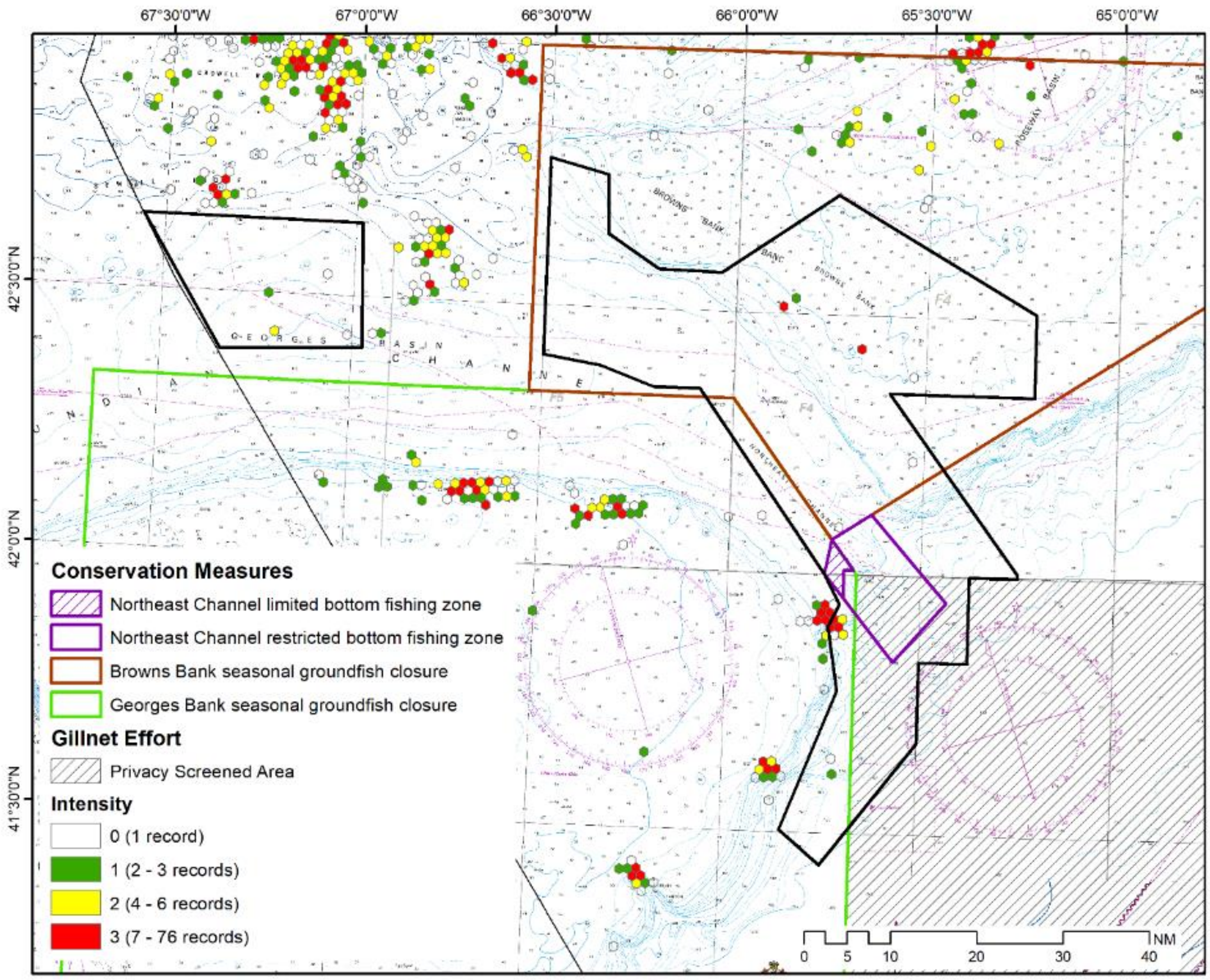


Figure 2.4.3-1. Map of groundfish gillnet fishing effort from 2008 to 2017 within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Intensity for the fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of recorded sets during the 2008-2017 period in the AOI assessment area. Groundfish gillnet effort in the grey hatched areas were not shown for privacy reasons. However, effort within the privacy screened areas was considered in the analysis. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis. The total fishing extent of the groundfish gillnet fishery within the AOI during this time period was approximately 42 $km^2$.

Existing Management Measures

The Scotia Fundy Fixed Gear Advisory Committee was established as a process to provide advice to DFO on issues that impact the fixed gear fleets. Subcommittees from this group attend the broader groundfish consultative forum, the Scotia-Fundy Groundfish Advisory Committee (DFO 2018*a*).

The main fleet fishing with groundfish gillnets within the AOI is the FG <45' fleet, which has its own Conservation Harvesting Plan (CHP). This plan applies to all FG <45' groundfish vessels in NAFO divisions 4TVWX + 5, with the exception of NAFO division 5Z, where all groundfish vessels must follow the 5Z Conservation Harvesting Plan (DFO 2019*c*). Two seasonal spawning closures overlap with the AOI (Figure 2.4.3-1): the Browns Bank spawning closure (February 1 to June 15) and Georges Bank spawning closure (end of the 5th week of the year to May 31). The FG <45' sector remains under a competitive fishery with the available groundfish quota divided into seven geographic community groups administered by Community Management Boards (DFO 2018*a*).

A licence condition for all FG <45' vessels authorizes the licence holder to direct their fishing only for the quota species that are under a TAC and for which community quotas have been allocated (DFO 2018*f*). Detailed catch and effort information for every trip must be recorded in logbooks and submitted to DFO (via a dockside monitoring company). When fishing on Georges Bank, all Canadian vessels are required to carry a VMS on board. A VMS is also required in 4X5Y for vessels using gillnets if the licence includes eligibility for a vessel 35' or greater (DFO 2018*f*).

Minimum mesh size and gear tending requirements are described in both the FG <45' and 5Z CHPs and licence conditions. The best estimates of incidental catch in the multi-species groundfish fishery are obtained using data collected by at-sea observers. A target of 5-10% is set for FG <45' observer coverage, except in 5Z, where observer coverage targets range from 25-100% (DFO 2018*a*).

Catch of non-directed species is managed through bycatch caps or limits, which are often species and fishery-specific and are described in each fishery's CHP. If no specific limit exists, a maximum bycatch of 10% of any bycatch species is generally applicable. If this limit is exceeded, DFO may temporarily close the fishery or the vessel class, and/or develop a specific bycatch cap for that species. Directed fishing for Cusk and White Hake is not permitted in 4VWX+5. High landings of either Cusk or hake could result in additional observer coverage for individuals at their own expense or in some circumstances high landings could result in closure for the associated vessel class. All Thorny Skate caught when fishing in 4VWX+5 must be released, as well as Atlantic Halibut under a certain size.

The groundfish gillnet fishery in Canadian waters incorporates measures to help prevent entanglement, including actively tending gear. This means that fishing vessels remain in the vicinity of the gear, which may mitigate some severe impacts and mortality through quicker intervention to release entangled animals (Tulloch et al. 2020). The FG<45' also participates in voluntary measure to reduce entanglement risk to North Atlantic Right Whales, including through using minimum amounts of rope, sinking or neutrally buoyant lines, and weakest break strengths feasible for operation (DFO 2018*a*). These voluntary measures are expected to reduce entanglement risk to other cetacean species. Additionally, amendments to the Marine Mammal Regulations in 2018 require all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018).

Bycatch Profile

The groundfish gillnet fishery has changed over time and efforts have shifted since the early 2000s. Because the historical footprint of this fishery has changed over time, bycatch records from the At-Sea Observer Program from 2000-2018 were included in order to better illustrate the bycatch profile for this fishery within the AOI assessment area (Table 2.4.3-1). It should be noted that historically, observer coverage for FG <45' fleet has often been less than 5% (DFO 2018*a*).

The bycatch records show that many non-target fish and invertebrate species are caught in a relatively high percentage of observed sets. All non-groundfish species caught must be returned to the water with the exception of a few species whose retention is permitted through licence conditions (e.g., most shark species) (DFO 2018*a*). American Lobster and Jonah Crab are caught in 41% and 18% of sets respectively. Catch of non-target fish species was highest for White Hake and Cusk. Several species of skates and sharks were recorded, as well as one species of bird (Great Shearwater). Bubblegum coral (*Paragorgia arborea*) was recorded in 2% of all sets.

Table 2.4.3-1. At-Sea Observer Program records from DFO's Industry Survey Database for the groundfish gillnet fishery (FG<45' fleet) in the Fundian Channel-Browns Bank AOI assessment area for 2000 to 2018. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 1,192.

| Species | Kept Weight (kg) | Discard Weight (kg) | # Unique Sets | % of Sets |
|---|---:|---:|---:|---:|
| Spiny Dogfish | 0 | 12,174 | 284 | 23.8 |
| American Lobster | 9 | 4,549 | 492 | 41.3 |
| Pollock | 462,971 | 1,931 | 1,170 | 98.2 |
| Porbeagle, Mackerel Shark | 418 | 1,735 | 24 | 2.0 |
| Jonah Crab | 0 | 1,242 | 224 | 18.8 |
| Barndoor Skate | 5 | 954 | 119 | 10.0 |
| Cod (Atlantic) | 182,649 | 502 | 1,034 | 86.7 |
| White Hake | 15,400 | 203 | 780 | 65.4 |
| Winter Skate | 0 | 190 | 31 | 2.6 |
| Sponges | 0 | 135 | 9 | 0.8 |
| Little Skate | 0 | 109 | 32 | 2.7 |
| Thorny Skate | 3 | 88 | 21 | 1.8 |
| Sea Raven | 14 | 74 | 34 | 2.9 |
| Blue Shark | 0 | 65 | 2 | 0.2 |
| Redfish unseparated | 748 | 59 | 113 | 9.5 |
| Sea Corn | 0 | 59 | 42 | 3.5 |
| Portuguese Shark | 0 | 45 | 1 | 0.1 |
| Greater Shearwater[7] | 0 | 43 | 11 | 0.9 |
| Argentine (Atlantic) | 0 | 27 | 10 | 0.8 |
| Shad American | 46 | 25 | 26 | 2.2 |
| Bubble Gum Coral | 0 | 24 | 24 | 2.0 |
| Halibut (Atlantic) | 420 | 23 | 30 | 2.5 |
| Atlantic (Striped) Wolffish | 66 | 19 | 17 | 1.4 |
| Haddock | 11,098 | 17 | 574 | 48.2 |
| Toad Crab, unident. | 0 | 15 | 7 | 0.6 |
| Jellyfishes | 0 | 11 | 10 | 0.8 |
| Cunner | 0 | 9 | 7 | 0.6 |
| Asteroidea S.C. | 0 | 7 | 7 | 0.6 |

[7] This was recorded as Greater Shearwater, however it should be noted the correct name is Great Shearwater.

| | | | | |
|---|---|---|---|---|
| Silver Hake | 0 | 7 | 7 | 0.6 |
| Longhorn Sculpin | 0 | 6 | 5 | 0.4 |
| Scallops | 0 | 5 | 1 | 0.1 |
| Alewife | 3 | 3 | 3 | 0.3 |
| American John Dory | 0 | 3 | 3 | 0.3 |
| Sea Scallop | 0 | 3 | 3 | 0.3 |
| Argentines (NS) | 0 | 2 | 2 | 0.2 |
| Balanidae F. | 0 | 2 | 2 | 0.2 |
| Biemna Variantia | 0 | 2 | 2 | 0.2 |
| Butterfish | 0 | 2 | 2 | 0.2 |
| Krill Shrimp | 0 | 2 | 2 | 0.2 |
| Mackerel (Atlantic) | 12 | 2 | 6 | 0.5 |
| Northern Stone Crab | 0 | 2 | 2 | 0.2 |
| Rosefish (Black Belly) | 0 | 2 | 1 | 0.1 |
| Short Lobster | 0 | 2 | 1 | 0.1 |
| Winter Flounder | 62 | 2 | 6 | 0.5 |
| Witch Flounder | 0 | 2 | 2 | 0.2 |
| American Plaice | 0 | 1 | 1 | 0.1 |
| Asterias sp. | 0 | 1 | 1 | 0.1 |
| Atlantic Rock Crab | 0 | 1 | 1 | 0.1 |
| Common Mussels | 0 | 1 | 1 | 0.1 |
| Cusk | 3,951 | 1 | 385 | 32.3 |
| Green Crab | 0 | 1 | 1 | 0.1 |
| Monkfish, Goosefish, Angler | 2,219 | 1 | 361 | 30.3 |
| Rock Grenadier (Roundnose) | 0 | 1 | 1 | 0.1 |
| Short-Fin Squid | 0 | 1 | 1 | 0.1 |
| Smooth Skate | 0 | 1 | 1 | 0.1 |
| Striped Bonito/Skipjack | 0 | 1 | 1 | 0.1 |
| Unid fish and invertebrates | 0 | 1 | 1 | 0.1 |
| Yellowtail Flounder | 7 | 1 | 4 | 0.3 |
| Brill/Windowpane | 2 | 0 | 2 | 0.2 |
| Shortfin Mako | 171 | 0 | 5 | 0.4 |
| Squirrel or Red Hake | 63 | 0 | 11 | 0.9 |
| **Total** | **680,337** | **24,431** | **N/A** | **N/A** |

**Risk Assessment – Groundfish gillnet fishery and large mature female lobster**

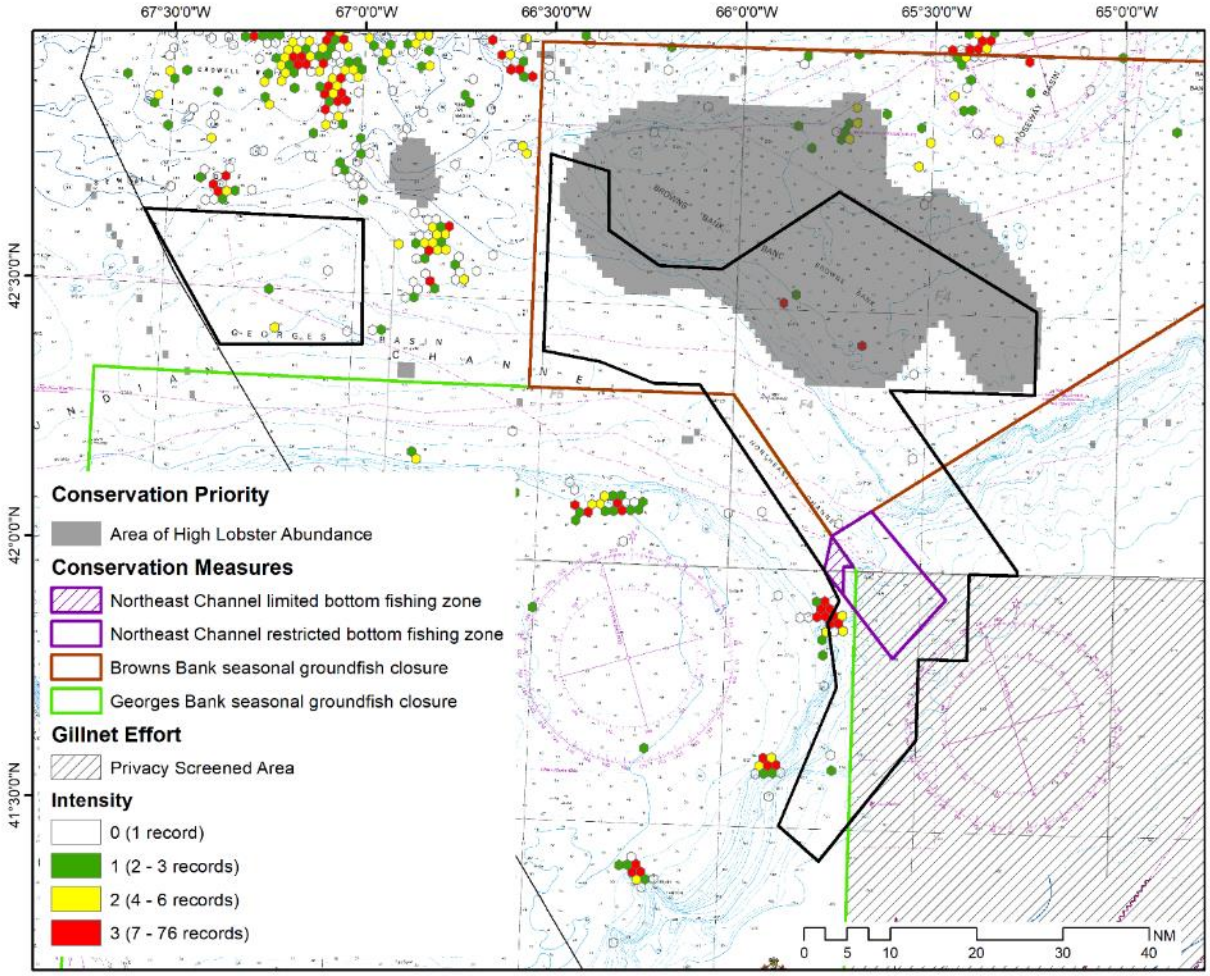


Figure 2.4.3-2. Overlap of high lobster abundance with the groundfish gillnet fishery footprint. Intensity for the groundfish gillnet fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area. Groundfish gillnet effort in the grey hatched areas were not shown for privacy reasons. However, effort within the privacy screened areas was considered in the analysis. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bycatch in the groundfish gillnet fishery will lead to negative impacts on the local lobster population within the AOI.

Table 2.4.3-2. Scoring for the risk posed by the groundfish gillnet fishery to large mature female lobster within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 3 x 1<br>= 6 (raw score) |

| | | |
|---|---|---|
| Intensity | 2 | Based on available effort data for the groundfish gillnet fishery in the assessment area, the average intensity of the fishery where it intersects with the area of high lobster abundance in the AOI is considered moderate. |
| Temporal | 3 | Large female lobster are present year-round. The groundfish gillnet fishery can occur year round; however, the area of high lobster abundance occurs within the Browns Bank seasonal spawning closure (February 1 to June 15). Considering this, there is potential temporal overlap for 7.5 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (less than 1%) between the groundfish gillnet fishery and the area of high lobster abundance within the AOI. |
| $Q_{Sensitivity}$ | 1 | The American Lobster population in LFA 41 is in the healthy zone, with reproductive potential currently found to be above the long-term average (DFO 2018*g*).<br><br>The effects to lobster from capture in a fishery can include injury, limb loss, and mortality, or longer term effects such as failure to molt, increased susceptibility to predation, and reduced foraging capability (Murphy and Kruse 1995). However, Broadhurst and Uhlmann (2007) observed that crustaceans may be more tolerant than other taxa to handling, discard, and transport because of their durable exoskeletons, benefits associated with limb autotomy, and air-breathing abilities (Wassenberg and Hill 1989; Hill and Wassenberg 1990; Cabral et al. 2002).<br><br>Mortality of discarded crustaceans appears to vary greatly depending on species, location, time of year, gear type, and other factors (Stoner 2012). Hill and Wassenberg (1990) found that crustacean discard survival from a shrimp otter trawl was approximately 50%, while other studies have detected higher crustacean mortality from bottom trawls (e.g., Wileman et al. 1999; Harris and Ulmestrand 2004). Harris and Ulmestrand (2004) demonstrated that discarded Norway Lobster have high mortality if they are dropped through a low salinity surface layer. Survival of discarded Snow Crab in Newfoundland and Labrador trap fisheries was found to increase with gentle handling and quick return to the water (Grant 2003). Other stressors on crustaceans include exposure to extreme temperatures, risk of desiccation, barotrauma and light exposure (Stoner 2012), showing that many factors influence discard survival.<br><br>Based on the nature of the gillnet fishery itself, caught lobster may be damaged when the net is hauled due to the weight of the catch and crushing or sheering from movement of the net. It is therefore assumed that some mortalities can be expected for discarded large female lobster bycatch from the groundfish gillnet fishery. Also, direct damage to eggs can occur during the course of capture and |

| | | |
|---|---|---|
| | | release as ovigerous females carry their eggs externally (Darnell et al. 2010).<br><br>Given the current healthy status of the local population within the AOI, it is expected that this fishery would have insignificant or undetectable population impacts. Therefore, a sensitivity score of 1 was assigned. |
| $Q_{Consequence}$ | Negligible | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>= 2 x 1<br>= 2 (raw score) |
| Likelihood | Moderate | Lobster are caught as bycatch in approximately 51% of sets, according to At-Sea Observer records (see Table 2.4.3-1). This percentage encompasses all lobster caught and not specifically large female lobster. Koepper et al. (2021) examined sex ratios of American lobster in LFA 33 and LFA 34, and found that females composed ~48% of the population. Regardless, the chance of catching large female lobster likely still falls within the 25-75% range (moderate). |
| Overall risk | Low | No additional management measures are suggested. |
| Uncertainty | Moderate | There is high certainty for lobster distribution and abundance in the assessment area. However, there were no studies found that directly assess the impacts of groundfish gillnet fisheries on lobster. Studies used to determine sensitivity mainly focused on impacts of otter/bottom trawl gear on crustacean discard survival, and did not include American Lobster in the assessments. Studies on the survival rate of discarded American Lobster would increase the certainty of this assessment. |

**Risk Assessment – Groundfish gillnet fishery and beaked whale habitat**

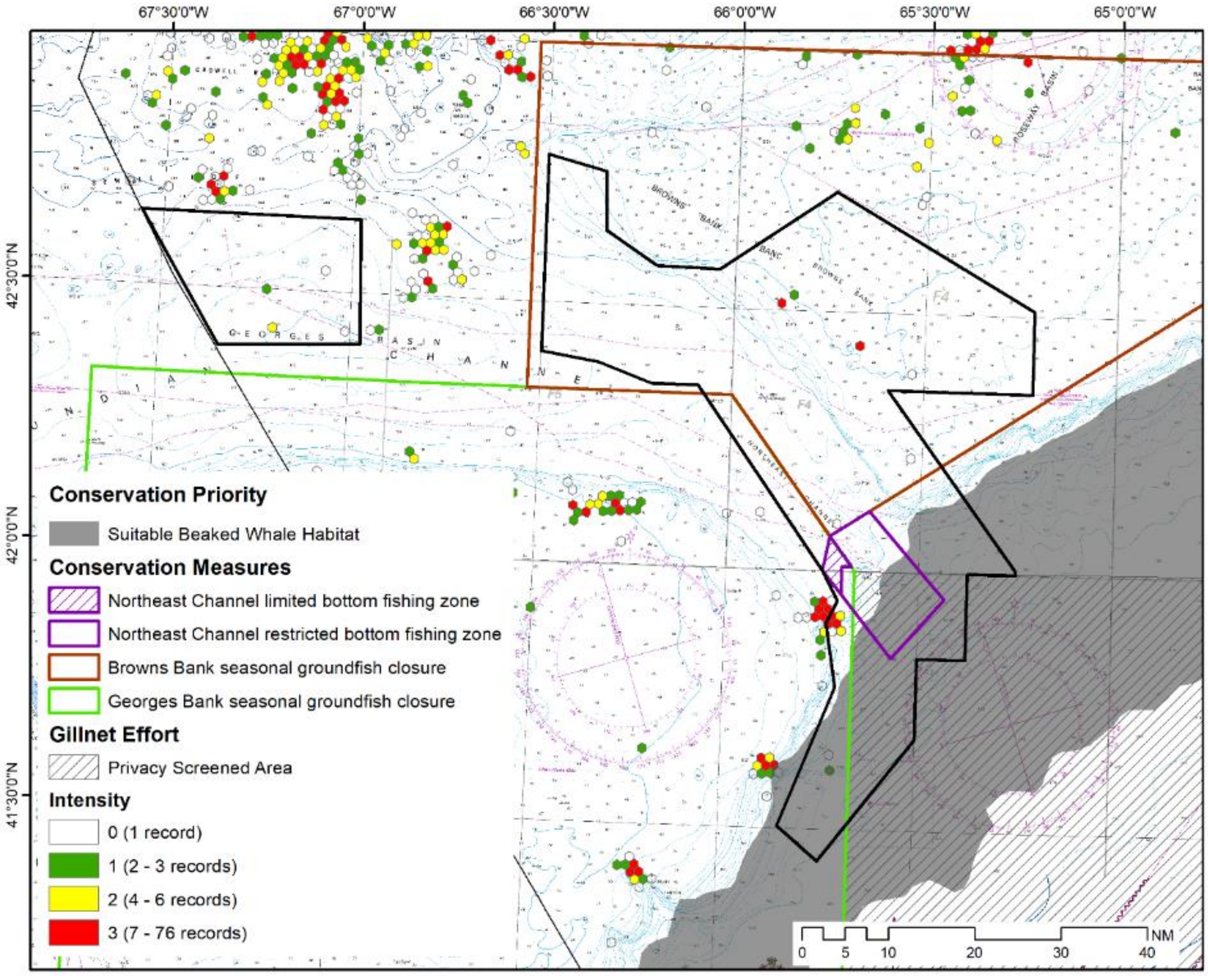


Figure 2.4.3-3. Overlap of extent of suitable beaked whale habitat with the groundfish gillnet fishery footprint. Intensity for the groundfish gillnet fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Groundfish gillnet effort in the grey hatched areas were not shown for privacy reasons. However, effort within the privacy screened areas was considered in the analysis. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that entanglement in groundfish gillnets will lead to negative impacts to beaked whales in their suitable habitat within the AOI.

Table 2.4.3-3. Scoring for the risk posed by the groundfish gillnet fishery to beaked whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 1<br>= 4 (raw score) |

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| Intensity | 1 | Based on available effort data for the groundfish gillnet fishery in the assessment area, the average intensity of the fishery where it intersects with suitable beaked whale habitat in the AOI is considered low. |
| Temporal | 4 | Beaked whales occur within the AOI year-round. The groundfish gillnet fishery can occur year-round in the areas outside of the seasonal groundfish closures, overlapping with beaked whale habitat. Therefore, there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (less than 1%) between the groundfish gillnet fishery and the extent of suitable beaked whale habitat within the AOI. |
| $Q_{Sensitivity}$ | 3 | Of the beaked whale species known to occur in and around the AOI (see Chapter 1, Section 1.4.3), more information is known about Sowerby's Beaked Whales and Northern Bottlenose Whales in terms of population status and threats. The information below therefore focuses mainly on these two species.<br><br>Entanglement in fishing gear is listed as a threat for both Sowerby's Beaked Whales (Special Concern – SARA) and Northern Bottlenose Whales, Scotian Shelf population (Endangered – SARA) (DFO 2016; DFO 2017*a*; DFO 2017*c*; DFO 2022).<br><br>Both Northern Bottlenose Whales and Sowerby's Beaked Whales are long-lived species that reproduce at a low rate, similar to other beaked whale species (DFO 2016; DFO 2017*c*). This low reproductive rate may limit a population's ability to adapt to or recover from disturbance (COSEWIC 2019). The Scotian Shelf population of Northern Bottlenose Whales is estimated at roughly 175 individuals (Feyrer 2021). Although the population is still considered Endangered and was declining up to 2004, recent estimates indicate this trend has since reversed and the population now appears to be increasing since at least 2010 (Feyrer 2021). However, this population has a potential biological removal (PBR: the maximum number of non-natural mortalities that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) of 0.3 individuals per year (DFO 2007*b*; DFO 2010*c*). This means that the level of allowable harm for this population is low (DFO 2016).<br><br>In addition to direct mortality from fishing gear entanglement, there is the possibility that whales break free from entanglement (potentially with gear attached) (Feyrer et al. 2021). Whales that survive the entanglement event but escape with injuries may still experience long-term health impacts, which can also result in population level impacts (Dolman and Brakes 2018). These can include stress responses (Pettis et al. 2004), compromised immune responses (Cassoff et al. 2011), and cumulative loss of body |

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| | | condition and constriction of body parts, with or without secondary infection that may impact health and fecundity even after gear is no longer attached (Moore and van der Hoop 2012).<br><br>There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). Scarring analysis conducted on Northern Bottlenose Whales found that the majority of anthropogenic scars (57%) were considered low to moderate severity, and 16% were considered severe injuries; however, scarring analysis does not account for cryptic mortalities (Feyrer et al. 2021). In general, ingestion of gear and entanglement with trailing gear are considered serious injuries for odontocetes (Angliss and DeMaster 1997; NMFS 2012). Depending on multiple factors such as the animal's body size relative to the gear and the species' sensitivity, loose gear may have the potential to become a serious injury (NMFS 2012). In addition, odontocetes may tire quickly as a result of their small body size, impacting their ability to reach the surface to breathe, and possibly leading to myopathy.<br><br>The groundfish gillnet fishery actively tends gear, with fishing vessels remaining in the vicinity of the gear, which may mitigate some severe impacts and mortality through quicker intervention to release entangled animals (Tulloch et al. 2020). The FG <45' fleet also undertakes voluntary measures to reduce entanglement severity through use of ropes with weaker break strengths (where feasible) (DFO 2018*a*), which could reduce instances of drowning from entanglement (Knowlton et al. 2015). However, impacts from remnant gear (e.g., hooks) and damage sustained during the escape are still possible, as noted above.<br><br>Considering the population size, status and low reproduction rate of the more at-risk beaked whale populations that can occur within the AOI, entanglement in groundfish gillnets could result in a detectable change in population size. However, there is no available data that suggests entanglement within the AOI by this gear type is exceeding the maximum sustainable level nor adversely impacting long-term recruitment dynamics. Taken together, a sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 2 \times 3$<br>$= 6$ (raw score) |
| Likelihood | Rare | Beaked whales dive to deep waters where they forage for fish and squid (COSEWIC 2011; COSEWIC 2019) and therefore may interact with benthic fishing gear while foraging. Additionally, Northern Bottlenose Whales are generally attracted to vessels, and in some areas demonstrate opportunistic associations with fishing vessels to feed on discards (e.g., Johnson et al. 2020). |

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| | | Beaked whale entanglement incidents in fishing gear in Atlantic Canada are rarely observed. However, there have been some direct observations of entanglements (described below), and additional evidence of interactions through scarring analysis (Feyrer et al. 2021). Of the beaked whale species that occur within the AOI, information related to entanglements mainly exists for Northern Bottlenose Whales and Sowerby's Beaked Whales.<br><br>There are no specific reports of beaked whale entanglement in groundfish gillnet gear within Maritimes Region, although gear type for reported entanglement events may not be known. There were ten reports of Northern Bottlenose Whale entanglement in fishing gear since 1981 impacting the Scotian Shelf population (Harris et al. 2013; Themelis et al. 2016; Feyrer et al. 2021). Additionally, two entangled Sowerby's Beaked Whales were observed in the Gully MPA in 2013, but it is not known from which fishery the gear originated (Narazaki 2013 as cited in DFO 2017*c*).<br><br>Given the low probability of these events being observed due to factors such as their offshore location (Whitehead and Hooker 2012; DFO 2022), the records of beaked whale entanglements described above are considered low estimates of actual occurrence. Entanglement scars have been observed on Northern Bottlenose Whales and Sowerby's Beaked Whales on the Scotian Shelf (Whitehead et al. 1997; DFO 2017*c*), suggesting that interactions with fishing gear occur more frequently than observed (DFO 2010*c*; Feyrer et al. 2021). Scarring evidence indicates Northern Bottlenose Whale interactions with fishing gear and propeller-vessel strikes occurs at a rate of 1.7 individuals per year (Feyrer et al. 2021).<br><br>While there is potential for beaked whale entanglement in groundfish gillnet within the AOI, based on available information and given the depth to which the whales must dive to encounter the gear, as well as voluntary management measures within the FG <45' fishery to reduce entanglement risk (where feasible for operation) (DFO 2018*a*), the likelihood was estimated as rare. |
| Overall risk | Moderate | Given the sensitivity, additional management measures may be considered to reduce the risks posed by this pressure, including gear modifications (e.g., incorporation of weak links) or restrictions where this fishery overlaps with the suitable beaked whale habitat within the future MPA. |
| Uncertainty | High | Since 2018, amendments to the Marine Mammal Regulations have required all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018). However, entanglement events may go unwitnessed. As well, entanglement scarring for beaked whales does not generally provide a clear link to fishing gear type. The potential for larger animals to break free from the gear before being noticed and recorded by |

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| | | observers can further limit the comprehensiveness of this data source. As a result, observer data are limited in their ability to approximate rates of cetacean bycatch and entanglement.<br><br>Additionally, as noted above, mortality may not be immediate, as entangled animals may die of sublethal effects such as starvation or infection at some future date (Pettis et al. 2004; Moore and van der Hoop 2012) and some animals eventually sink when they die (Moore 2014). There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). These factors obscure knowledge of entanglement-related mortality.<br><br>Beaked whale suitable habitat was defined using available data from visual detections, acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited. There is also uncertainty associated with the use of this area for Northern Bottlenose Whales in particular, given that it is toward the southern extent of their range. |

## Risk Assessment – Groundfish gillnet fishery and deep-water corals

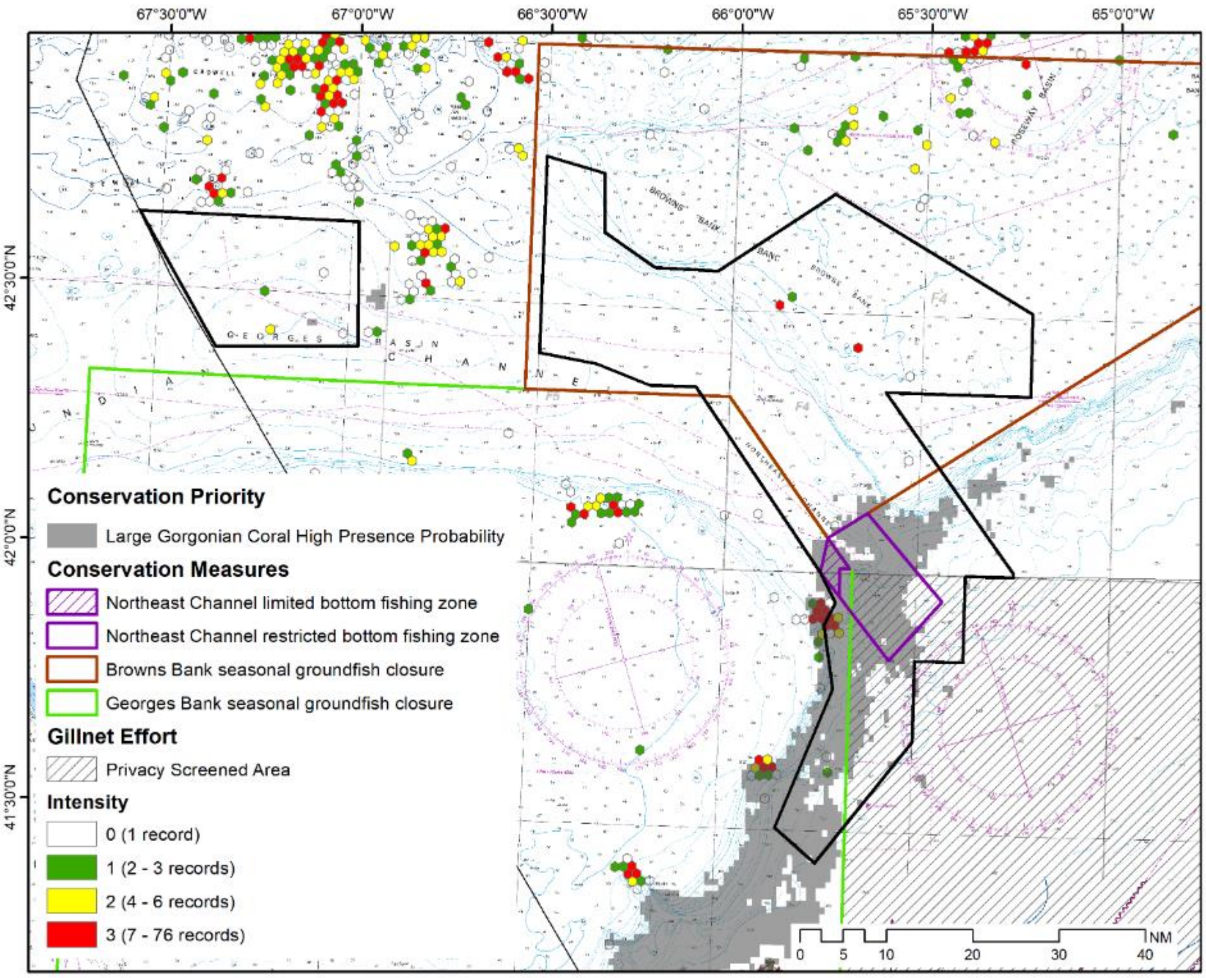


Figure 2.4.3-4. Overlap of the predicted extent of large gorgonian corals with the groundfish gillnet fishery footprint. Intensity for the groundfish gillnet fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area. Groundfish gillnet effort in the grey hatched areas were not shown for privacy reasons. However, effort within the privacy screened areas was considered in the analysis. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bottom disturbance from groundfish gillnets will lead to negative impacts on deep-water coral communities within the AOI.

Table 2.4.3-4. Scoring for the risk posed by the groundfish gillnet fishery to deep-water corals within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 3 x 4 x 1<br>= 12 (raw score) |

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| Intensity | 3 | Based on available effort data for the groundfish gillnet fishery in the assessment area, the average intensity of the fishery where it intersects with the predicted extent of deep-water corals in the AOI is considered high. |
| Temporal | 4 | Deep-water corals are present year-round and the groundfish gillnet fishery can occur year-round in the area that overlaps with corals. Therefore there is temporal overlap of up to 12 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (1.5%) between the groundfish gillnet fishery and the predicted extent of large gorgonian corals within the AOI. |
| $Q_{Sensitivity}$ | 5 | Corals are susceptible to fishing from both direct impacts (removal and/or damage) and indirect impacts (e.g. smothering) (DFO 2010*b*). The effect of fishing gear on corals is dependent on a number of factors including: morphology/skeletal composition of the coral, coral reproduction and growth rate, methods and timing of deployment of gear, and the frequency with which the location is fished.<br><br>Interaction between gillnets and benthic habitats can occur with the weights or anchors, the weighted rope along the bottom of the net, and the net itself (DFO 2010*a*). These components of the gear can lead to direct crushing of habitat, re-suspension of sediment leading to smothering, and entanglement causing damage. A study of fishing gear impacts to deep-water corals off of Newfoundland and Labrador found that gillnets caught high densities of corals in localized areas (Edinger et al. 2007).<br><br>Gorgonian corals are long-lived and slow to recover from physical damage (Witherell and Coon 2001). Growth rates and life spans of corals vary by species, studies of gorgonian corals have calculated growth rates of 5-26 mm per year and lifespans of 100 to 200 years (Roberts et al. 2006 as cited in Campbell and Simms 2009). Some of the species of deep-water corals found in Nova Scotia may take decades to centuries to recover from impacts associated with fishing activities, if they recover at all (DFO 2010*b*).<br><br>Due to the sensitivity of these corals to physical disturbance and the extremely slow recovery time, a sensitivity score of 5 was assigned. |
| $Q_{Consequence}$ | Very High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 5$<br>$= 20$ (raw score) |
| Likelihood | Almost certain | Bycatch records from 2000 to 2018 within the AOI assessment area indicate that corals were identified in 2% of observed sets. However, the groundfish gillnet fishery occurs annually and nets contact the seafloor as part of the fishery. Therefore, where this gear type overlaps with coral habitat, the likelihood of interaction is almost certain. |

| | | |
|---|---|---|
| Overall risk | High | Additional management measures are required to address risks from this pressure to deep-water corals, e.g., restricting this fishery in the predicted extent of large gorgonian corals within the future MPA. |
| Uncertainty | Low | While it is known that gorgonian corals are long-lived, easily damaged by fishing gear and slow to recover from damage (Witherell and Coon 2001), the impacts of fixed fishing gear on deep-water corals are not as well studied as the impact of mobile gear (DFO 2018*d*). However, there is sufficient evidence to support spatial closure to bottom contacting gear in areas of high coral concentration (e.g., Northeast Channel Coral Conservation Area) in accordance with DFO's *Policy for Managing the Impacts of Fisheries on Sensitive Benthic Areas* (DFO 2009*b*).<br><br>The presence probability map for deep-water corals within the AOI was developed using available data from research surveys. The identified coral area is predictive in nature due to limited survey coverage in the deeper waters. |

## Risk Assessment – Groundfish gillnet fishery and highly suitable habitat for Cusk

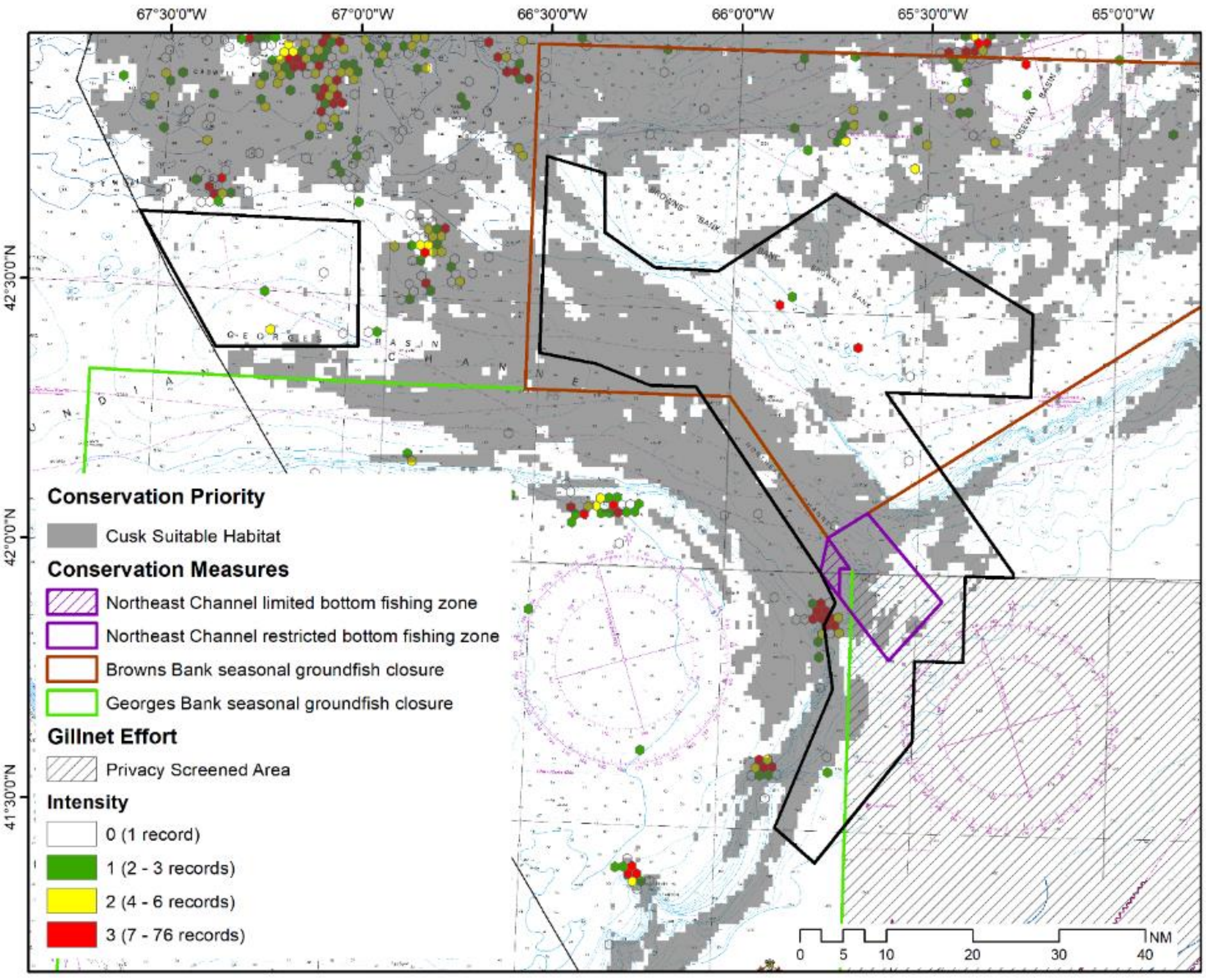


Figure 2.4.3-5. Overlap of predicted highly suitable Cusk habitat with the groundfish gillnet fishery footprint. Intensity for the groundfish gillnet fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Groundfish gillnet effort in the grey hatched areas were not shown for privacy reasons. However, effort within the privacy screened areas was considered in the analysis. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bycatch in groundfish gillnets will lead to negative impacts on the local population of Cusk in its suitable habitat within the AOI.

Table 2.4.3-5. Scoring for the risk posed by the groundfish gillnet fishery to Cusk within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 4 x 1<br>= 8 (raw score) |

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| Intensity | 2 | Based on available effort data for the groundfish gillnet fishery in the assessment area, the average intensity of the fishery where it intersects with the predicted extent of highly suitable Cusk habitat in the AOI is considered moderate. |
| Temporal | 4 | Cusk are presumed to be present year-round and the groundfish gillnet fishery can occur year-round in areas outside of the seasonal closures that overlap with Cusk habitat. Therefore there is a potential temporal overlap for up to 12 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (less than 1%) between the groundfish gillnet fishery and highly suitable Cusk habitat within the AOI. |
| $Q_{Sensitivity}$ | 2 | Fish species with a physoclistous swim bladder, such as Cusk, are likely to possess a lower survival rate when discarded due to their physiology (Cook et al. 2017). Cusk usually experience physical trauma when brought to the surface due to the expansion of gas in their swim bladders. Physical trauma can include: overexpansion or rupture of swim bladder, stomach eversion, intestinal protrusion through the cloaca, external hemorrhaging, organ torsion, subcutaneous gas bubbles, ocular gas bubbles (Rummer and Bennet 2005; Hannah et al. 2008; Pribyl et al. 2009; Campbell et al. 2010; Rogers et al. 2011; Butcher et al. 2012 as cited in Chen and Runnebaums 2014). Additionally, Cusk are likely to remain positively buoyant when brought to the surface, which increases the probability of predation (Chen and Runnebaums 2014). Cusk that are released are therefore not likely to survive (COSEWIC 2012*a*).<br><br>Fishing mortality is the only known major source of anthropogenic mortality for Cusk (Harris and Hanke 2010). Cusk is a bycatch (i.e., non-target) species in the groundfish fishery and may be legally landed and sold. There is a fleet cap on cusk bycatch for FG<45'of 500t in 4X5, although recent landings are reported well below this cap (DFO 2018*a*).<br><br>Recent DFO science advice places local (NAFO divisions 4VWX5Z) Cusk population biomass above the Limit Reference Point (DFO 2021*b*), and analyses using data from the Halibut Industry Survey suggests that the population abundance has been stable since 1999 (DFO 2014).<br><br>Taken together, the groundfish gillnet fishery could cause possible detectable changes in population size, but is only expected to have minimal impact on population dynamics. Therefore, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 2$<br>$= 6$ (raw score) |

| | | |
|---|---|---|
| Likelihood | Moderate | From 2000-2018, 1,192 sets were observed by at-sea observers in the Fundian Channel-Browns Bank assessment area (Table 2.4.3-1). Cusk was caught as bycatch in approximately 37% of sets. The likelihood of this interaction is therefore considered moderate. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) to address risks from this pressure to Cusk, e.g., restricting this fishery in highly suitable Cusk habitat within the future MPA. Potential increases in groundfish gillnet fishing activity within the AOI should be considered when determining management measures. |
| Uncertainty | Low | While the exact post-release mortality of Cusk has not been calculated, the peer-reviewed, science-based literature is clear that it is high, especially in situations where the Cusk are brought to the surface from significant depths.<br><br>The area of highly suitable habitat for Cusk was determined using the outputs of a habitat suitability model and is predictive in nature. |

**Risk Assessment – Groundfish gillnet fishery and shallow-diving pursuit generalists (shearwaters)**

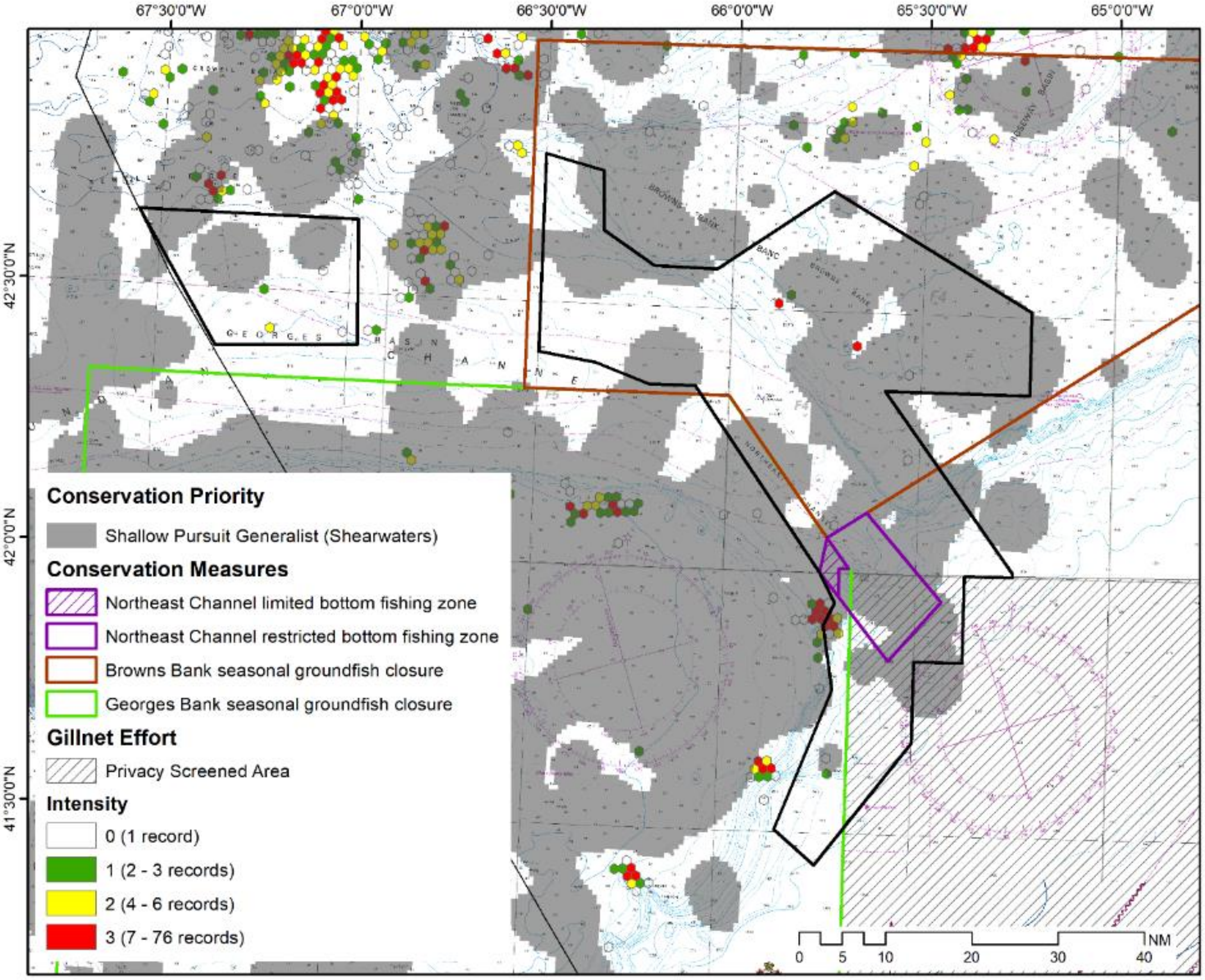


Figure 2.4.3-6. Overlap of predicted extent of shallow-diving pursuit generalists (shearwaters) with the groundfish gillnet fishery footprint. Intensity for the groundfish gillnet fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Groundfish gillnet effort in the grey hatched areas were not shown for privacy reasons. However, effort within the privacy screened areas was considered in the analysis. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bycatch in groundfish gillnets will lead to negative impacts to shearwaters in their foraging habitat within the AOI.

Table 2.4.3-6. Scoring for the risk posed by the groundfish gillnet fishery to shearwaters within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 3 x 3 x 1<br>= 9 (raw score) |
| Intensity | 3 | Based on available effort data for the groundfish gillnet fishery in the assessment area, the average intensity of the fishery where it intersects with the predicted extent of shearwater foraging grounds in the AOI is considered high. |
| Temporal | 3 | The groundfish gillnet fishery can occur year-round in the area overlapping shearwaters, however shearwaters are only present in their highest numbers on the Scotian Shelf from May through November. Therefore there is temporal overlap for up to 7 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (less than 1%) between the groundfish gillnet fishery and shearwater foraging habitat within the AOI. |
| $Q_{Sensitivity}$ | 2 | Shearwaters are shallow diving pursuit generalists that feed mainly on fish and squid. High bycatch rates of Shearwaters have been documented in demersal gillnets in areas where this activity overlaps with their foraging areas (Hedd et al. 2015). These birds can become entangled in the nets when diving for food, but they can also encounter nets closer to the surface before they fully sink or when they are being hauled (Løkkeborg 2008). Birds can also be attracted to vessels due to fisheries discards, and this can result in altered foraging behaviours as well as additional entanglements (Tasker et al. 2000).<br><br>Compared to other seabird species, Shearwaters reproduce slowly, so loss of adults could have impacts to a population (Anderson et al. 2011). Of the species shown to reach significant concentrations within the AOI, only one species of Shearwater, the Sooty Shearwater, is listed as near threatened by the IUCN (IUCN 2020). The other two species, Great Shearwater and Cory's Shearwater, have been listed as Least Concern (DFO 2020*b*).<br><br>However, given the relatively healthy global populations of Great and Sooty Shearwaters, changes to population dynamics for these species as a result of this interaction within the AOI is not expected. Therefore, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence}$ = $Q_{Exposure}$ x $Q_{Sensitivity}$<br>= 3 x 2<br>= 6 (raw score) |
| Likelihood | Rare | A summary of observer data from 1998-2011 indicates that gillnet fishing directing for Pollock results in the highest catches of shearwaters in the Maritimes Region for this gear type (Hedd et al. |

| | | |
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| | | 2015). 24 shearwaters were observed to be caught in this timeframe; however, this does not account for any unidentified bird species.<br><br>Shearwaters were recorded in 0.9% of observed sets for this fishery within the assessment area between 2000-2018 (Table 2.4.3-1). The likelihood of this interaction is estimated to be less than 5% (rare). |
| Overall risk | Moderate | No additional management measures are suggested. |
| Uncertainty | High | Important marine bird foraging areas were identified using available data from offshore seabird surveys. Survey coverage has been limited, and while identified foraging areas are based on occurrences, they contain a predictive component.<br><br>The overall low observer coverage for this fishery contributes to a low confidence level for the likelihood of interactions. As well, reporting on non-fish bycatch can be inconsistent and some entangled birds may be lost prior to hauling, so the observer record may not be comprehensive. Additionally, shearwaters complete extensive migrations and have a large habitat range, therefore it is difficult to determine how one activity in one location may impact the population. |

### 2.4.4 Groundfish Longline Fishery

Within the Fundian Channel-Browns Bank AOI, a significant portion of the groundfish landings come from the demersal longline fishery. The AOI overlaps two management units relevant to the groundfish longline fishery: NAFO Area 4X and NAFO Area 5Z (Figure 2.4.4-1). Within NAFO Area 4X, 67% of groundfish longline sets are directing for halibut (Themelis and den Heyer 2015). In NAFO Area 5Z, groundfish longline sets tend to target Atlantic Cod, Haddock, and Pollock. As of 2019/2020, cod can no longer be targeted in 4X. Since 2009, halibut and Haddock have become the top groundfish species in NAFO 4VWX5 in terms of annual landed value (DFO 2018*a*). While the fishery is open year-round, the majority of halibut longline fishing activity in the AOI occurs from June to October.

In the demersal longline fishery, a mainline is anchored to the seafloor with baited hooks attached to the mainline via shorter lines called gangions (DFO 2010*a*). Each end of the mainline is moored to the bottom and marked with a surface buoy/floats. Mainlines can be kilometers long, with hundreds or thousands of baited hooks attached. Hooks are set along the mainline at one to six meter intervals. When directing for halibut, large hooks are typically used (i.e., size 14-16), while smaller hooks generally indicate a set directing for Atlantic Cod, Pollock, or Haddock (Themelis and den Heyer 2015). Figure 2.4.4-1 illustrates the groundfish longline fishery footprint within the AOI assessment area.

Species selectivity in the groundfish longline fishery is low, resulting in high levels of bycatch which can include sensitive or endangered species (e.g., Anderson et al. 2011; Themelis and den Heyer 2015). Habitat damage from groundfish longlines depends on the configuration of the gear as well as bottom composition. Coral bycatch has been documented in the Atlantic Canadian groundfish longline fishery (Fuller et al. 2008).

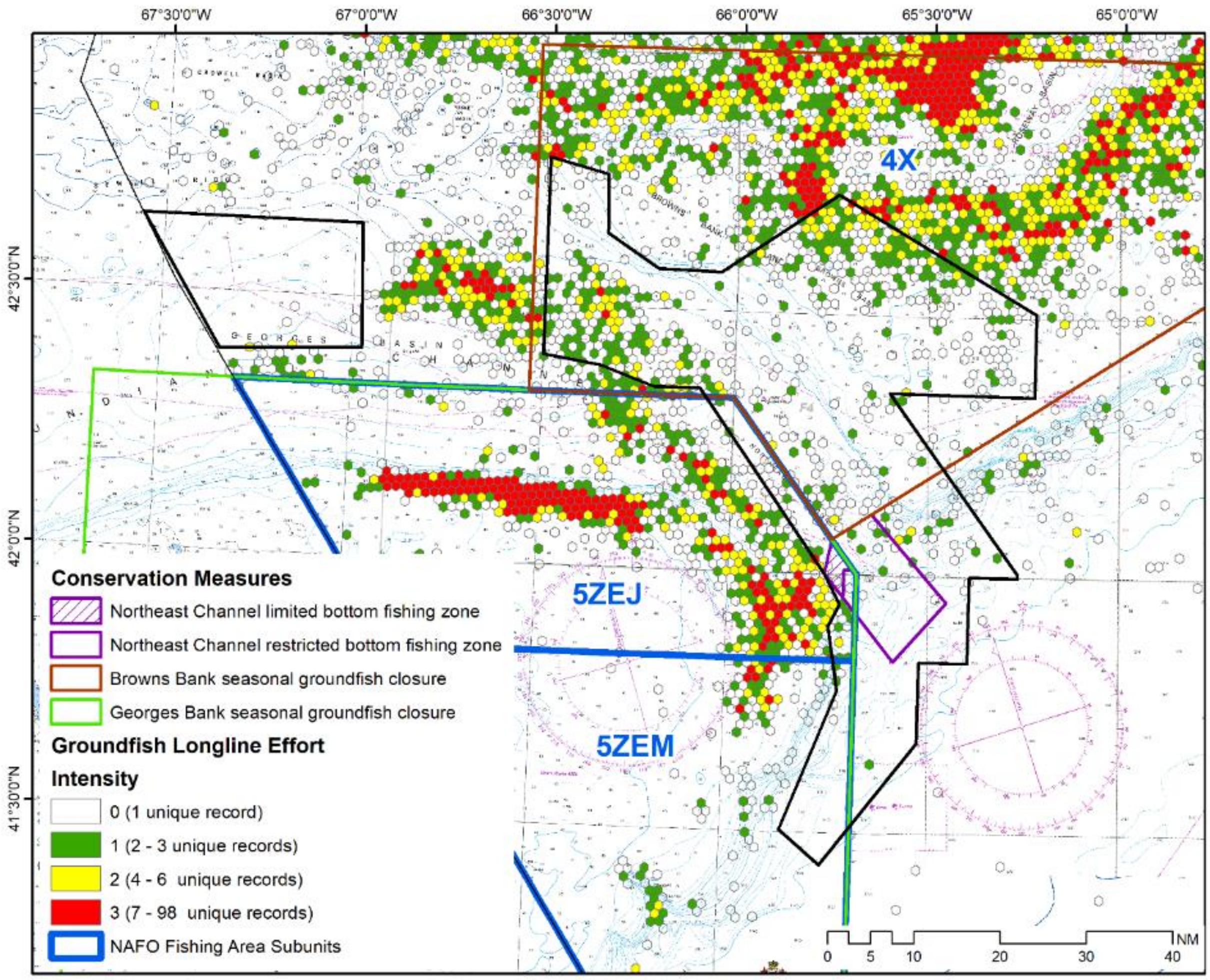


Figure 2.4.4-1. Map of groundfish longline fishing effort from 2008 to 2017 within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Intensity for the groundfish longline fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of recorded sets during the 2008-2017 period. Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis. The total fishing extent of the groundfish longline fishery within the AOI during this time period was approximately 864 $km^2$. NAFO fishing area subunit labels are also shown in blue text.

The groundfish longline fishery has changed over time and efforts have shifted since the early 2000s. To capture the historical extent of the fishery a map of landings from the groundfish longline fishery in the Maritimes region between 1999 and 2003 has been included (Figure 2.4.4-2). This historical map shows a concentration of landings in the Fundian Channel area. Additionally, because of the historical footprint of this fishery and the changes over time, the fisheries observer records analysed in this risk assessment cover the period from 2000-2018.

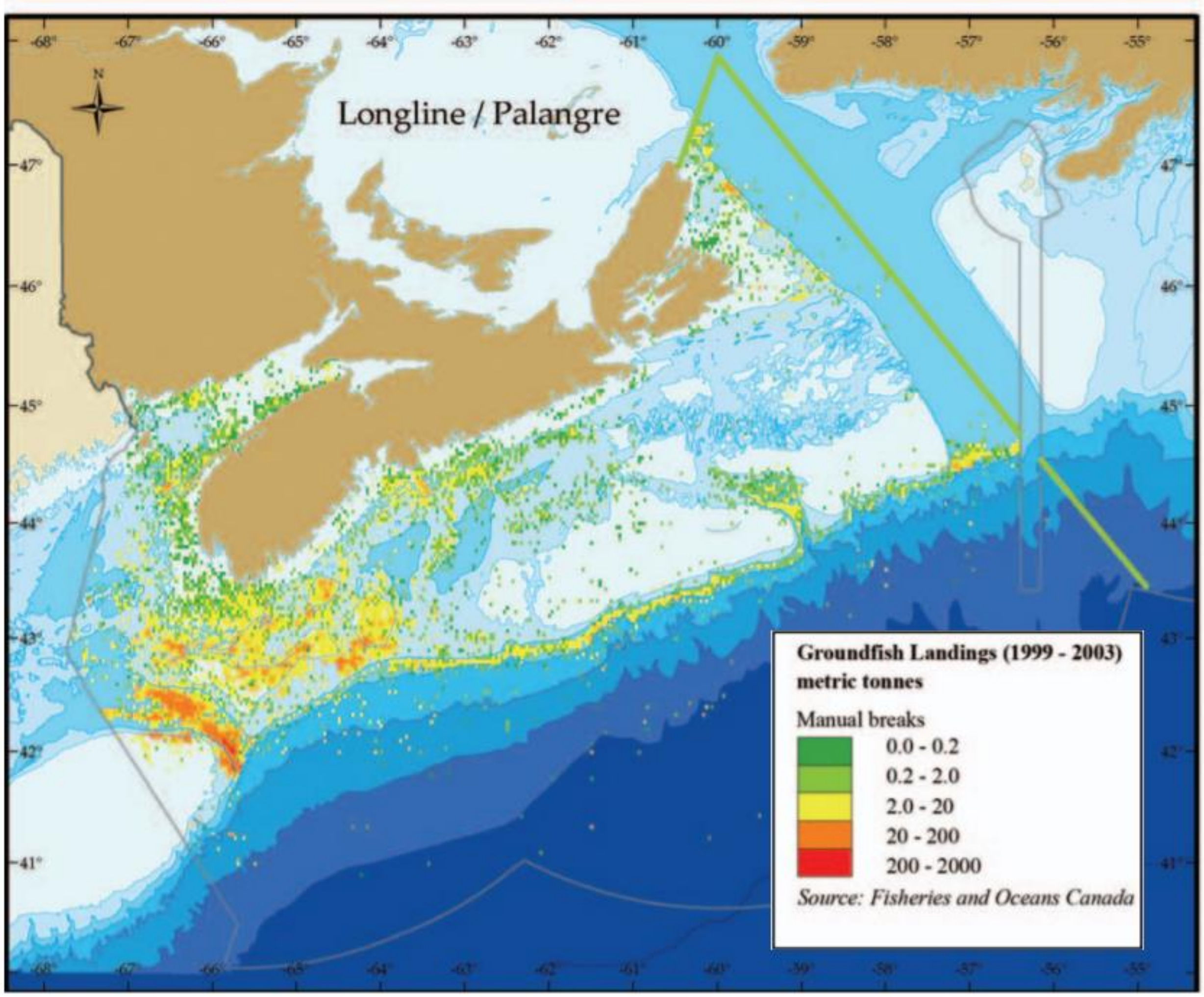

Figure 2.4.4-2. Historical groundfish longline footprint in the Maritimes Region from 1999-2003. As published in Breeze and Horsman 2005.

<u>Existing management measures</u>

The halibut fishery became regulated in Nova Scotia when a TAC was introduced in 1988 and a legal size was added in 1994. Currently, management measures for the fixed gear fishery include gear restrictions, dockside monitoring, minimum size, spawning and juvenile closures, bycatch restrictions, and TAC with community quotas (for the <45' fleet) (DFO 2018*a*). A CHP containing specific management measures must be created annually by the community management board responsible for the allocation of catch. DFO's CHP for fixed gear (FG) <45' 4TVWX+5 states that VMS is required in NAFO 4X when the vessel is greater than 35' and is authorized to fish by either longline or gillnet. All vessels fishing for groundfish in NAFO 5Z require VMS, regardless of vessel size or gear type. Observer coverage is required in 4VWX at a rate of 5 to 10% to be determined in collaboration by DFO and industry. Dockside monitoring is required under specific conditions for the FG <45' fleet (e.g., if >150 lbs of halibut is being landed in a single trip in 4X5Y) and 100% for other fixed gear fleets (DFO 2018*a*). Two seasonal spawning closures overlap with the AOI (Figure 2.4.4-1): the Browns Bank spawning closure (February 1 to June 15) and Georges Bank spawning closure (end of the 5th week of the year to May 31).

This fishery is multi-species, therefore licence conditions allow for the retention and landing of many species, however, vessels can only direct for quota species that are under a TAC (DFO 2018*f*). In 4X and 5Z, the main groundfish quota species are Atlantic Halibut, Atlantic Cod (5Z only as of 2019/2020), Haddock, and Pollock. Individual landings are monitored by the aforementioned community management boards. All fishing is closed for vessels fishing under the community management board when the quota for one of the main species has been reached. In addition, the minimum gape size, defined as the distance from the tip to the shank of the hook, is 12 mm and a “Small Fish Protocol” is in place for this fishery. Areas may be closed to fishing activity when the number of undersized fish reaches or exceeds 15% of the catch of any of the following species: Atlantic Cod, Pollock, White Hake, Atlantic Halibut, Witch Flounder, and other flatfish. Areas may also be closed for vessel classes if bycatch limits are reached or exceeded. For 4X5Y Haddock, areas will be closed when the number of undersized Haddock reaches or exceeds 40% of the catch. Cusk landings in 4VWX should not exceed 25% round weight of directed species or 4,000 lbs at any time. In 5Z, Cusk shall not exceed the lesser of 15% of the amount of Atlantic Cod, Haddock, and Pollock combined onboard or 3,000 lbs round weight. Area closures may be put in place to prevent the fishery surpassing bycatch limits (Harris et al. 2018).

The groundfish longline fishery in Canadian waters incorporates measures to help prevent entanglement, including actively tending gear. This means that fishing vessels remain in the vicinity of the gear, which may mitigate some severe impacts and mortality through quicker intervention to release entangled animals (Tulloch et al. 2020). The FG<45’ also participates in voluntary measure to reduce entanglement risk to North Atlantic Right Whales, including through using minimum amounts of rope, sinking or neutrally buoyant lines, and weakest break strengths feasible for operation (DFO 2018*a*). These voluntary measures are expected to reduce entanglement risk to other cetacean species. Additionally, amendments to the Marine Mammal Regulations in 2018 require all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018).

Bycatch Profile

In NAFO 4VWX, Atlantic Halibut has represented 41-70% of the catch by weight for years 1998-2013 (Themelis and den Heyer 2015). The most abundant bycatch species (by weight) were White Hake (11%), Cusk (10%), and Atlantic Cod (8%). In NAFO area 4X, Themelis and den Heyer (2015) found White Hake, Atlantic Cod, Cusk, Spiny Dogfish, Winter Skate, and Greenland Shark as the most abundant bycatch species by weight, with some seasonal variation. The Fundian Channel AOI assessment area At-Sea Observer records show various species of skate, Spiny Dogfish, Blue Shark, and Greenland Shark as the most abundant bycatch species by discard weight. It should be noted this is likely due to the large size of Greenland Sharks rather than frequent gear interactions. Observer records for the groundfish longline fishery in the Fundian Channel AOI assessment area (2000-2018) are reported in Table 2.4.4-1.

Available At-Sea Observer records for groundfish longline in the assessment area do not include many records of seabird catches, although earlier records do include catches of various Shearwater species, Northern Fulmars, and several species of gulls. However, this fishery is known to catch seabirds, with gulls, gannets, and shearwaters representing the majority of the bycatch (Hedd et al. 2015). In Hedd et al. 2015, seabirds were caught as bycatch in <0.1%-1.4% of demersal longline sets in 4VWX+5. Of those sets, seabird species composition varied by season and by targeted species, with gulls, gannets, shearwaters, and fulmars being recorded as bycatch.

Longline sets directing for different species use different size hooks and are set in different areas, therefore the bycatch profile may differ depending on the targeted species. In order to examine whether the bycatch profile is significantly different between targeted species, observer records have been broken down into records for the groundfish longline fishery in the Fundian Channel area, targeting halibut (Table 2.4.4-2) and records targeting Atlantic Cod/Haddock/Pollock (Table 2.4.4-3). The species most commonly caught as bycatch in sets targeting halibut include Cusk (52.16% of sets), Barndoor Skate (22.76% of sets), and White Hake (20.93% of sets). Likewise, in sets targeting Cod/Haddock/Pollock the bycatch species most commonly caught include Cusk (76.58% of sets), White Hake (52.52% of sets), and Barndoor Skate (49.22% of sets).

Table 2.4.4-1. At-Sea Observer Program records from DFO's Industry Survey Database for the groundfish longline fishery in the Fundian Channel-Browns Bank Area of Interest (AOI) assessment area for 2000 to 2018. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 10,651.

| **Species** | **Kept Weight (kg)** | **Discard Weight (kg)** | **# Unique Sets** | **% of Sets** |
|---|---|---|---|---|
| Barndoor Skate | 63,133 | 192,529 | 5,083 | 47.72 |
| Spiny Dogfish | 4,155 | 106,453 | 1,592 | 14.95 |
| Thorny Skate | 140 | 66,005 | 3197 | 30.02 |
| Winter Skate | 1,361 | 49,872 | 2,317 | 21.75 |
| Skates (NS) | 141 | 21,113 | 708 | 6.65 |
| Little Skate | 572 | 14,472 | 809 | 7.60 |
| Halibut (Atlantic) | 154,998 | 14,254 | 3,038 | 28.52 |
| Blue Shark | | 11,923 | 175 | 1.64 |
| Greenland Shark | | 7,752 | 12 | 0.11 |
| Basking Shark | 500 | 6,421 | 8 | 0.08 |
| Cusk | 333,784 | 5,862 | 8,010 | 75.20 |
| Smooth Skate | 30 | 4,132 | 200 | 1.88 |
| Haddock | 3,097,476 | 2,970 | 10,048 | 94.34 |
| Shortfin Mako | 930 | 1,539 | 28 | 0.26 |
| Porbeagle, Mackerel Shark | 1,911 | 1,302 | 45 | 0.42 |
| Black Dogfish | | 1,059 | 28 | 0.26 |
| Cod (Atlantic) | 1,457,520 | 1,058 | 10,142 | 95.22 |
| American Lobster | 2 | 922 | 334 | 3.14 |
| White Hake | 221,248 | 829 | 5,404 | 50.74 |
| Atlantic (Striped) Wolffish | 2,346 | 781 | 374 | 3.51 |
| Round Skate | | 569 | 49 | 0.46 |
| Northern Wolffish | 7 | 480 | 24 | 0.23 |
| Sea Corn | 25 | 417 | 191 | 1.79 |
| Sea Raven | 121 | 381 | 135 | 1.27 |
| Seals (NS) | | 348 | 4 | 0.04 |
| Rosefish (Black Belly) | 272 | 240 | 84 | 0.79 |
| Jensen's Skate | | 229 | 28 | 0.26 |

| | | | | |
|---|---|---|---|---|
| Shark (NS) | 127 | 205 | 4 | 0.04 |
| Redfish Unseparated | 4,091 | 176 | 478 | 4.49 |
| Monkfish, Goosefish, Angler | 10,548 | 150 | 1,236 | 11.60 |
| Spinytail Skate | 15 | 144 | 17 | 0.16 |
| Pollock | 49,499 | 143 | 3,622 | 34.01 |
| Swordfish | | 136 | 1 | 0.01 |
| Longhorn Sculpin | 28 | 135 | 75 | 0.70 |
| Portuguese Shark | | 104 | 1 | 0.01 |
| Atlantic Torpedo | | 89 | 5 | 0.05 |
| Bubble Gum Coral | 3 | 72 | 42 | 0.39 |
| Brier Skate | | 59 | 2 | 0.02 |
| Sea Scallop | 1 | 54 | 43 | 0.40 |
| Asteroidea S.C. | | 45 | 34 | 0.32 |
| Shorthorn Sculpin | | 45 | 19 | 0.18 |
| Sculpins | | 29 | 5 | 0.05 |
| Squirrel Or Red Hake | 2,466 | 22 | 267 | 2.51 |
| Greater Shearwater[8] | | 20 | 10 | 0.09 |
| Northern Stone Crab | | 19 | 18 | 0.17 |
| Deepwater Chimaera | | 15 | 1 | 0.01 |
| Ocean Pout (Common) | 3 | 15 | 10 | 0.09 |
| Yellow-Legged Gull[9] | | 15 | 2 | 0.02 |
| Great Black-Backed Gull | | 14 | 5 | 0.05 |
| Turbot, Greenland Halibut | 341 | 14 | 31 | 0.29 |
| Summer Flounder | 2 | 12 | 5 | 0.05 |
| White Skate | | 12 | 3 | 0.03 |
| Northern Fulmar | | 10 | 6 | 0.06 |
| Roughhead Grenadier | | 10 | 1 | 0.01 |
| Arctic Skate | | 9 | 1 | 0.01 |
| Basket Stars | | 9 | 4 | 0.04 |
| Jonah Crab | | 9 | 9 | 0.08 |
| Spotted Wolffish | 17 | 9 | 5 | 0.05 |
| Coral (NS) | | 8 | 8 | 0.08 |
| Helocid Pteropod | | 8 | 8 | 0.08 |
| Lobster Larvae | | 8 | 2 | 0.02 |
| Stones And Rocks | | 8 | 3 | 0.03 |
| Yellowtail Flounder | 7 | 8 | 6 | 0.06 |
| Ophiura Sp. | | 7 | 5 | 0.05 |
| Wolffish, Unidentified | | 7 | 3 | 0.03 |
| Herring Gull | | 6 | 4 | 0.04 |
| Dogfishes (NS) | | 5 | 3 | 0.03 |
| Grenadiers (NS) | | 5 | 1 | 0.01 |
| Snow Crab (Queen) | | 5 | 5 | 0.05 |
| Spiny Crab | | 5 | 4 | 0.04 |
| American Eel | | 4 | 1 | 0.01 |
| Grubby or Little Sculpin | | 4 | 2 | 0.02 |

[8] This was recorded as Greater Shearwater, however it should be noted the correct name is Great Shearwater.

[9] Note that the range for Yellow-Legged Gull does not extend to this area, therefore there is a high probability that this was a misidentification (K. Allard, Environment and Climate Change Canada Candian Wildlife Services, personal communication, 2021).

| | | | | |
|---|---|---|---|---|
| Winter Flounder | 50 | 4 | 17 | 0.16 |
| Longfin Hake | 4 | 3 | 7 | 0.07 |
| Sculpin (NS) | | 3 | 3 | 0.03 |
| Silver Hake | 61 | 3 | 8 | 0.08 |
| Sooty Shearwater | | 3 | 1 | 0.01 |
| Spider Crab (NS) | | 3 | 2 | 0.02 |
| Sun Star | | 3 | 3 | 0.03 |
| American Plaice | 13 | 2 | 8 | 0.08 |
| Atlantic Rock Crab | | 2 | 2 | 0.02 |
| Barnacles | | 2 | 2 | 0.02 |
| G.Land Bird | | 2 | 1 | 0.01 |
| Herring(Atlantic) | | 2 | 1 | 0.01 |
| Sea Anemone | | 2 | 2 | 0.02 |
| Sea Cauliflower (Duva Spp) | | 2 | 2 | 0.02 |
| Short-Fin Squid | | 2 | 1 | 0.01 |
| Tile Fish | 186 | 2 | 34 | 0.32 |
| Witch Flounder | 6 | 2 | 2 | 0.02 |
| Acanella Arbuscula | 1 | 1 | 2 | 0.02 |
| Anthozoa Sea Anemones | | 1 | 1 | 0.01 |
| Apristurus Sp. | | 1 | 1 | 0.01 |
| Berried Lobster | | 1 | 1 | 0.01 |
| Blue Antimora/Hake | | 1 | 1 | 0.01 |
| Hermit Crabs | | 1 | 1 | 0.01 |
| Mussels (NS) | | 1 | 1 | 0.01 |
| Pelagic Sea Snail | | 1 | 1 | 0.01 |
| Porcupine Crab | | 1 | 1 | 0.01 |
| Psenes Pellucidus | | 1 | 1 | 0.01 |
| Purple Sunstar | | 1 | 1 | 0.01 |
| Red Deepsea Crab | | 1 | 1 | 0.01 |
| Sea Cucumbers | | 1 | 1 | 0.01 |
| Spider Hazards Coral[10] | | 1 | 1 | 0.01 |
| Whelks | | 1 | 1 | 0.01 |
| Albacore Tuna | 26 | 0 | 1 | 0.01 |
| Hake (NS) | 2,608 | 0 | 79 | 0.74 |
| Off-Shore Hake | 142 | 0 | 26 | 0.24 |
| Redfish | 5 | 0 | 1 | 0.01 |
| Spotted Hake | 450 | 0 | 1 | 0.01 |
| Seasnail, Unidentified | 6 | | 2 | 0.02 |
| **Total** | 5,411,378 | 515,857 | N/A | N/A |

[10] Presumed to be misidentified *Lophelia pertusa* (J. Murillo-Perez, DFO Science, personal communication, 2020).

Table 2.4.4-2. At-Sea Observer Program records from DFO’s Industry Survey Database for sets targeting halibut in the groundfish longline fishery in the Fundian Channel-Browns Bank Area of Interest (AOI) assessment area for 2000 to 2018. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 602.

| Species | Kept Weight (kg) | Discard Weight (kg) | # Unique Sets | % of Sets |
|---|---|---|---|---|
| Halibut (Atlantic) | 65,364 | 7,799 | 565 | 93.85 |
| Barndoor Skate | 696 | 3,853 | 137 | 22.76 |
| Spiny Dogfish | | 2,187 | 53 | 8.80 |
| Thorny Skate | 21 | 1,406 | 118 | 19.60 |
| Blue Shark | | 1,231 | 14 | 2.33 |
| Greenland Shark | | 909 | 1 | 0.17 |
| Porbeagle, Mackerel Shark | 113 | 502 | 9 | 1.50 |
| Black Dogfish | | 479 | 6 | 1.00 |
| Winter Skate | | 367 | 53 | 8.80 |
| Seals (NS) | | 348 | 4 | 0.66 |
| Sea Raven | 86 | 147 | 57 | 9.47 |
| Little Skate | | 122 | 12 | 1.99 |
| Portuguese Shark | | 104 | 1 | 0.17 |
| Shortfin Mako | 247 | 100 | 6 | 1.00 |
| Atlantic (Striped) Wolffish | 96 | 100 | 45 | 7.48 |
| Northern Wolffish | | 80 | 2 | 0.33 |
| Cod (Atlantic) | 16,761 | 58 | 412 | 68.44 |
| Longhorn Sculpin | | 58 | 20 | 3.32 |
| Shorthorn Sculpin | | 38 | 15 | 2.49 |
| American Lobster | | 33 | 14 | 2.33 |
| Sea Corn | | 20 | 4 | 0.66 |
| Deepwater Chimaera | | 15 | 1 | 0.17 |
| Yellow-Legged Gull[11] | | 15 | 2 | 0.33 |
| Sculpins | | 13 | 1 | 0.17 |
| Cusk | 4,746 | 9 | 314 | 52.16 |
| Pollock | 1,141 | 5 | 113 | 18.77 |
| Skates (NS) | | 5 | 4 | 0.66 |
| Snow Crab (Queen) | | 5 | 5 | 0.83 |
| Dogfishes (NS) | | 4 | 2 | 0.33 |
| Round Skate | | 3 | 1 | 0.17 |
| Asteroidea S.C. | | 2 | 2 | 0.33 |
| Bubble Gum Coral | | 2 | 1 | 0.17 |
| Spiny Crab | | 2 | 2 | 0.33 |
| Haddock | 4,079 | 1 | 184 | 30.56 |
| Herring Gull | | 1 | 1 | 0.17 |
| Jonah Crab | | 1 | 1 | 0.17 |
| Monkfish, Goosefish, Angler | 87 | 1 | 27 | 4.49 |
| Northern Stone Crab | | 1 | 1 | 0.17 |
| Redfish, Unseparated | 678 | 1 | 37 | 6.15 |

[11] Note that the range for Yellow-Legged Gull does not extend to this area, therefore there is a high probability that this was a misidentification (K. Allard, Environment and Climate Change Canada Candian Wildlife Services, personal communication, 2021).

| | | | | |
|---|---|---|---|---|
| Sea Cucumbers | | 1 | 1 | 0.17 |
| Turbot, Greenland Halibut | 80 | 0 | 5 | 0.83 |
| White Hake | 10,337 | 0 | 126 | 20.93 |
| Ocean Pout (Common) | 1 | | 1 | 0.17 |
| **Total** | **104,533** | **20,028** | **N/A** | **N/A** |

Table 2.4.4-3. At-Sea Observer Program records from DFO's Industry Survey Database for sets targeting Cod*/Haddock/Pollock in the groundfish longline fishery in the Fundian Channel-Browns Bank Area of Interest (AOI) assessment area for 2000 to 2018. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 10,049.

| Species | Kept Weight (kg) | Discard Weight (kg) | # Unique Sets | % of Sets |
|---|---|---|---|---|
| Barndoor Skate | 62,437 | 188,676 | 4,946 | 49.22 |
| Spiny Dogfish | 4,155 | 104,266 | 1,539 | 15.31 |
| Thorny Skate | 119 | 64,599 | 3,079 | 30.64 |
| Winter Skate | 1,361 | 49,505 | 2,264 | 22.53 |
| Skates (NS) | 141 | 21,108 | 704 | 7.01 |
| Little Skate | 572 | 14,350 | 797 | 7.93 |
| Blue Shark | | 10,692 | 161 | 1.60 |
| Greenland Shark | | 6,843 | 11 | 0.11 |
| Halibut (Atlantic) | 89,634 | 6,455 | 2,473 | 24.61 |
| Basking Shark | 500 | 6,421 | 8 | 0.08 |
| Cusk | 329,038 | 5,853 | 7,696 | 76.58 |
| Smooth Skate | 30 | 4,132 | 200 | 1.99 |
| Haddock | 3,093,397 | 2,969 | 9,864 | 98.16 |
| Shortfin Mako | 683 | 1,439 | 22 | 0.22 |
| Cod (Atlantic)* | 1,440,759 | 1,000 | 9,730 | 96.83 |
| American Lobster | 2 | 889 | 320 | 3.18 |
| White Hake | 210,911 | 829 | 5,278 | 52.52 |
| Porbeagle, Mackerel Shark | 1,798 | 800 | 36 | 0.36 |
| Atlantic (Striped) Wolffish | 2,250 | 681 | 329 | 3.27 |
| Black Dogfish | | 580 | 22 | 0.22 |
| Round Skate | | 566 | 48 | 0.48 |
| Northern Wolffish | 7 | 400 | 22 | 0.22 |
| Sea Corn | 25 | 397 | 187 | 1.86 |
| Rosefish (Black Belly) | 272 | 240 | 84 | 0.84 |
| Sea Raven | 35 | 234 | 78 | 0.78 |
| Jensen's Skate | | 229 | 28 | 0.28 |
| Shark (NS) | 127 | 205 | 4 | 0.04 |
| Redfish Unseparated | 3,413 | 175 | 441 | 4.39 |
| Monkfish, Goosefish, Angler | 10,461 | 149 | 1,209 | 12.03 |
| Spinytail Skate | 15 | 144 | 17 | 0.17 |
| Pollock | 48,358 | 138 | 3,509 | 34.92 |
| Swordfish | | 136 | 1 | 0.01 |
| Atlantic Torpedo | | 89 | 5 | 0.05 |

* As of 2019/2020, Atlantic Cod can no longer be targeted in 4X5Y.

| | | | | |
|---|---|---|---|---|
| Longhorn Sculpin | 28 | 77 | 55 | 0.55 |
| Bubble Gum Coral | 3 | 70 | 41 | 0.41 |
| Brier Skate | | 59 | 2 | 0.02 |
| Sea Scallop | 1 | 54 | 43 | 0.43 |
| Asteroidea S.C. | | 43 | 32 | 0.32 |
| Squirrel or Red Hake | 2,466 | 22 | 267 | 2.66 |
| Greater Shearwater[12] | | 20 | 10 | 0.10 |
| Northern Stone Crab | | 18 | 17 | 0.17 |
| Sculpins | | 16 | 4 | 0.04 |
| Ocean Pout (Common) | 2 | 15 | 9 | 0.09 |
| Great Black-Backed Gull | | 14 | 5 | 0.05 |
| Turbot, Greenland Halibut | 261 | 14 | 26 | 0.26 |
| Summer Flounder | 2 | 12 | 5 | 0.05 |
| White Skate | | 12 | 3 | 0.03 |
| Northern Fulmar | | 10 | 6 | 0.06 |
| Roughhead Grenadier | | 10 | 1 | 0.01 |
| Arctic Skate | | 9 | 1 | 0.01 |
| Basket Stars | | 9 | 4 | 0.04 |
| Spotted Wolffish | 17 | 9 | 5 | 0.05 |
| Coral (NS) | | 8 | 8 | 0.08 |
| Helocid Pteropod | | 8 | 8 | 0.08 |
| Jonah Crab | | 8 | 8 | 0.08 |
| Lobster Larvae | | 8 | 2 | 0.02 |
| Stones And Rocks | | 8 | 3 | 0.03 |
| Yellowtail Flounder | 7 | 8 | 6 | 0.06 |
| Ophiura sp. | | 7 | 5 | 0.05 |
| Shorthorn Sculpin | | 7 | 4 | 0.04 |
| Wolffish, Unidentified | | 7 | 3 | 0.03 |
| Grenadiers (NS) | | 5 | 1 | 0.01 |
| Herring Gull | | 5 | 3 | 0.03 |
| American Eel | | 4 | 1 | 0.01 |
| Grubby or Little Sculpin | | 4 | 2 | 0.02 |
| Winter Flounder | 50 | 4 | 17 | 0.17 |
| Longfin Hake | 4 | 3 | 7 | 0.07 |
| Sculpin (NS) | | 3 | 3 | 0.03 |
| Silver Hake | 61 | 3 | 8 | 0.08 |
| Sooty Shearwater | | 3 | 1 | 0.01 |
| Spider Crab (NS) | | 3 | 2 | 0.02 |
| Spiny Crab | | 3 | 2 | 0.02 |
| Sun Star | | 3 | 3 | 0.03 |
| American Plaice | 13 | 2 | 8 | 0.08 |
| Atlantic Rock Crab | | 2 | 2 | 0.02 |
| Barnacles | | 2 | 2 | 0.02 |
| G.Land Bird | | 2 | 1 | 0.01 |
| Herring(Atlantic) | | 2 | 1 | 0.01 |
| Sea Anemone | | 2 | 2 | 0.02 |
| Sea Cauliflower (Duva spp) | | 2 | 2 | 0.02 |

[12] This was recorded as Greater Shearwater, however it should be noted the correct name is Great Shearwater.

| | | | | |
|---|---|---|---|---|
| Short-Fin Squid | | 2 | 1 | 0.01 |
| Tile Fish | 186 | 2 | 34 | 0.34 |
| Witch Flounder | 6 | 2 | 2 | 0.02 |
| Acanella Arbuscula | 1 | 1 | 2 | 0.02 |
| Anthozoa Sea Anemones | | 1 | 1 | 0.01 |
| Apristurus sp. | | 1 | 1 | 0.01 |
| Berried Lobster | | 1 | 1 | 0.01 |
| Blue Antimora/Hake | | 1 | 1 | 0.01 |
| Dogfishes (NS) | | 1 | 1 | 0.01 |
| Hermit Crabs | | 1 | 1 | 0.01 |
| Mussels (NS) | | 1 | 1 | 0.01 |
| Pelagic Sea Snail | | 1 | 1 | 0.01 |
| Porcupine Crab | | 1 | 1 | 0.01 |
| Psenes Pellucidus | | 1 | 1 | 0.01 |
| Purple Sunstar | | 1 | 1 | 0.01 |
| Red Deepsea Crab | | 1 | 1 | 0.01 |
| Spider Hazards Coral[13] | | 1 | 1 | 0.01 |
| Whelks | | 1 | 1 | 0.01 |
| Albacore Tuna | 26 | 0 | 1 | 0.01 |
| Hake (NS) | 2,608 | 0 | 79 | 0.79 |
| Off-Shore Hake | 142 | 0 | 26 | 0.26 |
| Redfish | 5 | 0 | 1 | 0.01 |
| Spotted Hake | 450 | 0 | 1 | 0.01 |
| Seasnail, Unidentified | 6 | | 2 | 0.02 |
| **Grand Total** | **5,306,845** | **495,829** | **N/A** | **N/A** |

[13] Presumed to be misidentified *Lophelia pertusa* (J. Murillo-Perez, DFO Science, personal communication, 2020).

**Risk Assessment - Groundfish longline fishery and large mature female lobster**

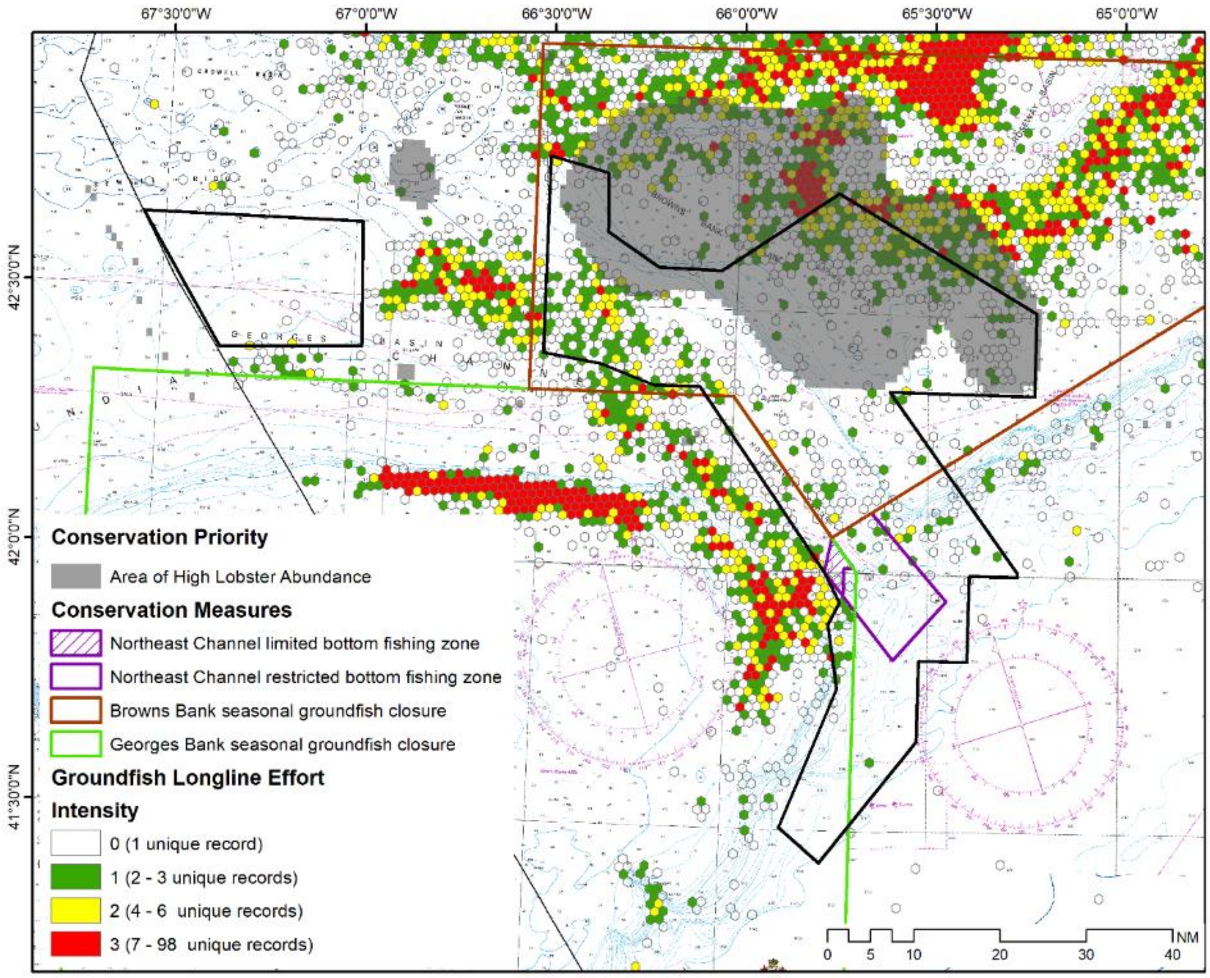


Figure 2.4.4-3. Overlap of high lobster abundance with the groundfish longline fishery footprint. Intensity for the groundfish longline fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bycatch in the groundfish longline fishery will lead to negative impacts on the local lobster population within the AOI.

Table 2.4.4-4. Scoring for the risk posed by the groundfish longline fishery to large mature female lobster within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 2<br>= 6 (raw score) |
| Intensity | 1 | Based on available effort data for the groundfish longline fishery in the assessment area, the average intensity of the |

| | | |
|---|---|---|
| | | fishery where it intersects with the area of high lobster abundance in the AOI is considered low. |
| Temporal | 3 | Large mature female lobster are present year-round. The groundfish longline fishery can occur year round; however, the area of high lobster abundance occurs within the Browns Bank seasonal spawning closure (February 1 to June 15). Considering this closure, there is potential temporal overlap for 7.5 months of the year. |
| Spatial | 2 | There is localized spatial overlap (34%) between the groundfish longline fishery footprint and the area of high lobster abundance within the AOI. |
| $Q_{Sensitivity}$ | 1 | The American Lobster population in LFA 41 is in the healthy zone, with reproductive potential currently found to be above the long-term average (DFO 2018*g*).<br><br>The effects to lobster from capture in a fishery can include injury, limb loss, and mortality, or longer term effects such as failure to molt, increased susceptibility to predation, and reduced foraging capacity (Murphy and Kruse 1995). However, Broadhurst and Uhlmann (2007) observed that crustaceans may be more tolerant than other taxa to handling, discard, and transport because of their durable exoskeletons, benefits associated with limb autotomy, and air-breathing abilities (Wassenberg and Hill 1989; Hill and Wassenberg 1990; Cabral et al. 2002).<br><br>Mortality of discarded crustaceans appears to vary greatly depending on species, location, time of year, gear type, and other factors (Stoner 2012). Hill and Wassenberg (1990) found that crustacean discard survival from a shrimp otter trawl was approximately 50%, and other studies have detected higher crustacean mortality from bottom trawls (e.g., Wileman et al. 1999; Harris and Ulmestrand 2004). Harris and Ulmestrand (2004) demonstrated that discarded Norway Lobster have high mortality if they are dropped through a low salinity surface layer. Survival of discarded Snow Crab in Newfoundland and Labrador trap fisheries was found to increase with gentle handling and quick return to the water (Grant 2003). Other stressors on crustaceans include exposure to extreme temperatures, risk of desiccation, barotrauma and light exposure (Stoner 2012), showing that many factors influence discard survival.<br><br>It is expected that lobster caught as bycatch in the groundfish longline fishery will survive when returned to the ocean, though direct damage to eggs can occur during the course of |

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| | | capture and release as ovigerous females carry their eggs externally (Darnell et al. 2010).<br><br>Given the current healthy status of the local population within the AOI, it is expected that this fishery would have insignificant or undetectable impacts. Therefore, a sensitivity score of 1 was assigned. |
| $Q_{Consequence}$ | Negligible | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 2 \times 1$<br>$= 2$ (raw score) |
| Likelihood | Rare | From 2000 to 2018, 10,651 groundfish longline fishing sets were observed by at-sea observers in the Fundian Channel-Browns Bank assessment area (Table 2.4.4-1). Of these sets, approximately 3% of sets contained lobster. The bycatch percentage encompasses all lobster caught and not specifically large female lobster. Koepper et al. (2021) examined sex ratios of American lobster in LFA 33 and LFA 34, and found that females composed ~48% of the population. Taken together, the chance of catching large female lobster is likely <5%. Therefore, a likelihood of rare was assigned. |
| Overall risk | Low | No additional management measures suggested. |
| Uncertainty | Low | There is high certainty for lobster distribution and abundance in the assessment area. However, there are few studies assessing the impacts of bottom longlines on lobster. Studies used to determine sensitivity mainly focused on impacts of otter/bottom trawl gear on crustacean discard survival, and did not include American Lobster in the assessments. Studies on the survival rate of discarded American Lobster would increase the certainty of this assessment. |

**Risk Assessment - Groundfish longline fishery and beaked whale habitat**

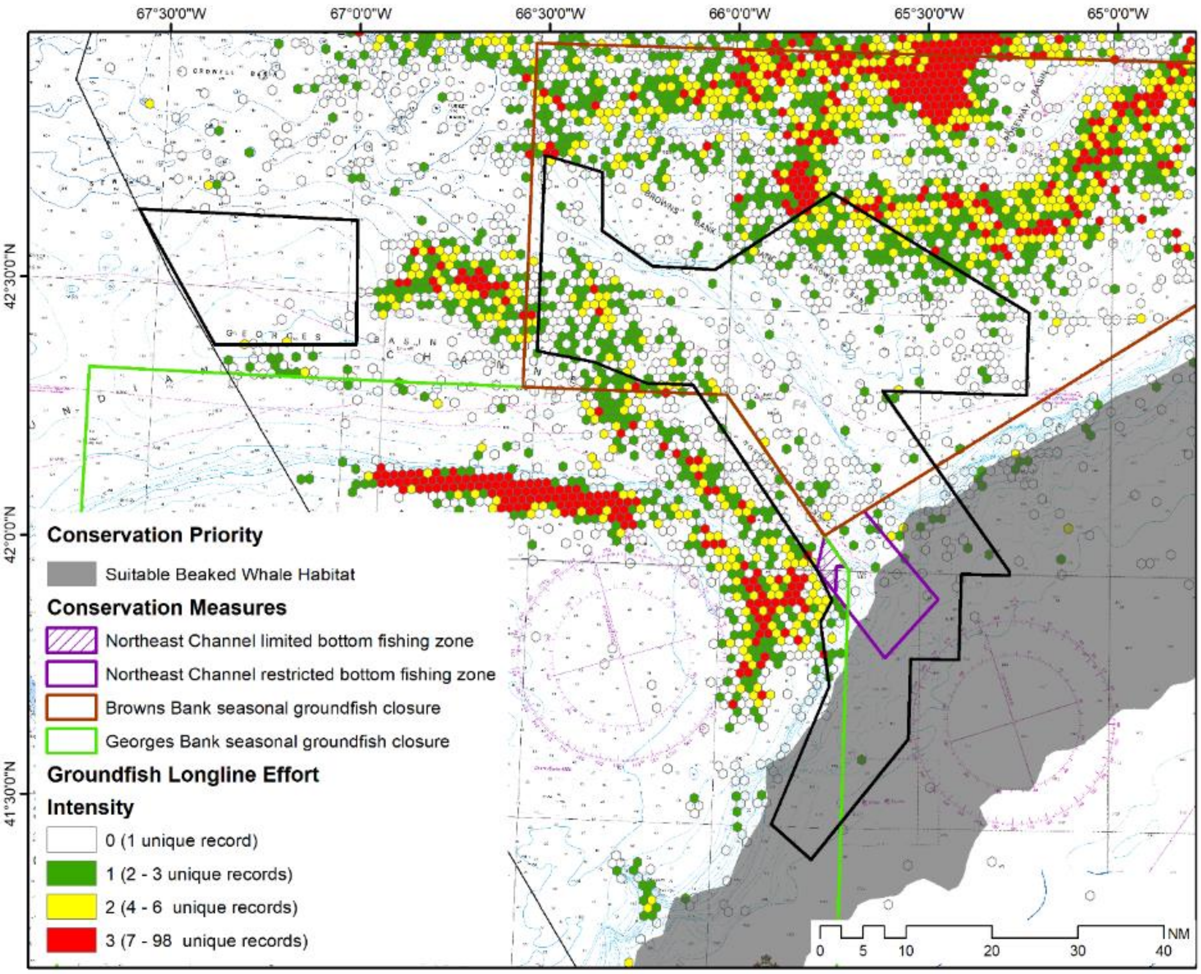


Figure 2.4.4-4. Overlap of extent of suitable beaked whale habitat with the groundfish longline fishery footprint. Intensity for the groundfish longline fishery was classified into low (1), medium (2), or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that entanglement in groundfish longline gear will lead to negative impacts to beaked whales in their suitable habitat within the AOI.

Table 2.4.4-5. Scoring for the risk posed by the groundfish longline fishery to beaked whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 1<br>= 4 (raw score) |
| Intensity | 1 | Based on available effort data for the groundfish longline fishery in the assessment, the average intensity of the fishery where it |

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| | | intersects with the extent of suitable beaked whale habitat in the AOI is considered low. |
| Temporal | 4 | Beaked whales occur within the AOI year-round and the groundfish longline fishery can occur year-round in the area overlapping beaked whale habitat, therefore there is potential temporal overlap of up to 12 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (5.5%) between the groundfish longline fishery footprint and the extent of suitable beaked whale habitat within the AOI. |
| $Q_{Sensitivity}$ | 3 | Of the beaked whale species known to occur in and around the AOI (see Chapter 1, Section 1.4.3), more information is known about Sowerby's Beaked Whales and Northern Bottlenose Whales in terms of population status and threats. The information below therefore focuses mainly on these two species.<br><br>Entanglement in fishing gear is listed as a threat for both Sowerby's Beaked Whales (Special Concern – SARA) and Northern Bottlenose Whales, Scotian Shelf population (Endangered – SARA) (DFO 2016; DFO 2017*a*; DFO 2017*c*; DFO 2022).<br><br>Both Northern Bottlenose Whales and Sowerby's Beaked Whales are long-lived species that reproduce at a low rate, similar to other beaked whale species (DFO 2016; DFO 2017*c*). This low reproductive rate may limit a population's ability to adapt to or recover from disturbance (COSEWIC 2019). The Scotian Shelf population of Northern Bottlenose Whales is estimated at roughly 175 individuals (Feyrer 2021). Although the population is still considered Endangered and was declining up to 2004, recent estimates indicate this trend has since reversed and the population now appears to be increasing since at least 2010. However, this population has a potential biological removal (PBR: the maximum number of non-natural mortalities that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) of 0.3 individuals per year (DFO 2007*b*; DFO 2010*c*). This means that the level of allowable harm for this population is low (DFO 2016).<br><br>In addition to direct mortality from fishing gear entanglement, there is the possibility that whales break free from entanglement (potentially with gear attached) (Feyrer et al. 2021). Whales that survive the entanglement event but escape with injuries may still experience long-term health impacts, which can also result in population level impacts (Dolman and Brakes 2018). These can include stress responses (Pettis et al. 2004), compromised immune responses (Cassoff et al. 2011), and cumulative loss of body condition and constriction of body parts, with or without secondary |

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| | | infection that may impact health and fecundity even after gear is no longer attached (Moore and van der Hoop 2012).<br><br>There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). Scarring analysis conducted on Northern Bottlenose Whales found that the majority of anthropogenic scars (57%) were considered low to moderate severity, and 16% were considered severe injuries; however, scarring analysis does not account for cryptic mortalities (Feyrer et al. 2021). In general, a fishing hook embedded in the head of an odontocetes is anticipated to have more severe impact compared to a larger baleen whale (NMFS 2012). The ingestion of gear or hooks and entanglement with trailing gear are also considered serious injuries for odontocetes (Angliss and DeMaster 1997; NMFS 2012). Depending on multiple factors such as the animal's body size relative to the gear and the species' sensitivity, loose gear may have the potential to become a serious injury (NMFS 2012). In addition, odontocetes may tire quickly as a result of their small body size, impacting their ability to reach the surface to breathe, and possibly leading to myopathy.<br><br>The groundfish longline fishery actively tends gear, with fishing vessels remaining in the vicinity of the gear, which may mitigate some severe impacts and mortality through quicker intervention to release entangled animals (Tulloch et al. 2020). The FG <45' fleet also undertakes voluntary measures to reduce entanglement severity through use of ropes with weaker break strengths (where feasible) (DFO 2018*a*), which could reduce instances of drowning from entanglement (Knowlton et al. 2015). However, impacts from remnant gear (e.g., hooks) and damage sustained during the escape are still possible, as noted above.<br><br>Considering the population size, status and low reproduction rate of the more at-risk beaked whale populations that can occur within the AOI, entanglement in groundfish longline gear could result in a detectable change in population size. However, there is no available data that suggests entanglement within the AOI by this gear type is exceeding the maximum sustainable level nor adversely impacting long-term recruitment dynamics. Taken together, a sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 2 \times 3$<br>$= 6$ (raw score) |
| Likelihood | Rare | Beaked whales dive to deep waters where they forage for fish and squid (COSEWIC 2011; COSEWIC 2019) and therefore may interact with benthic fishing gear while foraging. Additionally, Northern Bottlenose Whales are generally attracted to vessels, and |

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| | | in some areas demonstrate opportunistic associations with fishing vessels to feed on discards (e.g., Johnson et al. 2020).<br><br>Beaked whale entanglement incidents in fishing gear in Atlantic Canada are rarely observed. However, there have been some direct observations of entanglements (described below), and additional evidence of interactions through scarring analysis (Feyrer et al. 2021). Of the beaked whale species that occur within the AOI, information related to entanglements mainly exists for Northern Bottlenose Whales and Sowerby’s Beaked Whales.<br><br>There are no specific reports of beaked whale entanglement in groundfish longline gear within Maritimes Region, although gear type for reported entanglement events may not be known. There were ten reports of Northern Bottlenose Whale entanglement in fishing gear since 1981 impacting the Scotian Shelf population (Harris et al. 2013; Themelis et al. 2016; Feyrer et al. 2021). Additionally, two entangled Sowerby’s Beaked Whales were observed in the Gully MPA in 2013, but it is not known from which fishery the gear originated (Narazaki 2013 as cited in DFO 2017*c*).<br><br>Given the low probability of these events being observed due to factors such as their offshore location (Whitehead and Hooker 2012; DFO 2022), the records of beaked whale entanglements described above are considered low estimates of actual occurrence. Entanglement scars have been observed on Northern Bottlenose Whales and Sowerby’s Beaked Whales on the Scotian Shelf (Whitehead et al. 1997; DFO 2017*c*), suggesting that interactions with fishing gear occur more frequently than observed (DFO 2010*c*; Feyrer et al. 2021). Scarring evidence indicates Northern Bottlenose Whale interactions with fishing gear and propeller-vessel strikes occurs at a rate of 1.7 individuals per year (Feyrer et al. 2021).<br><br>While there is potential for beaked whale entanglement in groundfish longline within the AOI, based on available information and given the depth to which the whales must dive to encounter the gear, as well as voluntary management measures within the FG <45’ fishery to reduce entanglement risk (where feasible for operation) (DFO 2018*a*), the likelihood was estimated as rare. |
| Overall risk | Moderate | Additional management measures may be considered to address risks from this pressure including gear modifications (e.g., rope diameter, break strength) or restrictions where this fishery overlaps with the suitable beaked whale habitat within the future MPA. |
| Uncertainty | High | Since 2018, amendments to the Marine Mammal Regulations have required all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018). However, entanglement events may go unwitnessed. As well, entanglement scarring for beaked whales does not generally |

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| | | provide a clear link to fishing gear type. The potential for larger animals to break free from the gear before being noticed and recorded by observers can further limit the comprehensiveness of this data source. As a result, observer data are limited in their ability to approximate rates of cetacean bycatch and entanglement.<br><br>Additionally, as noted above, mortality may not be immediate, as entangled animals may die of sublethal effects such as starvation or infection at some future date (Pettis et al. 2004; Moore and van der Hoop 2012) and some animals eventually sink when they die (Moore 2014). There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). These factors obscure knowledge of entanglement-related mortality.<br><br>Beaked whale suitable habitat was defined using available data from visual detections, acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited. There is also uncertainty associated with the use of this area for Northern Bottlenose Whales in particular, given that it is toward the southern extent of their range. |

**Risk Assessment - Groundfish longline fishery and deep-water corals**

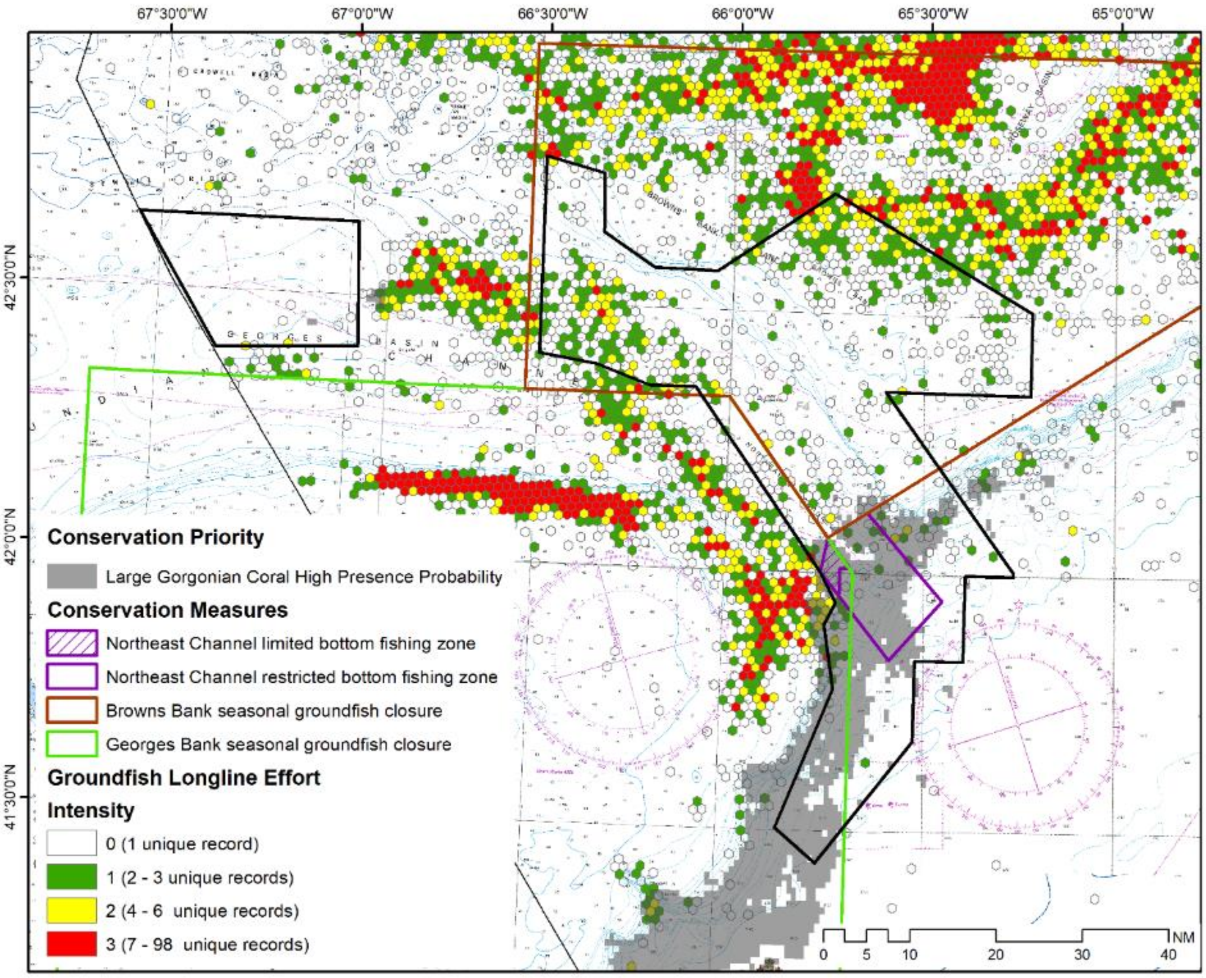


Figure 2.4.4-5. Overlap of predicted extent of large gorgonian corals with the groundfish longline fishery footprint. Intensity for the groundfish longline fishery was classified into low (1) medium (2) or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bottom disturbance from groundfish longline gear will lead to negative impacts on deep-water coral communities within the AOI.

Table 2.4.4-6. Scoring for the risk posed by the groundfish longline fishery within to deep-water corals within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 1<br>= 4 (raw score) |
| Intensity | 1 | Based on available effort data for the groundfish longline fishery in the assessment area, the average intensity of the fishery where it |

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| | | intersects with the predicted extent of deep-water corals in the AOI is considered low. |
| Temporal | 4 | The groundfish longline fishery can occur year-round in the area that overlaps with corals, and deep-water corals are present year-round, therefore there is temporal overlap of up to 12 months of the year. |
| Spatial | 1 | There are few restricted locations of spatial overlap (6%) between the groundfish longline fishery footprint and the predicted extent of large gorgonian corals within the AOI. |
| $Q_{Sensitivity}$ | 5 | Corals are susceptible to fishing from both direct (removal and/or damage) and indirect impacts (smothering) (DFO 2010*b*). The effect of fishing gear on corals is dependent on a number of factors including: morphology/skeletal composition of the coral, coral reproduction and growth rate, methods and timing of deployment of gear, and the frequency with which the site is fished.<br><br>Demersal longline gear can displace or remove features on the sea floor during setting and retrieval, resulting in benthic disturbance (DFO 2010*a*; Sampaio et al. 2012; Ewing and Kilpatrick 2014 as cited in Clark et al. 2016; DFO 2018*d*). The extent of the interaction depends on the characteristics of the gear, bottom type, and the conditions during setting/retrieval (DFO 2010*a*).<br><br>Breeze et al. (1997) reported that longlines can get tangled up in and catch coral, while Mortensen et al. (2005) noted that a snagged longline has a loose end that could move in the currents and cause further damage. Another review reported evidence of coral bycatch in up to 13% of observed longline sets (Fuller et al. 2008). This study also noted that habitat damage is dependent on gear configuration (i.e. weights, number of hooks, hauling speed) and bottom type.<br><br>A study conducted in the Northeast Channel Coral Conservation area, which lies within the AOI boundaries, found damaged coral in 29% of video transects, along with lost longlines either loose on the seafloor or entangled in corals in 37% of transects (Mortensen et al. 2005). The study found a positive relationship between the frequency of encountering lost longlines and the frequency of encountering damaged, living *Paragorgia arborea*. The study's observation of damage combined with an analysis of fishing effort led to the conclusion that damage to corals in the area was caused mainly by benthic longline, and the result was to prohibit all bottom contacting gear in the coral conservation area.<br><br>Gorgonian corals are long-lived and slow to recover from physical damage (Witherell and Coon 2001). Growth rates and life spans of corals vary by species, studies of gorgonian corals have calculated growth rates of 5-26 mm per year and lifespans of 100 to 200 years |

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| | | (Roberts et al. 2006 as cited in Campbell and Simms 2009). Some of the species of deep-water corals found in Nova Scotia may take decades to centuries to recover from impacts associated with fishing activities, if they recover at all (DFO 2010*a*).<br><br>Taken together, there is ample evidence to suggest that demersal longline causes physical damage to deep-water corals, including within the AOI. Due to the sensitivity of deep-water corals to physical disturbance and the extremely slow recovery time, a sensitivity score of 5 was assigned. |
| $Q_{Consequence}$ | High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 2 \times 5$<br>= 10 (raw score) |
| Likelihood | Almost certain | Over the 2000-2018 period, observer records show coral, including bubblegum coral, bamboo coral, *Lophelia pertusa* (spider hazards coral) and unidentified coral species, being caught and discarded in 0.01-0.39% of sets in the groundfish longline fishery (Table 2.4.4-1). Mortensen et al. (2005) reported damaged coral in 29% of video transects, along with lost longlines either loose on the seafloor or entangled in corals in 37% of transects at a study area within the AOI. Furthermore, the gear touches bottom when it is deployed, so bottom disturbance is considered almost certain. Taken together, a likelihood of almost certain was assigned. |
| Overall risk | High | Additional management measures are required to address risks from this pressure to deep-water corals, e.g., restricting this fishery in the predicted extent of large gorgonian corals within the future MPA |
| Uncertainty | Low | While it is known that gorgonian corals are long-lived, easily damaged by fishing gear and slow to recover from damage (Witherell and Coon 2001), the impacts of fixed fishing gear on deep-water corals are not as well studied as the impact of mobile gear (DFO 2018*d*). However, there is sufficient evidence based on CSAS advice, relevant international research, and survey findings in other similar areas in Atlantic Canada that bottom-contacting gears like bottom longline cause damage to corals, and several spatial closures have been implemented in areas of high coral concentration (e.g., Northeast Channel Coral Conservation Area) where all bottom contact fishing gear is prohibited.<br><br>The presence probability map for deep-water corals within the AOI was developed using available data from research surveys. The identified coral area is predictive in nature due to limited survey coverage in the deeper waters. |

**Risk Assessment - Groundfish longline fishery and significant concentrations of sponges**

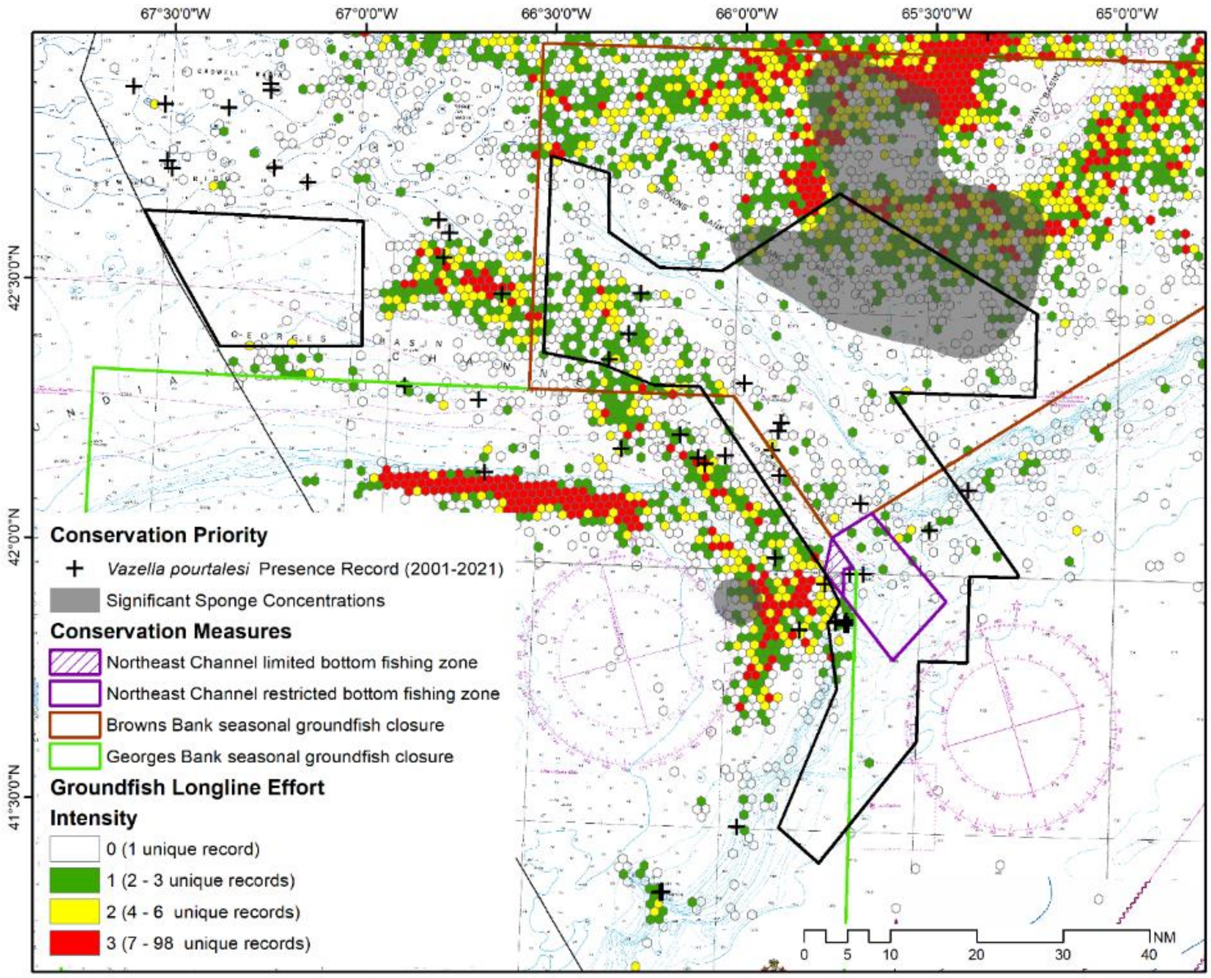


Figure 2.4.4-6. Overlap of predicted extent of significant concentrations of sponges and presence records for *Vazella pourtalesi* with the groundfish longline fishery footprint. Intensity for the groundfish longline fishery was classified into low (1), medium (2) or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bottom disturbance from groundfish longlines will lead to negative impacts on significant concentrations of sponges within the AOI.

Table 2.4.4-7. Scoring for the risk posed by the groundfish longline fishery to significant concentrations of sponges within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 2<br>= 6 (raw score) |
| Intensity | 1 | Based on available effort data for the groundfish longline fishery in the assessment area, the average intensity of the fishery where it |

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| | | intersects with significant concentrations of sponges in the AOI is considered low. |
| Temporal | 3 | Significant concentrations of sponges are present year-round. The groundfish longline fishery can occur year round; however, the significant concentration of sponges occurs within the Browns Bank seasonal spawning closure (February 1 to June 15). Considering this closure, there is potential temporal overlap for 7.5 months of the year. |
| Spatial | 2 | There is localized spatial overlap (28%) between the groundfish longline fishery footprint and important sponge areas within the AOI. |
| $Q_{Sensitivity}$ | 4 | Significant concentrations of sponges in the AOI include several species of sponges, with the family Polymastiidae (massive sponges) being prevalent (DFO 2020*b*). Note that *V. pourtalesi* sponges have also been detected in parts of the AOI; these hexactinellid glass sponges are also susceptible to physical damage (Morrison et al. 2020). Sponge dominated communities are considered indicator taxa for Vulnerable Marine Ecosystems (FAO 2009).<br><br>Clark et al. 2016 (modified from Hewitt et al. 2011) categorized the sensitivity of deep-sea benthic taxa to disturbance from mobile fishing gears and assigned erect branching or laminar sponges as highly sensitive, massive sponges as intermediate sensitivity, and encrusting sponges as tolerant. While this categorization was relative to mobile bottom-contacting gears, the conclusion that different types of sponges have differing levels of tolerance to disturbance should apply to fixed gears as well.<br><br>Demersal longline gear can displace or remove features on the sea floor during setting and retrieval, resulting in benthic disturbance (DFO 2010*a*; Sampaio et al. 2012; Ewing and Kilpatrick 2014 as cited in Clark et al. 2016; DFO 2018*d*). The extent of the interaction depends on the characteristics of the gear and the weather during setting/retrieval.<br><br>A study conducted in the Northeast Atlantic recorded sponge bycatch from demersal longline sets, including demosponges and hexactellinids, and noted additional damage can occur in areas of strong current where line and anchors drag along the bottom (Durán Muñoz et al. 2011).<br><br>While evidence suggests that demersal longline causes physical damage to sponges (Stone et al. 2015), recovery is possible. For example, a study conducted in 2003 found that Polymastiids showed good recovery and survival following damage (Duckworth 2003). The study found similar rates of growth in damaged and undamaged sponges, and estimated that damaged sponges could |

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| | | survive and recover from a loss of up to 90% of the individual's biomass. The estimated time for regrowth ranged from 155 weeks (for 50% biomass removal) to 400 weeks (for 90% biomass removal) on a Polymastiid sponge. Other species showed faster recovery of 39 to 75 weeks for 50% and 90% biomass removal respectively. Further, Pham and colleagues (2014) assessed the impact of groundfish longline on benthic communities through bycatch assessments and ROV analyses and found that vulnerable slow-growing species like sponges are still common in areas that have been subject to over 20 years of longline activity. However, it should be noted that the impact from longlines on sponges can be significant, particularly when fishing intensity is high (Clark et al. 2016; Duran Muñoz et al. 2011).<br><br>Taken together, due to the potential sensitivity of sponges to physical disturbance, combined with the estimated recovery time of possibly over 1 year, a sensitivity score of 4 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 2 \times 4$<br>$= 8$ (raw score) |
| Likelihood | Almost certain | During the 2000-2018 period, observer records from the Fundian Channel Assessment Area did not record any sponge bycatch from the groundfish longline fishery (Table 2.4.4-1). However, the gear touches bottom when it is deployed, so bottom disturbance is almost certain, and damaged sponges that remain on the bottom will not be recorded as bycatch. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) to address risks from this pressure, such as restricting this fishery where it overlaps with significant concentrations of sensitive sponge species within the future MPA. |
| Uncertainty | Medium | The impacts of groundfish longline and sponges have been fairly well studied. Sponge coverage and composition in the AOI has been confirmed through scientific surveys. There is sufficient evidence based on CSAS advice, relevant international research, and survey findings in other similar areas in Atlantic Canada that bottom-contacting gears like bottom longline cause damage to sensitive benthic features like sponges, and several spatial closures to have been implemented in areas of high coral and sponge concentration (e.g., Northeast Channel Coral Conservation Area) where all bottom contact fishing gear is prohibited.<br><br>Available information on sponge recovery and growth rates is limited. While there is some research on Polymastiid recovery, there are several other sponge species present in the significant sponge area for which no information on recovery is available. |

## Risk Assessment - Groundfish longline fishery and highly suitable habitat for Cusk

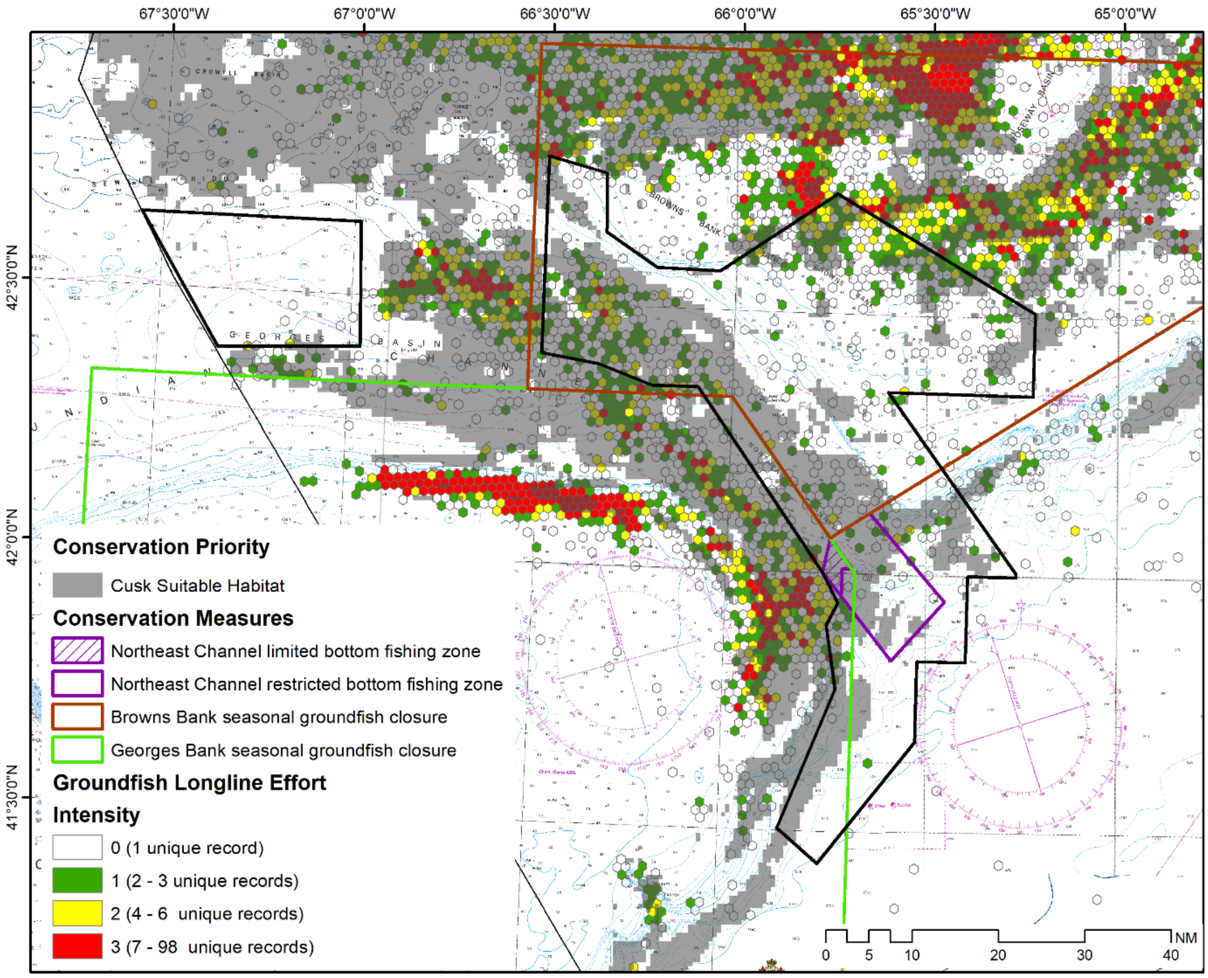


Figure 2.4.4-7. Overlap of predicted highly suitable Cusk habitat with the groundfish longline fishery footprint. Intensity for the groundfish longline fishery was classified into low (1), medium (2) or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bycatch by groundfish longlines will lead to negative impacts on the local population of Cusk in its suitable habitat within the AOI.

Table 2.4.4-8. Scoring for the risk posed by the groundfish longline fishery to Cusk within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 2<br>= 8 (raw score) |
| Intensity | 1 | Based on available effort data for the groundfish longline fishery in the assessment area, the average intensity of the fishery where it |

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| | | intersects with the predicted extent of highly suitable Cusk habitat in the AOI is considered low. |
| Temporal | 4 | Cusk occur within the AOI year-round and the groundfish longline fishery can occur year-round in the area overlapping suitable cusk habitat, therefore there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 2 | There is localized spatial overlap (41%) between the groundfish longline fishery footprint and highly suitable Cusk habitat within the AOI. |
| $Q_{Sensitivity}$ | 2 | Fish species with a physoclistous swim bladder, such as Cusk, are likely to possess a lower survival rate when discarded due to their physiology (Cook et al. 2017). Cusk usually experience physical trauma when brought to the surface due to the expansion of gas in their swim bladders. Physical trauma includes: overexpansion or rupture of swim bladder, stomach eversion, intestinal protrusion through the cloaca, external hemorrhaging, organ torsion, subcutaneous gas bubbles, ocular gas bubbles (Rummer and Bennet 2005; Hannah et al. 2008; Pribyl et al. 2009; Campbell et al. 2010; Rogers et al. 2011; Butcher et al. 2012 as cited in Chen and Runnebaums 2014). Additionally, Cusk are likely to remain positively buoyant when brought to the surface, which increases the probability of predation (Chen and Runnebaums 2014). Cusk that are released are therefore not likely to survive (COSEWIC 2012*a*).<br><br>Fishing mortality is the only known major source of anthropogenic mortality of Cusk (Harris and Hanke 2010). Groundfish longline is the greatest threat to Cusk based on landings records, accounting for over 95% of Cusk landings in the Maritimes Region (DFO 2018*a*). Cusk is a bycatch (non-target) species in the groundfish longline fishery and may be legally landed and sold. There is a fleet cap on cusk bycatch for FG<45'of 500t in 4X5, although recent landings are reported well below this cap.<br><br>Recent DFO science advice places local (NAFO divisions 4VWX5Z) Cusk population biomass above the Limit Reference Point (DFO 2021*b*), and analyses using data from the Halibut Industry Survey suggests that the population abundance has been stable since 1999 (DFO 2014).<br><br>Taken together, the groundfish longline fishery could cause potential detectable changes in population size, but is only expected to have minimal impact on population dynamics. Therefore, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 2$<br>$= 6$ (raw score) |

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| Likelihood | Moderate | From 2000 to 2018, 10,651 groundfish longline fishing sets were observed by at-sea observers in the Fundian Channel-Browns Bank assessment area (Table 2.4.4-1 – 2.4.4-3). Of these sets, approximately 75% of sets contained Cusk. In differentiating between targeted species, it was found that Cusk was caught in approximately 52% of sets targeting halibut, and in approximately 76% of sets targeting cod, Haddock, and Pollock. Because most of the fishery overlapping the AOI currently targets halibut, a likelihood score of moderate was assigned. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) to address risks from this pressure to Cusk, e.g., restricting this fishery in highly suitable Cusk habitat within the future MPA. |
| Uncertainty | Low | There is significant evidence that mortality in the groundfish longline fishery is a high threat to the population in the Maritimes Region.<br><br>While the exact post-release mortality of Cusk has not been calculated, the peer-reviewed, science-based literature is clear that it is high, especially in situations where the Cusk are brought to the surface from significant depths.<br><br>The area of highly suitable habitat for Cusk was determined using the outputs of a habitat suitability model and is predictive in nature. |

**Risk Assessment - Groundfish longline fishery and shallow-diving pursuit generalists (shearwaters)**

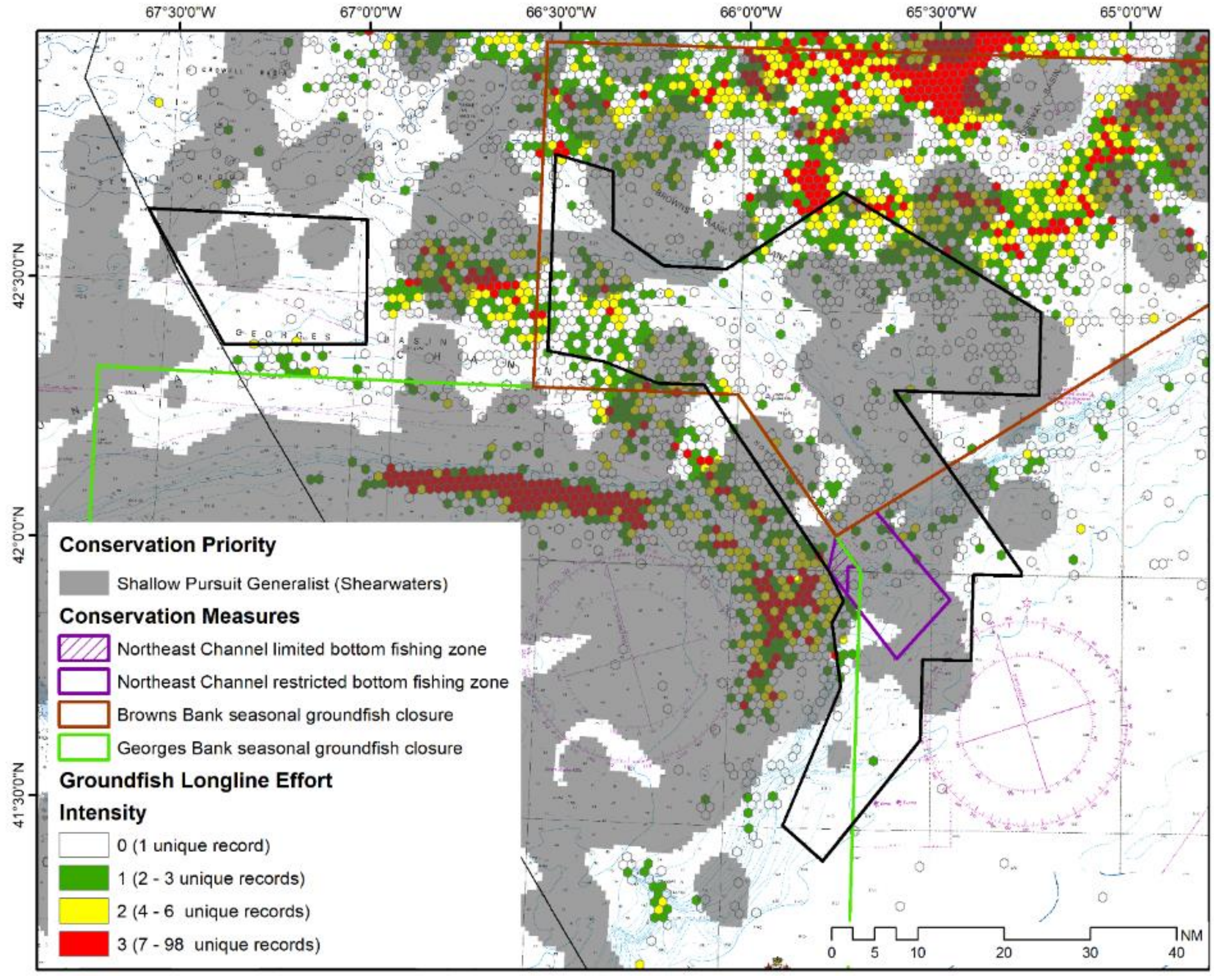


Figure 2.4.4-8. Overlap of predicted extent of shallow-diving pursuit generalists (shearwaters) with the groundfish longline fishery footprint. Intensity for the groundfish longline fishery was classified into low (1), medium (2) or high (3) intensity categories based on quantile breaks using data on total number of sets during the 2008-2017 period in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Grid cells containing only one recorded set (clear circles) were not considered part of the fishing footprint for the purposes of this analysis.

**Risk Statement**: There is a risk that bycatch in groundfish longline gear will lead to negative impacts to shearwaters in their foraging habitat within the AOI.

Table 2.4.4-9. Scoring for the risk posed by the groundfish longline fishery to shearwaters within the AOI.

| Risk factor | Score | Rationale |
| --- | --- | --- |
| $Q_{Exposure}$ | 1 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 1<br>= 3 (raw score) |

| | | |
|---|---|---|
| Intensity | 1 | Based on available effort data for the groundfish longline fishery in the assessment area, the average intensity of the fishery where it intersects with the predicted extent of shearwater foraging grounds in the AOI is considered low. |
| Temporal | 3 | The groundfish longline fishery can occur year-round in areas that overlap with shearwater foraging habitat and shearwaters are present May through November. Therefore, there is potential temporal overlap for up to 7 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (9%) between the groundfish longline fishery footprint and shearwater foraging habitat within the AOI. |
| $Q_{Sensitivity}$ | 2 | Shearwaters are shallow diving pursuit generalists that feed mainly on fish and squid. Birds that tend to scavenge on the surface are most susceptible to being hooked or entangled, such as albatrosses, petrels, shearwaters, gulls and skuas (Brothers et al. 1999).<br><br>Globally, mortality in longline fisheries is considered a critical threat to seabirds in the Procellariidae family (including shearwaters; Gilman et al. 2005). Shearwaters are known to be attracted to fishing vessels and to interact with fishing gear, largely during setting and hauling (Anderson et al. 2011). Seabirds may attack floating or sinking hooks and become hooked in their bills or bodies, or could collide with the line and become entangled (Løkkeborg 2008). Once caught on a hook or in the line, drowning is likely, particularly if the bird is entangled during setting of the gear (DFO 2007*a*; Løkkeborg 2008). Injury and eventual death from swallowing hooks is also possible (Bugoni et al. 2008). Birds can also be attracted to vessels due to fisheries discards, and this can result in altered foraging behaviours as well as additional entanglements (Tasker et al. 2000).<br><br>Compared to other seabird species, this family of seabirds reproduce slowly, so loss of adults could have impacts to a population (Anderson et al. 2011). Of the species shown to reach significant concentrations within the AOI, only one species of Shearwater, the Sooty Shearwater, is listed as near threatened by the IUCN (IUCN 2020). The other two species, Great Shearwater and Cory's Shearwater, have been listed as Least Concern (DFO 2020*b*).<br><br>However, given the relatively healthy global populations of Great and Sooty Shearwaters, changes to population dynamics for these species as a result of this interaction within the AOI is not expected. Therefore, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Negligible | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 1 \times 2$<br>$= 2$ (raw score) |

| | | |
|---|---|---|
| Likelihood | Rare | A study that analyzed bycatch caught during the annual halibut survey found that between 1998-2016 only 25 seabirds, from seven species, were identified as bycatch over the 18 year study period. Of the 25 birds, five individuals were identified as species of shearwater (Hurley et al. 2019).<br><br>Another study that looked more broadly at all observer records from Atlantic Canada between 1998-2011 found that shearwater bycatch rates in the Maritimes region demersal longline fishery were low overall with 0.002 shearwaters observed per 1000 hooks over the study period (Hedd et al. 2015). In this study, Shearwaters were more commonly caught as bycatch in longline sets targeting cod and Haddock than in sets targeting halibut. Observer records in the Fundian Channel AOI between 2000-2018 recorded Shearwater bycatch, including Great Shearwater (0.09% of sets) and Sooty Shearwater (0.01% of sets) (Table 2.4.4-1). Therefore likelihood was considered rare. |
| Overall risk | Low | No additional management measures suggested. |
| Uncertainty | Moderate | Shearwater entanglement in longline gear has been documented in fisheries in the Scotian shelf.<br><br>Important marine bird foraging areas were identified using available data from offshore seabird surveys. Survey coverage has been limited, and while identified foraging areas are based on occurrences, they contain a predictive component.<br><br>The overall low observer coverage for this fishery (FG <45') contributes to a low confidence level for the likelihood of interactions. As well, reporting on non-fish bycatch can be inconsistent and some entangled birds may be lost prior to hauling, so the observer record may not be comprehensive (Anderson et al. 2011). Additionally, shearwaters complete extensive migrations and have a large habitat range, therefore it is difficult to determine how one activity in one location may impact the population. |

### 2.4.5 Pelagic Longline Fishery

The Canadian large pelagic longline fishery extends from Georges Bank to the Flemish Cap, and occurs when swordfish, the main species targeted, migrate into Canadian waters (Stone and Dixon 2001). This fishery targets swordfish and other tunas (Albacore, Bigeye and Yellowfin), therefore it is in effect a multi-species fishery. Longline fishing effort generally follows swordfish movements associated with seasonal warming trends of surface water temperature (Hanke et al. 2012). Within the Fundian Channel-Browns Bank AOI, fishing effort is most heavily concentrated along the shelf edge (see Figure 2.4.5-1).

There are currently 77 pelagic longline licences in Atlantic Canada, 76 of which are in DFO Maritimes Region, and in any given year about 65-75% of them are typically active (DFO

2013*b*). Entry into this fishery is limited to the current number of licences. The majority of the vessels licensed to fish swordfish and other tunas are <45' in length, and the rest are 65' or larger.

Pelagic longline gear in Atlantic Canada consists of a monofilament mainline from which monofilament branch lines hang, each with a baited circle hook (Knapman et al. 2017). Float lines suspend the mainline at the appropriate depth (approximately seven meters), and high flyer buoys attached at either end mark the location of the gear. In order to take advantage of swordfish feeding habits, the gear is typically set during the early evening, allowed to soak overnight and then retrieved at daybreak. The length of the gear set ranges from roughly 30 to about100 km, with number of hooks per set between 600 and 1100.

Pelagic longline gear selectivity is difficult to control, apart from carefully considering the spatial and temporal habitats of the target species and fishing within those areas/time periods. It is estimated that about 45% of catch by weight is discarded within the Atlantic swordfish longline fleet (Oceana Canada 2017). A considerable proportion of catch is discarded due to the catch of non-target species, such as Blue Shark, and to some degree because of management restrictions, such as size limits (DFO 2013*b*). The survival of discarded animals is not well understood for many species, and can depend on many factors such as environmental conditions, soak time, hook location, and handling (Carruthers et al. 2009; Neilson et al. 2012). Highest among the discards in the Atlantic swordfish longline fleet by a wide margin are sharks, particularly Blue Sharks, and some interactions with turtles and cetaceans also occur (Oceana Canada 2017). Seabirds can also get hooked or entangled in pelagic longline gear, which occurs most commonly while the line is being set (Gilman et al. 2005).

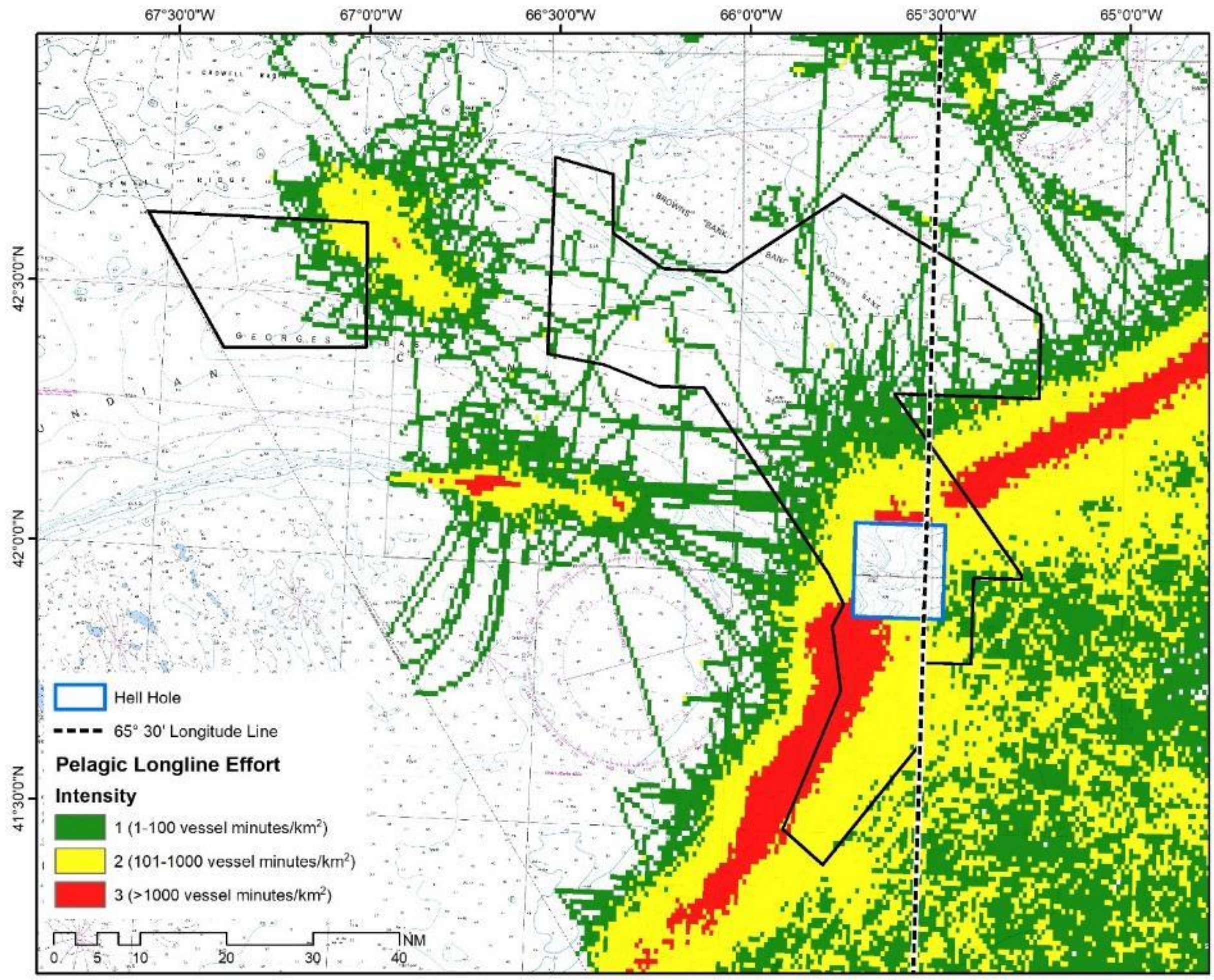


Figure 2.4.5-1. Map showing approximate fishing effort of vessels using pelagic longline gear within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent) based on Vessel Monitoring System (VMS) data from 2003 to 2018. The data were filtered to target vessels actively fishing using pelagic longline gear as per Butler et al. (2019). However, some effort from vessels using other gear types permissible under a pelagic longline licence, such as rod and reel and harpoon, are also present in the data. VMS data from within the Hell Hole (a pelagic longline closure; blue polygon) were removed as tracks were presumed to be swordfish trolling (rod and reel) or harpooning activity, or vessels transiting the area. Intensity for the fishery was classified into low (1), medium (2) or high (3) intensity categories based on a Log10 scale of vessel minutes per $km^2$. The predicted fishing extent of the pelagic longline fishery within the AOI during this time period was approximately 3090 $km^2$. The stippled vertical line indicates the 65’30’0” W longitude line; for fishing west of this line, 100% observer coverage was required prior to August 1 during 1997-1999 time period.

Existing Management Measures

Swordfish longline licence conditions are used in conjunction with licence conditions for the other tunas and together identify the authorized directed species as well as the permitted by-catch species. Pelagic longline vessels are also licensed to fish with harpoon gear, and their harpoon landings are attributed to the longline quota (DFO 2013*b*). The fishing season for pelagic longline extends year-round subject to quota availability, though fishing activity is concentrated when swordfish are in Canadian waters, which is within a May to November window. A seasonal fisheries closure called the Hell Hole exists within the AOI in the outer portion of the Fundian Channel and excludes longline gear annually from July 1st to November 30th (DFO 2013*b*). Figure 2.4.5-1 shows the VMS data removed from within the Hell Hole. However, the Hell Hole was opened to limited pelagic longline activity for the 2018 fishing season, therefore there was some longlining activity in the VMS data for this area in 2018. Since typically there is no pelagic longline activity in the Hell Hole, risk from pelagic longline within the Hell Hole was not assessed.

All licence holders are required to hail out prior to departing on a fishing trip and to hail in upon return, and all vessels are required to have VMS. Use of corrodible circle hooks is required to increase the chances of survival for released species. Dehooking/disentanglement equipment must be carried onboard for the safe handling of sea turtles. Landings of two species of shark are limited by quota caps: Porbeagle 50 t, and Blue Shark 250 t (DFO 2013*b*). A quota cap used to exist for Shortfin Mako, but the mandatory release of live Shortfin Mako caught in this fishery was made a licence condition requirement in 2018 and 2019. In 2020, licence conditions prohibited the retention of all Shortfin Mako caught in the pelagic longline fishery (C. MacDonald, DFO Resource Management, personal communication, 2021). Detailed catch and effort information for every trip must be recorded, and the weight and species of fish landed must be verified by a dockside observer. At-Sea Observer Program coverage requirements for this fishery is 10%, though the actual amount of coverage from 2005-2010 ranged from 2.8-11.4% across the Atlantic Canadian swordfish fishery (DFO 2013*b*). In more recent years (from 2017-2019), observer coverage achieved for this fishery was approximately 10% (C. MacDonald, personal communication, 2021).

The pelagic longline fishery in Canadian waters incorporates measures to help prevent entanglement, including actively tending gear, the use of lower breaking strength for the monofilament main line, monofilament leaders and buoy lines, and the required use of circle hooks (Knapman et al. 2017). Pelagic longline gear is considered actively tended, as the vessel remains with the gear while it soaks (C. MacDonald, personal communication, 2022). Active tending may mitigate severe impacts and mortality through quicker intervention to release entangled animals (Tulloch et al. 2020), though the length of gear (30-95 km), and night time deployment may limit the ability to detect and intervene. Additionally, pelagic longline gear uses monofilament main line with a breaking strength of less than 1000 lbs, and leaders and buoy lines have a breaking strength of between 300 and 400 lbs (C. MacDonald, personal communication, 2022). Ropes with lower breaking strengths increase the likelihood that whales can break free and thereby avoid immediate life threatening entanglements: breaking strengths of ≤1700 lbs could reduce the number of life-threatening entanglements for large whales by at least 72% (Knowlton et al. 2015). Additionally, amendments to the Marine Mammal Regulations in 2018 require all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018).

The practice of setting and hauling by the Canadian pelagic longline fleet minimizes the possibility of baited hooks being available during the peak feeding times for most seabirds. As swordfish are the primary target species and feed near the surface at night, gear is set in the early evening and is retrieved at daybreak (Knapman et al. 2017). Further, the use of circle hooks decreases the probability of catching seabirds (Li et al. 2012) and increases the chances of survival for released species (DFO 2013*b*).

<u>Bycatch Profile</u>

At-Sea Observer Program records from within the AOI assessment area show that a variety of shark species make up the main bycatch of this fishery by weight (see Table 2.4.5-1 to 2.4.5-3). In all pelagic longline bycatch tables, the category 'Dolphin (common)' is understood to be an error in the dataset and is actually indicating catch of Dolphinfish, or Mahi-Mahi (C. MacDonald, personal communication, 2022). From 2009-2018, Blue Sharks and Shortfin Mako Sharks were caught in 97% and 65% of observed sets, respectively. Pilot Whales were recorded in two sets (1300 kg) and Atlantic White-sided dolphin was recorded in one set (200 kg), as was a non-specified whale (400 kg). Leatherback and Loggerhead Turtles were caught in 7% and 15% of sets respectively, and seabirds were recorded within two sets.

Table 2.4.5-2 and Table 2.4.5-3 detail bycatch for 2002-2003 and 1997-1999, respectively. These time periods contain high observer levels for this fishery and are included to provide additional information on pelagic longline bycatch profiles in the Fundian Channel-Brown Bank AOI. From 2002-2003, a period with up to 50% observer coverage, Blue Sharks and Shortfin Mako Sharks were caught in 86.9% and 71% of observed sets, respectively. Dolphins (NS) were caught in 0.9% of observed sets, Leatherback and Loggerhead Turtles were caught in 10.3% and 24.3% of sets respectively, and seabirds (in this case Great Shearwaters) were recorded in 2.8% of sets. For 1997-1999, 100% observer coverage was required prior to August 1 for fishing west of the 65'30'0" W longitude line (see Figure 2.4.5-1). During this timeframe, Blue Sharks and Shortfin Mako Sharks were caught in 50.2% and 53.5% of observed sets, respectively. Pilot Whale was recorded in 0.3% of sets (500 kg). Turtles ('Tortoises and Sea Going Turtles' plus 'Hard Shell Sea Turtle NS) were caught in 8% of sets, and seabirds were recorded in 0.3% of sets.

Table 2.4.5-1. At-Sea Observer Program records from DFO's Industry Survey Database for the pelagic longline fishery in the Fundian Channel-Browns Bank AOI assessment area for 2009 to 2018. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 215.

| Species | Kept Weight (kg) | Discard Weight (kg) | # Unique Sets | % of Sets |
|---|---|---|---|---|
| Blue Shark | 0 | 137,753 | 209 | 97.21 |
| Swordfish | 171,939 | 16,515 | 207 | 96.28 |
| Shark, Sand | 0 | 12,364 | 19 | 8.84 |
| Tiger Shark | 0 | 11,949 | 38 | 17.67 |
| Bluefin Tuna | 7,853 | 6,840 | 53 | 24.65 |
| Porbeagle, Mackerel Shark | 158 | 5,221 | 30 | 13.95 |
| Shortfin Mako | 10,148 | 5,128 | 140 | 65.12 |
| Leatherback Sea Turtle | 0 | 3,734 | 16 | 7.44 |
| Basking Shark | 0 | 2,615 | 5 | 2.33 |
| Atlantic Manta | 0 | 2,316 | 8 | 3.72 |
| Loggerhead Sea Turtle | 0 | 2,301 | 33 | 15.35 |
| Ocean Sunfish | 0 | 2,061 | 17 | 7.91 |
| Atlantic Pilot Whale | 0 | 1,300 | 2 | 0.93 |
| White Marlin | 197 | 1,090 | 28 | 13.02 |
| Great Hammerhead Shark | 0 | 874 | 10 | 4.65 |

| | | | | |
|---|---|---|---|---|
| Thresher Shark | 0 | 775 | 4 | 1.86 |
| Yellowfin Tuna | 11,498 | 703 | 82 | 38.14 |
| Bigeye Tuna | 16,086 | 680 | 69 | 32.09 |
| Black Marlin | 0 | 555 | 3 | 1.40 |
| Blue Marlin | 62 | 521 | 13 | 6.05 |
| Pelagic Stingray | 0 | 521 | 39 | 18.14 |
| Dusky Shark | 0 | 470 | 4 | 1.86 |
| Whales (NS) | 0 | 400 | 1 | 0.47 |
| Tortoises and sea going turtles | 0 | 239 | 4 | 1.86 |
| Atl White Sided Dolphin | 0 | 200 | 1 | 0.47 |
| Albacore Tuna | 2,466 | 112 | 49 | 22.79 |
| Longfin Mako | 0 | 95 | 1 | 0.47 |
| Oceanic Whitetip Shark | 0 | 80 | 2 | 0.93 |
| Dolphin (common)[*] | 1,439 | 76 | 52 | 24.19 |
| Shark (NS) | 0 | 75 | 1 | 0.47 |
| Smooth, Hammerhead Shark | 0 | 30 | 1 | 0.47 |
| Longnose Lancetfish | 0 | 22 | 6 | 2.79 |
| Oilfish | 0 | 7 | 1 | 0.47 |
| Greater Shearwater[14] | 0 | 4 | 1 | 0.47 |
| Remora | 0 | 4 | 2 | 0.93 |
| Monkfish, Goosefish, Angler | 0 | 3 | 1 | 0.47 |
| Northern Gannet | 0 | 3 | 1 | 0.47 |
| Lined Seahorse | 0 | 1 | 1 | 0.47 |
| Wahoo | 108 | 0 | 4 | 1.86 |
| **Total** | **221,954** | **217,637** | **N/A** | **N/A** |

Table 2.4.5-2. At-Sea Observer Program records from DFO's Industry Survey Database for the pelagic longline fishery in the Fundian Channel-Browns Bank AOI assessment area for 2002 to 2003, a period of up to 50% observer coverage. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 107.

| **Species** | **Kept Weight (kg)** | **Discard Weight (kg)** | **# Unique Sets** | **% of Sets** |
|---|---|---|---|---|
| Blue Shark | 0 | 42,589 | 93 | 86.9 |
| Leatherback Sea Turtle | 0 | 6,456 | 11 | 10.3 |
| Swordfish | 53,387 | 5,494 | 105 | 98.1 |
| Bluefin Tuna | 4,849 | 4,299 | 32 | 29.9 |
| Loggerhead Sea Turtle | 0 | 3,530 | 26 | 24.3 |
| Ocean Sunfish | 0 | 1,190 | 8 | 7.5 |
| Porbeagle, Mackerel Shark | 0 | 1,002 | 16 | 15.0 |
| Black Marlin | 0 | 905 | 3 | 2.8 |
| Tiger Shark | 0 | 790 | 8 | 7.5 |
| White Marlin | 141 | 777 | 21 | 19.6 |
| Pelagic Stingray | 0 | 644 | 56 | 52.3 |
| Bigeye Tuna | 21,708 | 586 | 68 | 63.6 |

[*] This category is indicating catch of Dolphinfish, or Mahi Mahi, and is an error in the dataset.

[14] This was recorded as Greater Shearwater, however it should be noted the correct name is Great Shearwater.

| | | | | |
|---|---|---|---|---|
| Albacore Tuna | 23,005 | 454 | 71 | 66.4 |
| Shortfin Mako | 4,171 | 438 | 76 | 71.0 |
| Yellowfin Tuna | 17,924 | 294 | 73 | 68.2 |
| Green Sea Turtle | 0 | 200 | 2 | 1.9 |
| Thresher Shark | 380 | 183 | 3 | 2.8 |
| Atlantic Manta | 0 | 160 | 1 | 0.9 |
| Longnose Lancetfish | 0 | 143 | 14 | 13.1 |
| Dolphins (NS) | 0 | 100 | 1 | 0.9 |
| Tunas, Swordfishes, etc. | 0 | 100 | 1 | 0.9 |
| Kemps Ridley Sea Turtle | 0 | 75 | 1 | 0.9 |
| Rays (NS) | 0 | 70 | 1 | 0.9 |
| Escolar | 0 | 45 | 1 | 0.9 |
| Dolphin (Common)[*] | 2,035 | 23 | 48 | 44.9 |
| Oilfish | 0 | 14 | 2 | 1.9 |
| Greater Shearwater[15] | 0 | 7 | 3 | 2.8 |
| Striped Bonito/Skipjack | 0 | 4 | 2 | 1.9 |
| Blue Marlin | 45 | 0 | 2 | 1.9 |
| **Total** | **127,645** | **70,572** | **N/A** | **N/A** |

Table 2.4.5-3. At-Sea Observer Program records from DFO's Industry Survey Database for the pelagic longline fishery in the Fundian Channel-Browns Bank AOI assessment area for 1997 to 1999, a period where 100% at sea observer coverage was required for pelagic longline vessels fishing west of the 65'30'0" W longitude line before Aug 1st. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 301.

| **Species** | **Kept Weight (kg)** | **Discard Weight (kg)** | **# Unique Sets** | **% of Sets** |
|---|---|---|---|---|
| Blue Shark | 741 | 157,535 | 151 | 50.2 |
| Swordfish | 133,106 | 7,315 | 270 | 89.7 |
| Bluefin Tuna | 48,569 | 5,393 | 61 | 20.3 |
| Tortoises and sea going turtles | 0 | 2,130 | 23 | 7.6 |
| White Marlin | 1,366 | 967 | 35 | 11.6 |
| Shortfin Mako | 9376 | 958 | 161 | 53.5 |
| Longnose Lancetfish | 0 | 890 | 41 | 13.6 |
| Blue Marlin | 1,510 | 777 | 45 | 15.0 |
| Tiger Shark | 0 | 664 | 11 | 3.7 |
| Pelagic Stingray | 0 | 651 | 65 | 21.6 |
| Atlantic Pilot Whale | 0 | 500 | 1 | 0.3 |
| Yellowfin Tuna | 10,108 | 449 | 152 | 50.5 |
| Porbeagle, Mackerel Shark | 46,341 | 223 | 20 | 6.6 |
| Hard Shell Sea Turtle NS | 0 | 218 | 1 | 0.3 |
| Bigeye Tuna | 19,316 | 128 | 80 | 26.6 |
| Albacore Tuna | 14,750 | 74 | 75 | 24.9 |
| Wahoo | 6 | 51 | 3 | 1.0 |

[*] This category is indicating catch of Dolphinfish, or Mahi Mahi, and is an error in the dataset.

[15] This was recorded as Greater Shearwater, however it should be noted the correct name is Great Shearwater.

| | | | | |
|---|---|---|---|---|
| Dolphin(Common)* | 1,184 | 48 | 64 | 21.3 |
| Finfishes (NS) | 0 | 26 | 2 | 0.7 |
| Oilfish | 0 | 23 | 2 | 0.7 |
| Bigscale Pomfret | 0 | 6 | 1 | 0.3 |
| Monkfish, Goosefish, Angler | 0 | 2 | 1 | 0.3 |
| Double-Crested Cormorant | 0 | 1 | 1 | 0.3 |
| Atlantic Pomfret | 2 | 0 | 1 | 0.3 |
| Black Marlin | 479 | 0 | 3 | 1.0 |
| Escolar | 7 | 0 | 1 | 0.3 |
| Opah | 4,229 | 0 | 23 | 7.6 |
| Thresher Shark | 32 | 0 | 1 | 0.3 |
| **Total** | **291,122** | **179,029** | **N/A** | **N/A** |

**Risk Assessment – Pelagic longline fishery and beaked whale habitat**

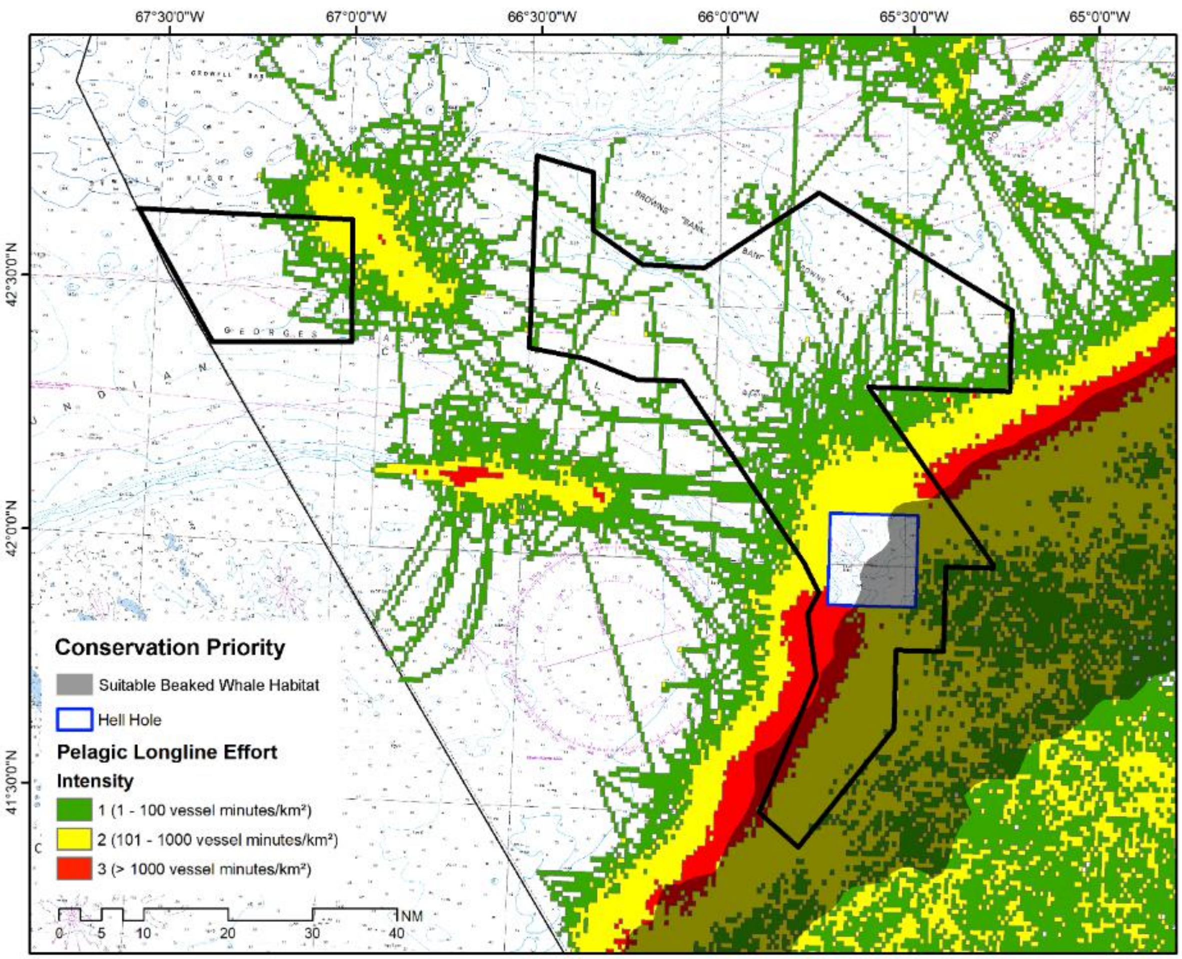


Figure 2.4.5-2. Overlap of extent of suitable beaked whale habitat with approximate fishing footprint of vessels using pelagic longline gear within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Intensity for the fishery was

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* This category is indicating catch of Dolphinfish, or Mahi Mahi, and is an error in the dataset.

classified into low (1), medium (2) or high (3) intensity categories based on a Log10 scale of vessel minutes per $km^2$ using available Vessel Monitoring System (VMS) data from 2003 to 2018. VMS data from within the Hell Hole (a pelagic longline closure) were removed as tracks were presumed to be swordfish trolling (rod and reel) or harpooning activity.

**Risk Statement**: There is a risk that entanglement in pelagic longline gear will lead to negative impacts to beaked whales in their suitable habitat within the AOI.

Table 2.4.5-4. Scoring for the risk posed by the pelagic longline fishery to beaked whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 5 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 3 x 3<br>= 18 (raw score) |
| Intensity | 2 | Based on available VMS data for the pelagic longline fishery in the assessment area, the average intensity of the fishery where it intersects with the extent of suitable beaked whale habitat in the AOI is considered moderate. |
| Temporal | 3 | Beaked whales occur within the AOI year-round. The season for the pelagic longline fishery is open year-round; however, swordfish, the main species targeted for this fishery, only occur in Canadian waters from May through November (Stone and Dixon 2001). This aligns with logbook data from 2008-2017 within the AOI assessment area showing that activity for this fishery occurred within a May to November window. Therefore there is potential temporal overlap of up to seven months of the year. |
| Spatial | 3 | There is widespread spatial overlap (85.6%) between the pelagic longline fishery footprint and the extent of suitable beaked whale habitat within the AOI. |
| $Q_{Sensitivity}$ | 3 | Of the beaked whale species known to occur in and around the AOI (see Chapter 1, Section 1.4.3), more information is known about Sowerby's Beaked Whales and Northern Bottlenose Whales in terms of population status and threats. The information below therefore focuses mainly on these two species.<br><br>Entanglement in fishing gear is listed as a threat for both Sowerby's Beaked Whales (Special Concern – SARA) and Northern Bottlenose Whales, Scotian Shelf population (Endangered – SARA) (DFO 2016; DFO 2017*a*; DFO 2017*c*; DFO 2022).<br><br>Both Northern Bottlenose Whales and Sowerby's Beaked Whales are long-lived species that reproduce at a low rate, similar to other beaked whale species (DFO 2016; DFO 2017*c*). This low reproductive rate may limit a population's ability to adapt to or recover from disturbance (COSEWIC 2019). The Scotian Shelf population of Northern Bottlenose Whales is estimated at roughly 175 individuals (Feyrer 2021). Although the population is still |

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| | | considered Endangered and was declining up to 2004, recent estimates indicate this trend has since reversed and the population now appears to be increasing since at least 2010 (Feyrer 2021). However, this population has a potential biological removal (PBR: the maximum number of non-natural mortalities that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) of 0.3 individuals per year (DFO 2007*b*; DFO 2010*c*). This means that the level of allowable harm for this population is low (DFO 2016).<br><br>In addition to direct mortality from fishing gear entanglement, there is the possibility that whales break free from entanglement (potentially with gear attached) (Feyrer et al. 2021). Whales that survive the entanglement event but escape with injuries may still experience long-term health impacts, which can also result in population level impacts (Dolman and Brakes 2018). These can include stress responses (Pettis et al. 2004), compromised immune responses (Cassoff et al. 2011), and cumulative loss of body condition and constriction of body parts, with or without secondary infection that may impact health and fecundity even after gear is no longer attached (Moore and van der Hoop 2012).<br><br>There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). Scarring analysis conducted on Northern Bottlenose Whales found that the majority of anthropogenic scars (57%) were considered low to moderate severity, and 16% were considered severe injuries; however, scarring analysis does not account for cryptic mortalities (Feyrer et al. 2021). In general, a fishing hook embedded in the head of an odontocetes is anticipated to have more severe impact compared to a larger baleen whale (NMFS 2012). The ingestion of gear or hooks and entanglement with trailing gear are also considered serious injuries for odontocetes (Angliss and DeMaster 1997; NMFS 2012). Depending on multiple factors such as the animal's body size relative to the gear and the species' sensitivity, loose gear may have the potential to become a serious injury (NMFS 2012). In addition, odontocetes may tire quickly as a result of their small body size, impacting their ability to reach the surface to breathe, and possibly leading to myopathy.<br><br>Pelagic longline gear is actively tended, which may mitigate severe impacts and mortality through quicker intervention to release entangled animals (Tulloch et al. 2020), though the length of gear (30-95 km), and night time deployment may limit the ability to detect and intervene. Additionally, pelagic longline gear used in Canadian waters incorporates measures to reduce entanglement severity, including the use of monofilament lines with lower breaking strengths, which could reduce instances of |

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| | | drowning from entanglement (Knowlton et al. 2015). However, impacts from remnant gear (e.g., hooks) and damage sustained during the escape are still possible, as noted above.<br><br>Considering the population size, status and low reproduction rate of the more at-risk beaked whale populations that can occur within the AOI, entanglement in pelagic longline gear could result in a detectable change in population size. However, there is no available data that suggests entanglement within the AOI by this gear type is exceeding the maximum sustainable level nor adversely impacting long-term recruitment dynamics. Taken together, a sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 5 \times 3$<br>$= 15$ (raw score) |
| Likelihood | Rare | Odontocetes, including Northern Bottlenose Whales, have been shown to be attracted to fisheries bait or catch and can be caught on the hooks of pelagic longline gear (Angliss and DeMaster 1997; Gilman et al. 2006; Werner et al. 2015; Fader et al. 2021). Northern Bottlenose Whales are generally attracted to vessels, and in some areas demonstrate opportunistic associations with fishing vessels to feed on discards (e.g., Johnson et al. 2020).<br><br>Beaked whale entanglement incidents in fishing gear in Atlantic Canada are rarely observed. However, there have been some direct observations of entanglements (described below), and additional evidence of interactions through scarring analysis (Feyrer et al. 2021). Of the beaked whale species that occur within the AOI, information related to entanglements mainly exists for Northern Bottlenose Whales and Sowerby's Beaked Whales.<br><br>There were ten reports of Northern Bottlenose Whale entanglement in fishing gear since 1981 impacting the Scotian Shelf population (Harris et al. 2013; Themelis et al. 2016; Feyrer et al. 2021) with two events attributed to pelagic longline gear (Harris et al. 2013). Additionally, two entangled Sowerby's Beaked Whales were observed in the Gully MPA in 2013, but it is not known from which fishery the gear originated (Narazaki 2013 as cited in DFO 2017*c*).<br><br>Given the low probability of these events being observed due to factors such as their offshore location (Whitehead and Hooker 2012; DFO 2022), the records of beaked whale entanglements described above are considered low estimates of actual occurrence. Entanglement scars have been observed on Northern Bottlenose Whales and Sowerby's Beaked Whales on the Scotian Shelf (Whitehead et al. 1997; DFO 2017*c*), suggesting that interactions with fishing gear occur more frequently than observed (DFO |

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| | | 2010*c*; Feyrer et al. 2021). Scarring evidence indicates Northern Bottlenose Whale interactions with fishing gear and propeller-vessel strikes occurs at a rate of 1.7 individuals per year (Feyrer et al. 2021).<br><br>While there is potential for beaked whale entanglement in pelagic longline gear within the AOI, based on available information, the likelihood was estimated as rare. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) to address risks from this pressure, including gear modifications (e.g., bait choice, adjusted fishing methods, etc.) or restrictions where this fishery overlaps with suitable beaked whale habitat within the future MPA. |
| Uncertainty | High | Since 2018, amendments to the Marine Mammal Regulations have required all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018). However, entanglement events may go unwitnessed. As well, entanglement scarring for beaked whales does not generally provide a clear link to fishing gear type. The potential for larger animals to break free from the gear before being noticed and recorded by observers can further limit the comprehensiveness of this data source. As a result, observer data are limited in their ability to approximate rates of cetacean bycatch and entanglement.<br><br>Additionally, as noted above, mortality may not be immediate, as entangled animals may die of sublethal effects such as starvation or infection at some future date (Pettis et al. 2004; Moore and van der Hoop 2012) and some animals eventually sink when they die (Moore 2014). There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). These factors obscure knowledge of entanglement-related mortality.<br><br>Beaked whale suitable habitat was defined using available data from visual detections, acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited. There is also uncertainty associated with the use of this area for Northern Bottlenose Whales in particular, given that it is toward the southern extent of their range. |

**Risk Assessment – Pelagic longline fishery and shallow-diving pursuit generalists (shearwaters)**

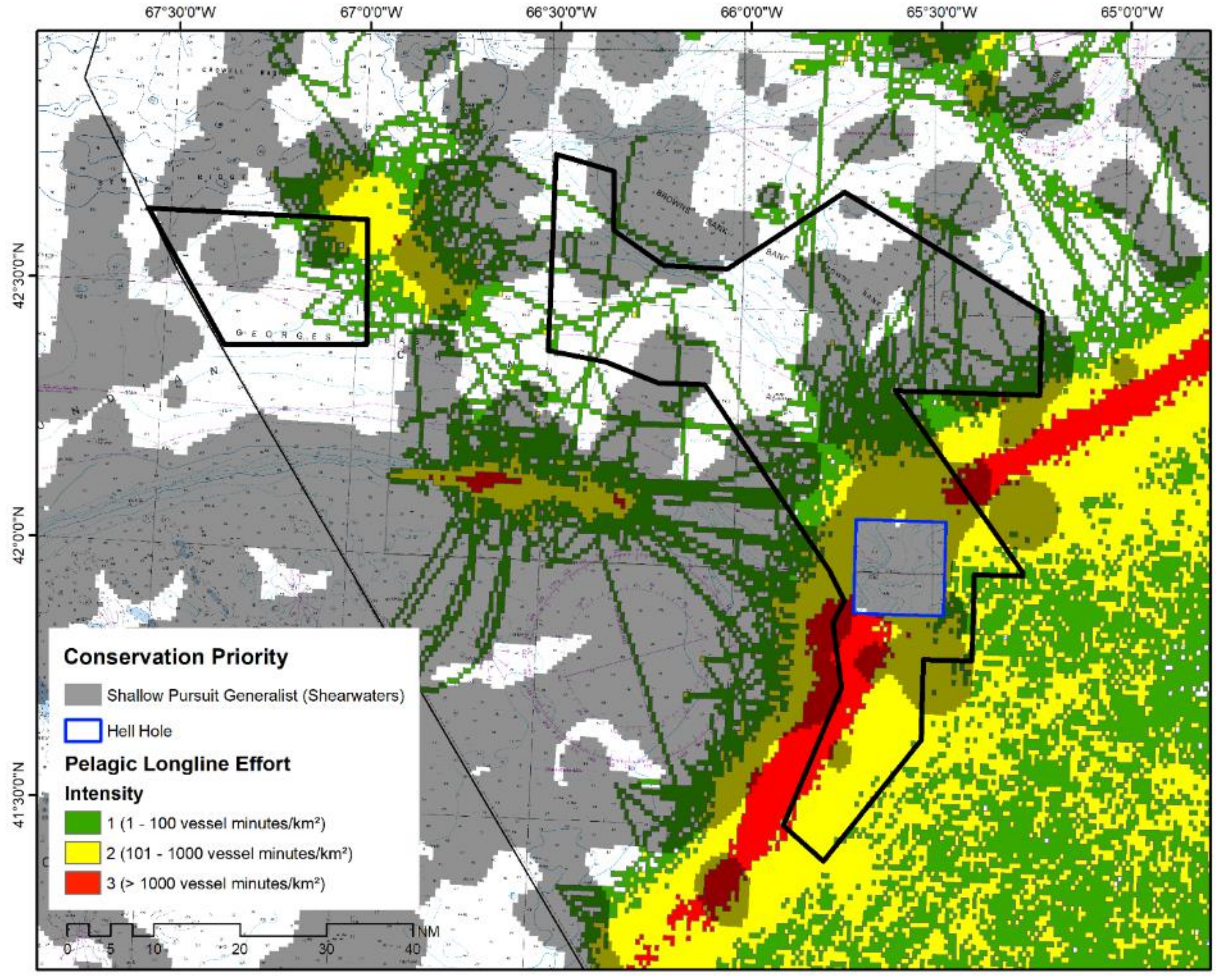


Figure 2.4.5-3. Overlap of shallow-diving pursuit generalists (shearwaters) with approximate fishing footprint of vessels using pelagic longline gear within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent). Intensity for the fishery was classified into low (1), medium (2), or high (3) intensity categories based on a Log10 scale of vessel minutes per $km^2$ using available Vessel Monitoring System (VMS) data from 2003 to 2018. VMS data from within the Hell Hole (a pelagic longline closure) were removed as tracks were presumed to be swordfish trolling (rod and reel) or harpooning activity.

**Risk Statement**: There is a risk that bycatch in the pelagic longline fishery will lead to negative impacts to shearwaters in their foraging habitat within the AOI.

Table 2.4.5-5. Scoring for the risk posed by the pelagic longline fishery to shearwaters within the AOI.

| Risk factor | Score | Rationale |
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| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 3 x 2<br>= 12 (raw score) |

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| Intensity | 2 | Based on available VMS data for the pelagic longline fishery in the assessment area, the average intensity of the fishery where it intersects with the predicted extent of shearwater foraging habitat in the AOI is considered moderate. |
| Temporal | 3 | Shearwaters are present in highest numbers on the Scotian Shelf from May through November to forage and the pelagic longline fishery is open year-round. However, swordfish, the main species targeted for this fishery, only occur in Canadian waters from May through November (Stone and Dixon 2001). This aligns with logbook data from 2008-2017 within the AOI assessment area showing that activity for this fishery occurred within a May to November window. Therefore there is potential temporal overlap of up to seven months of the year. |
| Spatial | 2 | There is localized spatial overlap (44%) between the pelagic longline fishery footprint and predicted shearwater foraging habitat within the AOI. |
| $Q_{Sensitivity}$ | 2 | Shearwaters are shallow diving pursuit generalists that feed mainly on fish and squid. Shearwaters are known to be attracted to fishing vessels and to interact with fishing gear, largely during setting and hauling (Anderson et al. 2011). Birds that tend to scavenge on the surface are most susceptible to being hooked or entangled, such as albatrosses, petrels, shearwaters, gulls and skuas (Brothers et al. 1999).<br><br>When longline gear is first set, baited hooks float on the surface and are available to foraging seabirds attracted to the vessel (Løkkeborg 2008). During this time, seabirds may attack the baited hooks or collide with the line and become hooked or entangled, resulting in drowning when the longline sinks. Seabirds may also dive down to attack baited hooks that have already sunk, and more rarely, seabirds could become hooked when gear is being hauled (Løkkeborg 2008). Injury and eventual death from swallowing hooks is also possible (Bugoni et al. 2008). Birds can also be attracted to vessels due to fisheries discards, and this can result in altered foraging behaviours as well as additional entanglements (Tasker et al. 2000).<br><br>Globally, mortality in longline fisheries is considered a critical threat to seabirds in the Procellariidae family (including shearwaters; Gilman et al. 2005). Pelagic longline has been shown to impact shearwater populations in other parts of the world, for example, it is estimated that 4-6% of Cory's Shearwater breeding population in the Mediterranean is killed annually in this fishery (Cooper et al. 2003). In eastern Canada, the highest seabird bycatch rates are in the pelagic longline fishery, particularly along Scotian Shelf during the summer and autumn (Hedd et al. 2015).<br><br>The pelagic longline fishery reduces severity of Shearwater entanglements through use of circle hooks, which decrease the |

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| | | probability of catching seabirds (Li et al. 2012) and increase the chances of survival for released species (DFO 2013*b*).<br><br>Compared to other seabird species, Shearwaters reproduce slowly, so loss of adults could have impacts to a population (Anderson et al. 2011). Of the species shown to reach significant concentrations within the AOI, only one species of Shearwater, the Sooty Shearwater, is listed as near threatened by the IUCN (IUCN 2020). The other two species, Great Shearwater and Cory's Shearwater, have been listed as Least Concern (DFO 2020*b*).<br><br>However, given the relatively healthy global populations of Great and Sooty Shearwaters, changes to population dynamics for these species as a result of this interaction within the AOI was considered unlikely. Therefore, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 2$<br>$= 8$ (raw score) |
| Likelihood | Rare | Shearwaters more commonly feed during the day, with peak foraging activity reported at dusk and dawn for both Great and Sooty Shearwater (Shaffer et al. 2009; Ronconi et al. 2010). Swordfish pelagic longline gear is set in the evening and haul back begins prior to dawn. reducing temporal overlap with peak Shearwater feeding periods. Setting longlines at night to avoid daytime and dusk feeding activity has been a common strategy to mitigate seabird impacts generally, and has proved effective for certain species groups (Løkkeborg 2008).<br><br>Shearwaters were recorded in 0.5% of observed sets from 2009 to 2018 (Table 2.4.5-1), 2.8% of sets recorded during the period of 50% coverage (2002-2003; Table 2.4.5-2), and no Shearwater records were noted in the earlier period of high observer coverage from 1997-1999 (Table 2.4.5-3) within the assessment area. Taken together, a likelihood of less than 5% (rare) was assigned. |
| Overall risk | Moderate | No additional management measures suggested. |
| Uncertainty | High | The observed bycatch profile from two time periods when observer coverage was exceptionally high show similar species and trends when compared to the 2009-2018 dataset. However, reporting on non-fish bycatch can be inconsistent.<br><br>Very little is known about total seabird bycatch from pelagic longlining in the Western North Atlantic (Zhou et al. 2019). This is because seabird bycatch is typically only recorded by observers during hauling, and birds hooked during gear setting may drop off the hook due to mechanical action or predation (Anderson et al. 2011; Zhou et al. 2019). It has been estimated that only half of all birds caught during longline gear setting are retrieved when the line |

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| | | is hauled (Brothers 2008 as cited in Anderson et al. 2011; Lebreton and Véran 2013).<br><br>Important marine bird foraging areas were identified using available data from offshore seabird surveys. Survey coverage has been limited, and while identified foraging areas are based on occurrences, they contain a predictive component.<br><br>As well, shearwaters complete extensive migrations and have a large habitat range, therefore it is difficult to determine how one activity in one location may impact the population. |

### 2.4.6 Buoy Gear Fishery

Buoy gear is a type of free floating, actively tended fishing gear used to target swordfish. Buoy gear was added to allow pelagic longline licence holders additional flexibility to harvest their individual allocation as opposed to longline fishing. This is a new gear type within DFO Maritimes Region and has been added to licence conditions for the pelagic longline fleet beginning in 2021. An evaluation of the general effectiveness of this new gear type in terms of catch and bycatch will be completed based on at sea observer coverage once the number of samples is sufficient. Of the 77 pelagic longline licences in Atlantic Canada, between 8 - 15 licence holders will use this new gear during the swordfish fishing season (C. MacDonald, personal communication, 2023).

A buoy gear set consists of two to three baited hooks supported by three to four buoys at the surface, which include a bite indicator buoy that goes under water when a fish bites, a float buoy for the fish to pull against when caught, a high flyer to assist in finding the gear (some licence holders may use AIS buoys), and an optional handling buoy that would be gaffed for gear retrieval (see Figure 2.4.6-1) (Kerstetter and Bayse 2009; C. MacDonald, personal communication, 2021). All of the buoys are attached to a monofilament mainline that is also attached to the baited hooks (Kerstetter and Bayse 2009). The total length of the horizontal part of the mainline (from the first buoy to the last) would be approximately 15-21 meters if the four buoys are used, and approximately 10-14 meters if three buoys are used (C. MacDonald, personal communication, 2021). Typically two hooks are set deep and a third hook can be added higher in the water column near the thermocline. This deep-set gear enables fishers to set their hooks at 250-350 meters to reach swordfish at depths where they commonly feed during the day (Oceana 2017; NOAA 2021). Up to 20 buoy gear sets are authorized for daily use; therefore up to 60 hooks may be fished per day. Relative to a vessel fishing with pelagic longline (which may use up to approximately 1000 hooks per day), the spatial footprint for this gear is much smaller. Illumination may be used as part of the gear set-up, including the use of deep drop LED fishing lights. At-sea observers deployed in 2021 will be documenting buoy gear equipment set-up within the region (C. MacDonald, personal communication, 2021).

Vessels fishing with buoy gear actively tend buoys, steaming back and forth along the sets to monitor the gear, check for fish, and change bait as necessary (C. MacDonald, personal communication, 2021). In absence of any sign of fish strikes, each buoy is generally retrieved every two to three hours to check bait status (Romanov et al. 2013). The bite indicator buoys allow licence holders to retrieve their catch within minutes when a fish is on a hook (PEW 2015;

Oceana 2017). As fish are hooked, they are hauled and the hooks are rebaited and buoys are reset. All buoy gear is retrieved and taken onboard the vessel upon conclusion of a trip.

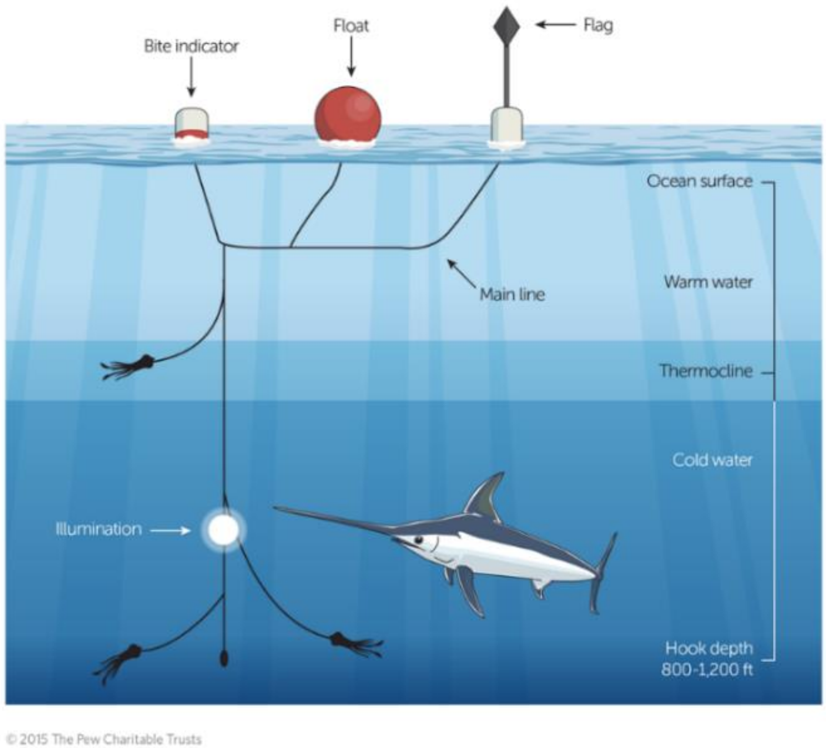


Figure 2.4.6-1. Example buoy gear set-up from PEW (2015). Actual gear set-up within DFO Maritimes Region may vary from this depiction.

As this is a new gear type within DFO Maritimes Region, no data are available to indicate the spatial footprint of vessels fishing with this gear. For this assessment, the pelagic longline licence spatial footprint (plus the Hell Hole) is used as a proxy to indicate where this gear may be used, although the true spatial extent for buoy gear is anticipated to be much smaller based on the lower number of licence holders using the gear and smaller gear footprint (see Figure 2.4.6-2).

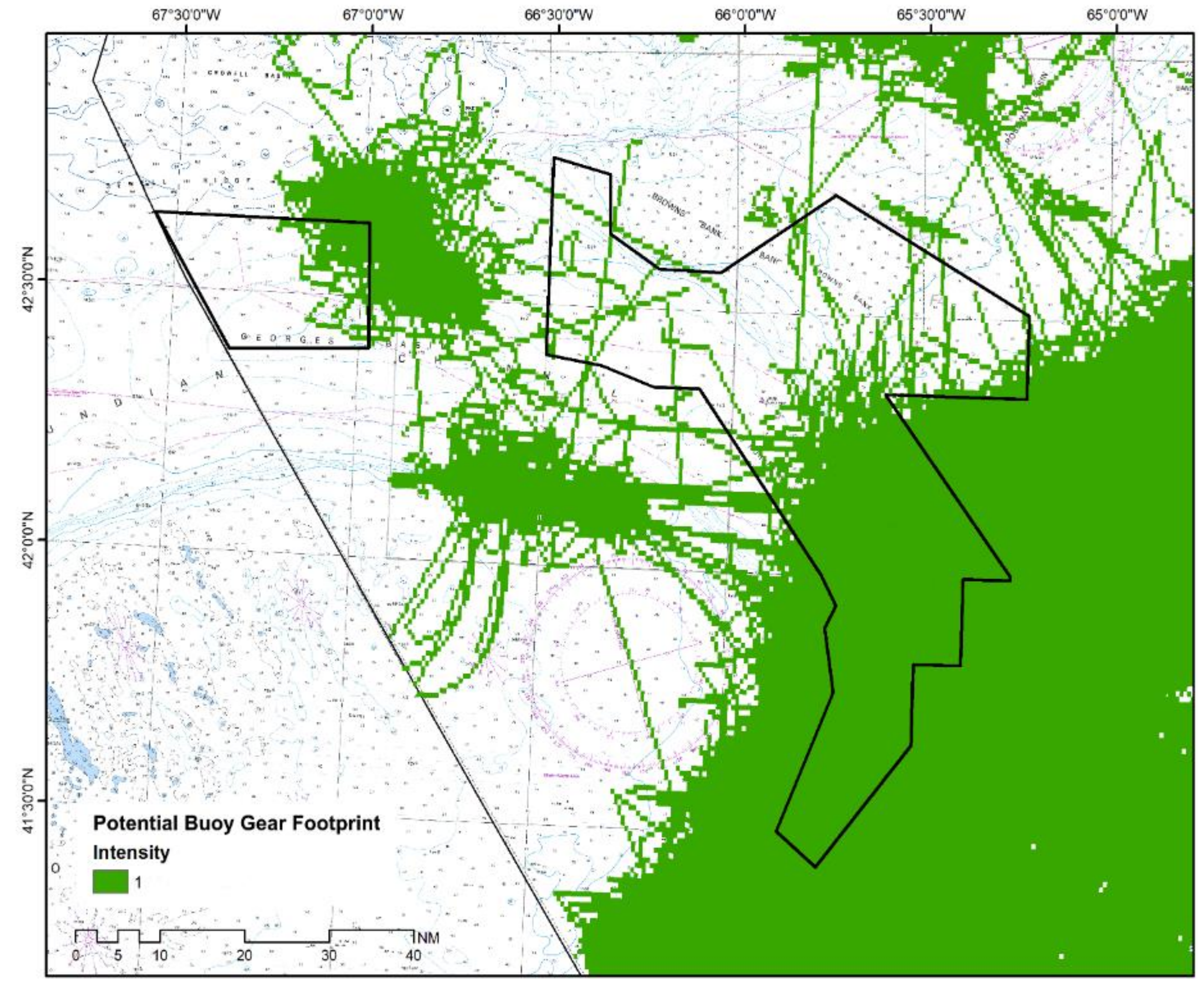


Figure 2.4.6-2. Map showing potential fishing footprint of vessels using buoy gear within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) assessment area (map extent) based on use of pelagic longline licence Vessel Monitoring System (VMS) data from 2003 to 2018 as a proxy. Actual buoy gear spatial footprint is likely much smaller due to fewer licence holders using this gear and smaller gear footprint compared to pelagic longline. As a novel gear type, intensity data for the fishery are not currently available. Intensity was uniformly classified as low (1).

Existing Management Measures

Buoy gear has been added to licence conditions for the pelagic longline fleet. Therefore, vessels using this gear must adhere to the general Canadian Atlantic swordfish longline conditions, as well as specific buoy gear conditions. Buoy gear operators are prohibited from deploying more than 20 individual buoy gears per vessel per day, and a single buoy gear deployment may have a maximum of three hooks. Further, corrodible circle hooks must be used to reduce post-release mortality and a strike detection buoy must be incorporated into buoy gear design to reduce the amount of time non-target species are likely to be on the line. A VMS is not required when only using buoy gear; however, the presence of any pelagic longline gear on board the vessel will constitute a longline trip and VMS must be operating for that trip. At-Sea Observer Program coverage requirements for this fishery is 10%. For additional management measures applicable to all pelagic longline licences, see Section 2.4.5.

Bycatch Profile

As buoy gear is a new fishing gear type in this region, no bycatch data from the At-Sea Observer Program are currently available. Bycatch profiles from buoy gear fisheries operating in the United States would indicate that bycatch for this gear type is fairly low (Romanov et al. 2013; Sepulveda et al. 2014; Oceana 2015; Oceana 2017; NOAA 2021). United States research shows that swordfish compose between 80.7 to 92% of total catches (Bayse and Kerstetter 2010; Romanov et al. 2013; Oceana 2017; Sepulveda and Aalbers 2018; NOAA 2021), with remaining bycatch mainly consisting of species such as bigeye thresher sharks, opah, and other shark species (Oceana 2017; NOAA 2021). Additionally, due to the active tending of buoy gear, bycatch is released fairly quickly, with estimated time between initiation of haul back to bycatch release ranging from 8-20 minutes (Sepulveda et al. 2019). As a result, survival rates of released bycatch are expected to be high, with reported ranges from 86 to 93% survival (Romanov et al. 2013; Oceana 2015; Sepulveda et al. 2019). In the United States buoy gear fishery, limited interaction with species of concern, such as cetaceans, have been observed: reports from both the California and Atlantic fisheries have indicated that no marine mammals, birds, or sea turtles were killed or seriously injured (Oceana 2015; NOAA 2018; NOAA 2021). Risk assessments conducted by the National Oceanic and Atmospheric Administration’s National Marine Fisheries Service in the United States have determined the likelihood of buoy gear injuring marine mammals and protected species to be remote (NMFS 2013; Oceana 2015; NOAA 2018).

**Risk Assessment – Buoy gear and beaked whale habitat**

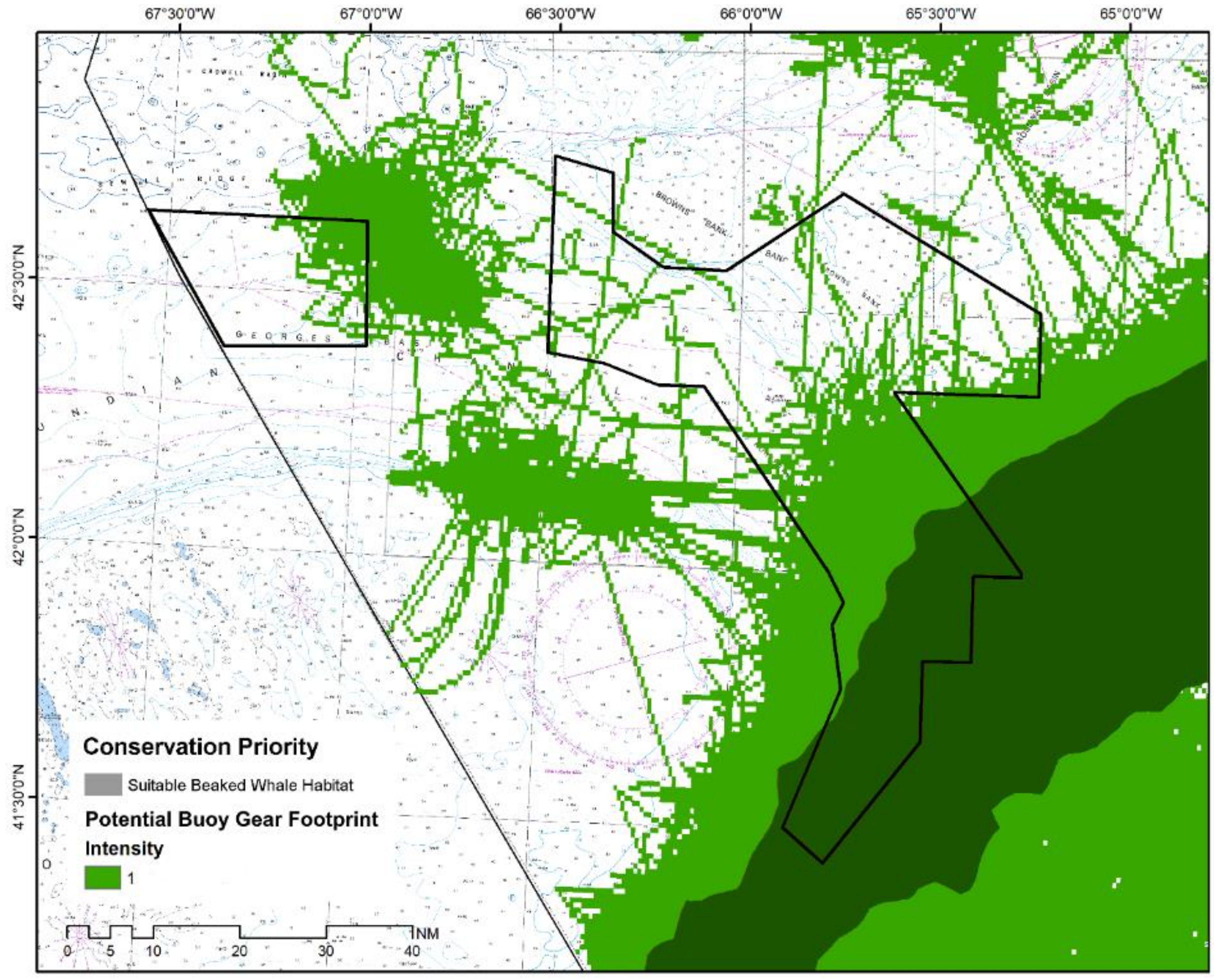


Figure 2.4.6-3. Overlap of suitable beaked whale habitat with potential fishing footprint of vessels using buoy gear within the Fundian Channel-Browns Bank Area of Interest (AOI). Pelagic longline licence Vessel Monitoring System (VMS) data from 2003 to 2018 were used as a proxy for areas potentially fished with buoy gear. Actual buoy gear spatial footprint is likely much smaller due to fewer licence holders using the gear and smaller gear footprint compared to pelagic longline. As a novel gear type, intensity data for the fishery is not currently available. Intensity was uniformly classified as 1.

**Risk Statement:** There is a risk that entanglement in buoy gear will lead to negative impacts on beaked whales in their suitable habitat within the AOI.

Table 2.4.6-1. Scoring for the risk posed by buoy gear to beaked whales within the AOI.

| Risk factor | Score | Rationale |
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| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 3<br>= 9 (raw score) |
| Intensity | 1 | Data from the United States show buoy gear daily soak times varied based on the vessel and season; however, annual averages ranged from 6.3 - 7.6 hr/set (Sepulveda and Aalbers 2018). Based on an |

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| | | anticipated 10 licence holders that will use buoy gear in the region as well as shorter gear deployment times, smaller number of hooks used per day, and shorter monofilament line compared to pelagic longline gear (C. MacDonald, personal communication, 2021), the average intensity of the fishery where it intersects with the extent of suitable beaked whale habitat in the AOI is anticipated to be low. |
| Temporal | 3 | Beaked whales occur within the AOI year-round. Use of buoy gear is likely occurring within a similar timeframe to pelagic longline operations (May through November), following when swordfish can be found within Canadian waters. Therefore, there is potential temporal overlap of up to seven months of the year. |
| Spatial | 3 | The use of buoy gear is permitted anywhere pelagic longline fishing may occur, as well as within the Hell Hole. As such, buoy gear activity may be occurring in any of the green areas shown in Figure 2.4.6-3, resulting in high spatial overlap with suitable beaked whale habitat. Although it is unlikely in practice that buoy gear will occupy this full spatial extent, a score of three (widespread spatial overlap) was assigned using a precautionary approach. |
| $Q_{Sensitivity}$ | 2 | Of the beaked whale species known to occur in and around the AOI (see Chapter 1, Section 1.4.3), more information is known about Sowerby's Beaked Whales and Northern Bottlenose Whales in terms of population status and threats. The information below therefore focuses mainly on these two species.<br><br>Entanglement in fishing gear is listed as a threat for both Sowerby's Beaked Whales (Special Concern – SARA) and Northern Bottlenose Whales, Scotian Shelf population (Endangered – SARA) (DFO 2016; DFO 2017*a*; DFO 2017*c*; DFO 2022).<br><br>Both Northern Bottlenose Whales and Sowerby's Beaked Whales are long-lived species that reproduce at a low rate, similar to other beaked whale species (DFO 2016; DFO 2017*c*). This low reproductive rate may limit a population's ability to adapt to or recover from disturbance (COSEWIC 2019). The Scotian Shelf population of Northern Bottlenose Whales is estimated at roughly 175 individuals (Feyrer 2021). Although the population is still considered Endangered and was declining up to 2004, recent estimates indicate this trend has since reversed and the population now appears to be increasing since at least 2010 (Feyrer 2021). However, this population has a potential biological removal (PBR: the maximum number of non-natural mortalities that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) of 0.3 individuals per year (DFO 2007*b*; DFO 2010*c*). This means that the level of allowable harm for this population is low (DFO 2016).<br><br>In addition to direct mortality from fishing gear entanglement, there is the possibility that whales break free from entanglement |

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| | | (potentially with gear attached) (Feyrer et al. 2021). Whales that survive the entanglement event but escape with injuries may still experience long-term health impacts, which can also result in population level impacts (Dolman and Brakes 2018). These can include stress responses (Pettis et al. 2004), compromised immune responses (Cassoff et al. 2011), and cumulative loss of body condition and constriction of body parts, with or without secondary infection that may impact health and fecundity even after gear is no longer attached (Moore and van der Hoop 2012).<br><br>There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). Scarring analysis conducted on Northern Bottlenose Whales found that the majority of anthropogenic scars (57%) were considered low to moderate severity, and 16% were considered severe injuries; however, scarring analysis does not account for cryptic mortalities (Feyrer et al. 2021). In general, a fishing hook embedded in the head of an odontocetes is anticipated to have more severe impact compared to a larger baleen whale (NMFS 2012). The ingestion of gear or hooks and entanglement with trailing gear are also considered serious injuries for odontocetes (Angliss and DeMaster 1997; NMFS 2012). Depending on multiple factors such as the animal's body size relative to the gear and the species' sensitivity, loose gear may have the potential to become a serious injury (NMFS 2012). In addition, odontocetes may tire quickly as a result of their small body size, impacting their ability to reach the surface to breathe, and possibly leading to myopathy.<br><br>In general, survival rates of released fish bycatch are expected to be high for buoy gear (86-93% survival documented for released swordfish and bigeye thresher sharks) (Romanov et al. 2013; Oceana 2015; Sepulveda et al. 2019). Since no documented interactions with cetaceans have occurred in the United States fishery to date (NOAA 2021), survival rates for buoy gear/cetacean interactions do not currently exist. However, as this gear type is actively tended, entangled whales can be released fairly quickly, with estimated time between haul back initiation to release of entangled animals ranging from 8-20 minutes (Sepulveda et al. 2019). Active tending of gear may mitigate some severe impacts and mortality through quicker interventions to release entangled animals (Tulloch et al. 2020).<br><br>Considering the population size, status and low reproduction rate of the more at risk beaked whale populations that can occur within the AOI, entanglement in buoy gear could possibly result in detectable changes in population size. However, instances of severe impacts from entanglement events in this gear type are expected to be very limited based on data from the United States and due to the active tending of buoy gear and quick detection/release of any animals that |

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| | | may be caught in the gear (8-20 minutes). Attraction of beaked whales to the gear/bait could cause some behavioural changes or non-lethal injuries. Taken together, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 2$<br>$= 6$ (raw score) |
| Likelihood | Rare | Examination of buoy gear fishery operations in the United States indicates low interactions with marine mammal species (Bayse and Kerstetter 2010; Sepulveda et al. 2014; Oceana 2015). An experimental fishery in California documented only two marine mammal interactions from 2011-2017 (Oceana 2017): both of which were Northern Elephant Seals that were released alive within 15 minutes of initial strike detection, and one seal was observed to shed the hook (PIER 2017; Sepulveda and Aalbers 2018). Whale entanglement with this gear type is expected to be very limited based on data from the United States showing zero documented interactions, including zero interactions in 2020 for 1,062 fishing days reported (NOAA 2021). Further, risk and environmental assessments conducted by NOAA's National Marine Fisheries Service (NMFS) in the United States have suggested the likelihood of buoy gear injuring marine mammals and protected species to be remote, classifying this gear type as Category III (lowest likelihood/risk) under the *Marine Mammal Protection Act* (Oceana 2015; NMFS 2013; NOAA 2018). Their assessments are based on analysis of potential interactions via spatial and temporal overlap, as well as analysis of industry bycatch data.<br><br>Based on available United States buoy gear fisheries information for marine mammal interactions (NMFS 2013), it was estimated that the likelihood of interaction of beaked whales and buoy gear within the AOI would be rare. |
| Overall risk | Moderate | No additional management measures suggested given the low sensitivity score. However, due to the recent addition of this gear type to the pelagic longline licence in 2021, this risk assessment should be revised as data on spatial footprint and bycatch become available within the AOI assessment area. |
| Uncertainty | High | There is no research or data available within this region for buoy gear due to the novel nature of this fishing gear type in DFO Maritimes Region. Research on this gear type in the United States provides some limited context on potential species interaction rates and associated risks; however, extrapolation of United States fisheries data to a Canadian context results in high uncertainty.<br><br>The use of the pelagic longline footprint as a proxy for buoy gear spatial extent represents areas where the gear is more likely be used, but likely overestimates the total spatial extent of the activity. With |

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| | | no available spatial data to use for the analysis, the use of the pelagic longline footprint is the best available information at this time and represents a precautionary approach. However, this adds significant uncertainty to the spatial overlap score.<br><br>Further, beaked whale habitat was defined using available data from visual detections, acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited. There is also uncertainty associated with the use of this area for Northern Bottlenose Whales in particular, given that it is toward the southern extent of their range. |

### 2.4.7 Midwater Trawl Fishery

Groundfish are harvested as a multi-species groundfish fishery by multiple mobile and fixed gear fleets. Although midwater trawl gear is not currently operated within the AOI, the mobile gear (MG) fleets (<65’ fleet, 65’-100’ fleet, and >100’ fleet) are permitted to fish with midwater trawls (DFO 2018*a*), and this gear type may become more widely used in future. Target species for the midwater trawl fishery in the vicinity of the Fundian Channel-Browns Bank AOI may include Silver Hake, Redfish, Pollock, and Haddock. The AOI overlaps two management units relevant to the groundfish fishery: NAFO Area 4X and NAFO Area 5Z. Currently, the mobile gear groundfish fleet’s main target species are Haddock in 4X5Y and 5Z, Pollock in 4X5, Silver Hake in specific authorized areas of 4VWX, and Redfish in Unit 3. Currently, the Silver Hake authorized fishing areas do not overlap with the AOI (DFO 2020*c*). As part of the AOI site selection process, efforts were made to avoid important fishing areas for bottom-contacting mobile gear (i.e., current Redfish, Pollock and Haddock bottom trawl fisheries); therefore, overlap of the AOI with the footprint of these fisheries is minimal. However, industry has requested that the Silver Hake fishery be expanded beyond current authorized fishing areas, and preparatory work for a Silver Hake framework assessment is underway that could support discussions related to this request (K. Cooper-MacDonald, DFO Resource Management, personal communication, 2022). If an expansion of the Silver Hake fishery were to occur, there are areas within the AOI that could be targeted. As a result, a potential midwater trawl fishery targeting Silver Hake was used as the focus for this assessment.

Midwater trawls are cone-shaped nets with a closed cod-end that operate using trawl doors at various depths within the water column (MSC n.d.; DFO 2010*a*; DFO 2011). Midwater trawl nets are typically larger than otter trawl nets, have fewer weights, and do not have rollers (DFO 2010*a*; DFO 2011). Midwater trawl gear may be fished at various depths via use of net sensors that wirelessly send depth information to the fishing vessel. Using this information, the operator will pay out an appropriate warp length to set the depth of gear operation. Changes to the warp length and vessel speed will vary the depth of gear operation (DFO 1968).

Although there is low species selectivity from midwater trawl gear, the fishing practice of targeting schooling fish provides some species selectivity (DFO 2010*a*). Size selectivity mostly occurs through the cod-end (Glass 2000; Cheng et al. 2020). Specifically, a T90 cod-end in midwater trawls may reduce capture of undersized Redfish (Cheng et al. 2020). In midwater trawls targeting groundfish, discarded fish largely include undersized individuals of the target species and non-target groundfish (DFO 2010*a*). Post-release survival varies depending on the set duration, handling time on deck, and characteristics of the bycatch species. In general, bycatch rates for midwater trawls are fairly low (~1-3%). Additionally, although midwater trawls are designed to operate above the seafloor, benthic contact during operation, particularly from doors and footropes, can occur (Kenchington et al. 2009; DFO 2010*a*; Donaldson et al. 2010; Boutillier et al. 2013; Chosid and Pol 2020). Contact with sensitive bottom features (e.g., corals, sponges) can cause structural damage and sediment resuspension; however, midwater trawl gear is not designed to withstand substantial bottom contact, and gear damage is likely to occur before widespread damage occurs to seafloor structures (DFO 2010*a*). Entanglement of marine mammals and seabirds in midwater trawls has also been documented (DFO 2011; Hedd et al. 2015; Chosid and Pol 2020).

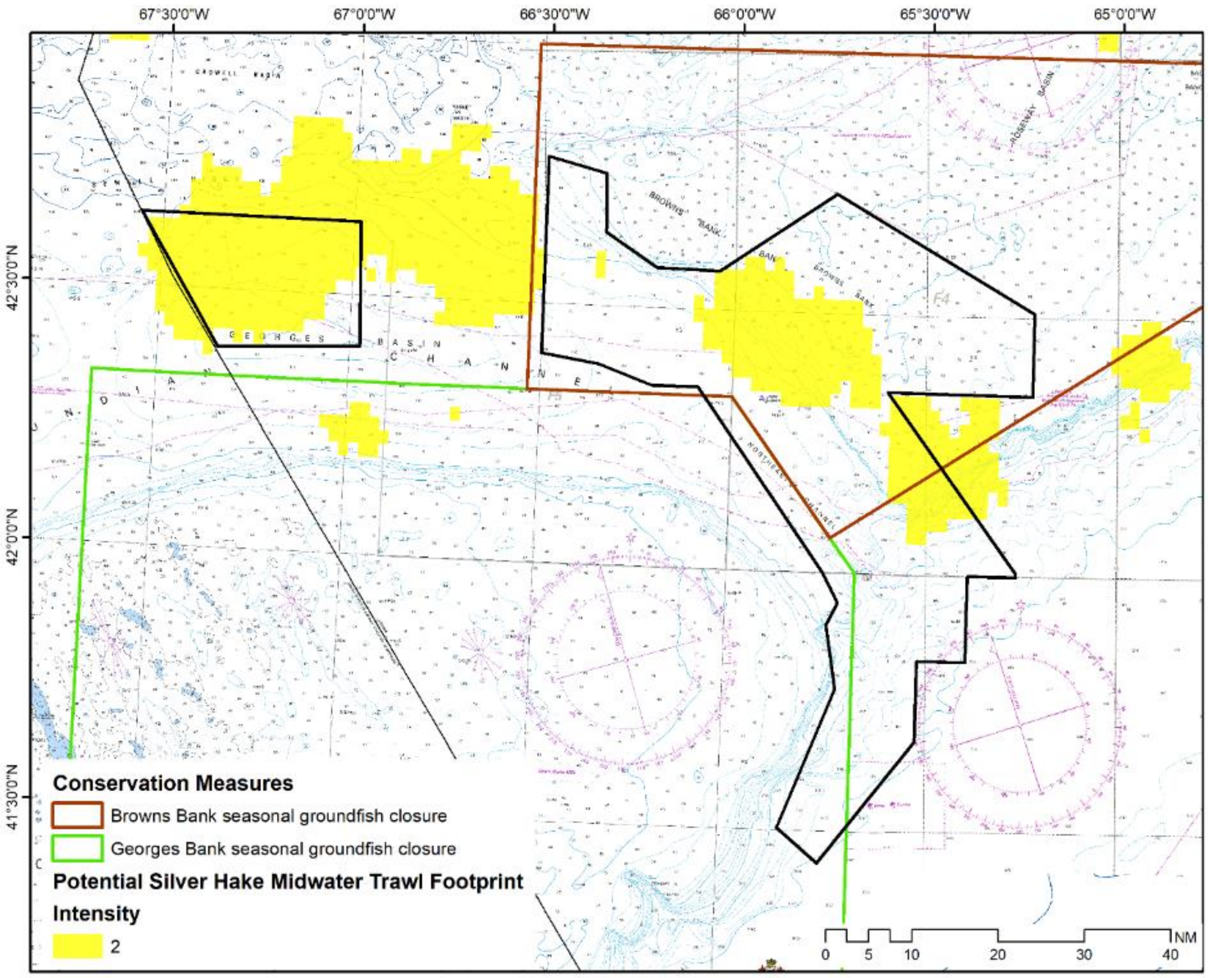


Figure 2.4.7-1. Map of potential Silver Hake midwater trawl fishing footprint within the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). The predicted footprint for this fishery is shown as the top 40% of ranked values across time periods for Silver Hake biomass caught in the DFO Summer RV survey in 4VWX+5Z from 1970-2020. As groundfish midwater trawl gear is not currently operated within the AOI, intensity data is not available. As such, the median intensity score, moderate (2), was assigned.

Existing management measures

Currently, the mobile groundfish fishery predominantly use otter trawls in the vicinity of the Fundian Channel-Browns Bank AOI; however, under current licencing conditions, mobile groundfish fleets could operate midwater trawls. The <65' fleet, or inshore fleet, has targeted at-sea observer coverage of 5-10%, and 10-20% in Redfish Unit 3. Additionally, within 5Z, industry-funded observer coverage is a minimum of 25%, where June-July coverage is 100%, August coverage is 50%, and September-December coverage is 50%. Within 4X, this fleet is authorized to direct for Cod/Haddock/Pollock, Winter Flounder, Redfish (Unit 3), and Silver Hake (within specific authorized areas). Within 5Z, licence conditions only authorize directing for Haddock and Pollock. Bycatch in this fleet are managed by quota caps for White Hake (4X+5), Cusk, Wolffish (4X+5), and Dogfish. The 65'-100' fleet (midshore fleet) and >100' fleet (offshore fleet) are both authorized to fish Atlantic-wide, and in the Maritimes Region target the same stocks as the inshore fleet (DFO 2018*a*). At-sea observer coverage targets for these fleets are 5-10%, with higher observer coverage required for 5Z.

The Scotia-Fundy Groundfish Advisory Committee is the main consultative forum for groundfish topics, including total allowable catches, licensing policies, and management measures (DFO 2018*a*). Additionally, the MG <65' fleet have established advisory processes to provide advice to the Department on issues that impact their fleet. Given the Atlantic-wide nature of the licences, the midshore and offshore fleet sectors are consulted nationally or through regional advisory committees, as appropriate. All fleets require the use of vessel monitoring systems (VMS), 100% dockside monitoring, minimum mesh sizes, small fish protocol, and bycatch limits. Silver Hake-directed trawls require a minimum 55m square mesh net and the use of a grate (DFO 2018*a*), which is used to mitigate bycatch of non-target species including Haddock, Pollock, and Cod (Halliday and Cooper 1999). Within 5Z, license conditions only allow directing for Haddock and Pollock, where a minimum mesh size of 125mm and fully operational horizontal separator panel, to mitigate cod bycatch, are required (DFO 2018*a*). Two seasonal spawning closures overlap with the AOI (Figure 2.4.7-1): Browns Bank spawning closure (February 1 to June 15) and Georges Bank spawning closure (end of the 5$^{th}$ week of the year to May 31).

The groundfish midwater trawl fishery is actively tended, meaning that the vessel remains in the vicinity of the gear while fishing. Actively tending gear may mitigate some severe impacts and mortality through quicker intervention to release entangled animals (Tulloch et al. 2020). Additionally, amendments to the Marine Mammal Regulations in 2018 require all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018).

Bycatch profile

Groundfish midwater trawl does not currently operate within the AOI. Potential future groundfish midwater trawl within the assessment area are anticipated to target Silver Hake, Cod/Haddock/Pollock, and Redfish. All available at-Sea Observer Program records for midwater trawls targeting these species in NAFO 4X and 4W are included in the bycatch profile. In order to examine whether the bycatch profile is significantly different between targeted species, observer records have been separated into records targeting Silver Hake (Table 2.4.7-1) and records targeting Cod/Haddock/Pollock and Redfish (Table 2.4.7-2).

The species caught as bycatch in sets targeting Silver Hake include American Lobster (8.9% of sets), White Hake (8.9% of sets), Cusk (5.4% of sets), Thorny Skate (4.8% of sets), and Atlantic Wolffish (0.4%). In sets targeting Cod/Haddock/Pollock and Redfish, bycatch species include Cusk (33.3% of sets), and White Hake (3.3% of sets).

Table 2.4.7-1. At-Sea Observer Program records taken from DFO's Industry Survey Database for all available data on midwater trawl sets targeting "Silver Hake", or "Silver Hake, Squid, Argentine" in 4X and 4W. Available data included records from 1977 to 2014. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 789.

| Species | Kept Weight (kg) | Discard Weight (kg) | # Unique Sets | % of Sets |
|---|---|---|---|---|
| Spiny Dogfish | 12 | 80,761 | 103 | 13.1 |
| Short-Fin Squid | 1,373,477 | 27,903 | 478 | 60.6 |
| Argentine (Atlantic) | 102,021 | 12,552 | 102 | 12.9 |
| Swordfish | | 9,862 | 53 | 6.7 |
| Silver Hake | 886,709 | 9,105 | 387 | 49.0 |
| Pollock | 6,996 | 5,478 | 80 | 10.1 |
| Basking Shark | | 5,000 | 1 | 0.1 |
| Haddock | 9,647 | 2,272 | 140 | 17.7 |
| Skates And Rays (NS) | 4,762 | 1,500 | 49 | 6.2 |
| Squirrel or Red Hake | 1,247 | 1,474 | 72 | 9.1 |
| Mackerel (Atlantic) | 1,169,437 | 1,367 | 269 | 34.1 |
| American Plaice | 2,874 | 1,107 | 101 | 12.8 |
| Porbeagle, Mackerel Shark | | 910 | 12 | 1.5 |
| Dogfishes (NS) | 15 | 850 | 4 | 0.5 |
| White Hake | 2,532 | 754 | 70 | 8.9 |
| Redfish, Unseparated | 5,010 | 557 | 71 | 9.0 |
| Yellowtail Flounder | 10 | 455 | 10 | 1.3 |
| Bigeye Tuna | | 450 | 2 | 0.3 |
| American Lobster | | 429 | 70 | 8.9 |
| Brachiuran Crabs | | 317 | 20 | 2.5 |
| Ocean Sunfish | | 244 | 1 | 0.1 |
| Cod (Atlantic) | 4,881 | 216 | 74 | 9.4 |
| Monkfish, Goosefish, Angler | 1,923 | 209 | 96 | 12.2 |
| Blue Shark | | 170 | 2 | 0.3 |
| Witch Flounder | 97 | 153 | 58 | 7.4 |
| Jellyfishes | | 150 | 1 | 0.1 |
| Thorny Skate | 162 | 136 | 38 | 4.8 |
| Lanternfish, Horned | | 125 | 1 | 0.1 |
| Cusk | 838 | 101 | 43 | 5.4 |
| Shortfin Mako | | 100 | 1 | 0.1 |
| Spinytail Skate | | 70 | 4 | 0.5 |
| Off-Shore Hake | 40 | 45 | 4 | 0.5 |
| Halibut (Atlantic) | 1,950 | 27 | 70 | 8.9 |

| | | | | |
|---|---|---|---|---|
| Barracudina, Unidentified | | 25 | 1 | 0.1 |
| Ocean Pout (Common) | 47 | 12 | 14 | 1.8 |
| Redfish, Deep Water | 100 | 11 | 3 | 0.4 |
| Herring (Atlantic) | 157,306 | 10 | 128 | 16.2 |
| Spotted Wolffish | | 10 | 1 | 0.1 |
| Striped Atlantic Wolffish | 5 | 10 | 3 | 0.4 |
| Atlantic Torpedo | | 5 | 1 | 0.1 |
| Butterfish | | 2 | 2 | 0.3 |
| Jonah Crab | | 2 | 1 | 0.1 |
| Sculpins | | 2 | 3 | 0.4 |
| Alewife | 107 | 1 | 4 | 0.5 |
| Arctic Skate | | 1 | 1 | 0.1 |
| Black Ruff | | 1 | 1 | 0.1 |
| Krill Shrimp | | 1 | 1 | 0.1 |
| Longhorn Sculpin | | 1 | 1 | 0.1 |
| Marine Invertebrates (NS) | | 1 | 1 | 0.1 |
| Shad American | 1 | 1 | 2 | 0.3 |
| Spider (Queen, Snow), Unidentified | | 1 | 1 | 0.1 |
| Spiny Skinned Animals | | 1 | 3 | 0.4 |
| Mollusca P. | | 0 | 1 | 0.1 |
| Simonyi's Frostfish | | 0 | 1 | 0.1 |
| Blennies, Shannies, Gunnels | 10 | | 1 | 0.1 |
| Cunner | 240 | | 1 | 0.1 |
| Flounder, Unidentified | 70 | | 3 | 0.4 |
| Hake (NS) | 31 | | 6 | 0.8 |
| Longfin Squid, Longfin Inshore Squid | 85 | | 2 | 0.3 |
| Lumpfish | 3 | | 2 | 0.3 |
| Opah | 30 | | 1 | 0.1 |
| Sand Lances (NS) | 6 | | 2 | 0.3 |
| Skates (NS) | 164 | | 9 | 1.1 |
| Winter Flounder | 9 | | 2 | 0.3 |
| Yellowfin Tuna | 140 | | 2 | 0.3 |
| **Total** | **3,732,994** | **164,947** | **N/A** | **N/A** |

Table 2.4.7-2. At-Sea Observer Program records taken from DFO's Industry Survey Database for all available data on midwater trawl sets targeting Cod/Haddock/Pollock and Redfish in 4X and 4W. Available data included records from 1977 to 2014. Information recorded includes kept weight, discarded weight, number of unique sets, and percentage of observed sets containing each species. The total number of observed sets was 30.

| Species | Kept Weight (kg) | Discard Weight (kg) | # Unique Sets | % of Sets |
|---|---|---|---|---|
| Jellyfishes | | 521 | 3 | 10.0 |
| Skates (NS) | | 430 | 10 | 33.3 |
| Pollock | 22,572 | 295 | 23 | 76.7 |
| Swordfish | 100 | 200 | 3 | 10.0 |
| Black Dogfish | | 100 | 1 | 3.3 |
| Cusk | 10 | 68 | 10 | 33.3 |
| Cod (Atlantic) | 6,244 | 65 | 19 | 63.3 |
| American Plaice | | 23 | 6 | 20.0 |
| Redfish, Unseparated | 18,681 | 22 | 15 | 50.0 |
| Haddock | 237 | 10 | 15 | 50.0 |
| Halibut (Atlantic) | 8 | 10 | 3 | 10.0 |
| Monkfish, Goosefish, Angler | 5 | 10 | 2 | 6.7 |
| White Hake | | 10 | 1 | 3.3 |
| Witch Flounder | | 10 | 1 | 3.3 |
| Yellowtail Flounder | | 10 | 1 | 3.3 |
| Winter Flounder | | 5 | 1 | 3.3 |
| Wolffish, Unidentified | 37 | 5 | 5 | 16.7 |
| Short-Fin Squid | 155 | 4 | 4 | 13.3 |
| Argentine (Atlantic) | 10 | | 1 | 3.3 |
| **Total** | **48,059** | **1,798** | **N/A** | **N/A** |

**Risk Assessment – Midwater trawl and large mature female lobster**

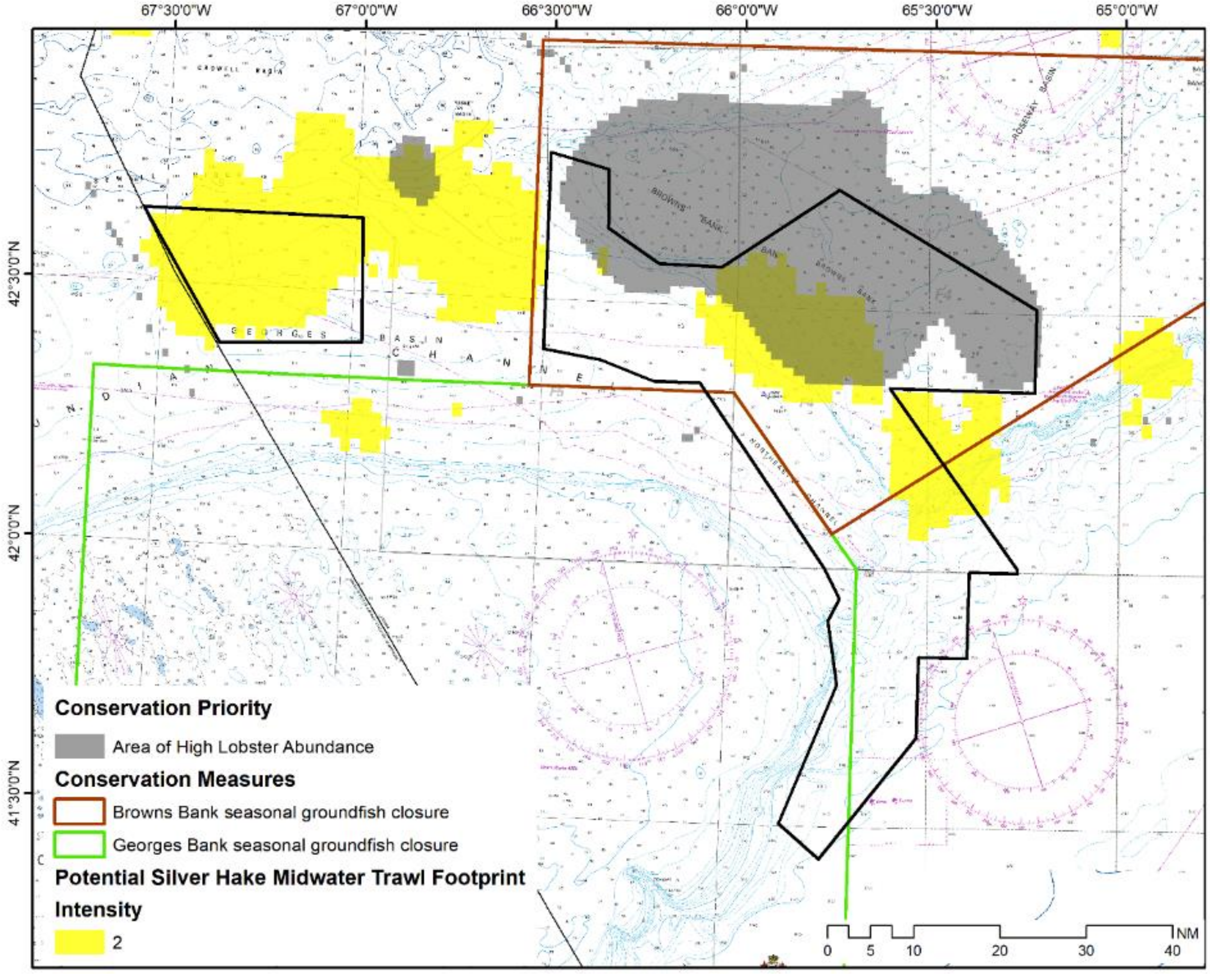


Figure 2.4.7-2. Overlap of high lobster abundance with potential groundfish midwater trawl fishery footprint in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). Groundfish midwater trawl gear is not currently operated within the AOI and intensity data is not available. As such, the median intensity score, moderate (2), was assigned.

**Risk Statement**: There is a risk that bycatch in midwater trawls will lead to negative impacts on the local lobster population within the AOI.

Table 2.4.7-3. Scoring for the risk posed by the midwater trawl fishery to large mature female lobster within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 3 x 2<br>= 12 (raw score) |
| Intensity | 2 | Midwater trawl gear is not currently operated within the AOI, hence intensity data is not available. As such, the median intensity score, moderate, was assigned. |
| Temporal | 3 | Large female lobster are present year-round. The midwater trawl fishery can occur year-round; however, the area of high lobster |

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| | | abundance occurs within the Browns Bank seasonal spawning closure (February 1 to June 15). Considering this, there is potential temporal overlap for 7.5 months of the year. |
| Spatial | 2 | There is localized spatial overlap (28.6%) between the potential groundfish midwater trawl footprint and the area of high lobster abundance within the AOI. |
| $Q_{Sensitivity}$ | 1 | The American Lobster population in LFA 41 is in the healthy zone, with reproductive potential currently found to be above the long-term average (DFO 2018*g*).<br><br>The effects to lobster from capture in a fishery can include injury, limb loss, and mortality, or longer term effects such as failure to molt, increased susceptibility to predation, and reduced foraging capability (Murphy and Kruse 1995). However, Broadhurst and Uhlmann (2007) observed that crustaceans may be more tolerant than other taxa to handling, discard, and transport because of their durable exoskeletons, benefits associated with limb autotomy, and air-breathing abilities (Wassenberg and Hill 1989; Hill and Wassenberg 1990; Cabral et al. 2002).<br><br>Mortality of discarded crustaceans appears to vary greatly depending on species, location, time of year, gear type, and other factors (Stoner 2012). Hill and Wassenberg (1990) found that crustacean discard survival from a shrimp otter trawl was approximately 50%, while other studies have detected higher crustacean mortality from bottom trawls (e.g., Wileman et al. 1999; Harris and Ulmestrand 2004). Harris and Ulmestrand (2004) demonstrated that discarded Norway Lobster have high mortality if they are dropped through a low salinity surface layer. Survival of discarded Snow Crab in Newfoundland and Labrador trap fisheries was found to increase with gentle handling and quick return to the water (Grant 2003). Other stressors on crustaceans include exposure to extreme temperatures, risk of desiccation, barotrauma and light exposure (Stoner 2012), showing that many factors influence discard survival.<br><br>Physical damage to bycaught lobsters can occur through abrasion and compression within the cod-end, which may result in major injuries (Wileman et al. 1999; Harris and Ulmestrand 2004). Extent of impacts vary depending on catch size, composition, trawl duration and speed. It is therefore assumed that some mortalities can be expected for discarded large female lobster bycatch from the midwater fishery. Also, direct damage to eggs can occur during the course of capture and release as ovigerous females carry their eggs externally (Darnell et al. 2010).<br><br>Given the current healthy status of the local population within the AOI, it is expected that this fishery would have insignificant or |

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| | | undetectable population impacts. Therefore, a sensitivity score of 1 was assigned. |
| $Q_{Consequence}$ | Low | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 1$<br>$= 4$ (raw score) |
| Likelihood | Rare | Lobster are caught as bycatch in approximately 8.9% of sets targeting Silver Hake, according to At-Sea Observer records (Table 2.4.7-1). No lobster were documented as bycatch in sets targeting Cod/Haddock/Pollock and Redfish (Table 2.4.7-2). Note that the bycatch percentage encompasses all lobster caught, not specifically large female lobster. Koepper et al. (2021) examined sex ratios of American Lobster in LFA 33 and LFA 34, and found that females composed ~48% of the population. Taken together, the chance of catching large female lobster is likely <5%. Therefore, a likelihood of rare was assigned. |
| Overall risk | Low | No additional management measures suggested. As this risk assessment is for a fishery that does not currently operate within the AOI, this analysis should be revised as more information, such as data on spatial footprint and bycatch, become available within the AOI assessment area. |
| Uncertainty | High | Due to the minimal use of midwater trawls within the region at the time of assessment, a proxy fisheries footprint was developed using predicted species distribution of Silver Hake, which was identified as a potential target species for this fishery. Intensity was also presumed to be moderate due to a lack of available data.<br><br>There is high certainty for lobster distribution and abundance in the assessment area. However, there were no studies found that directly assess the impacts of midwater fisheries on lobster. Studies used to determine sensitivity mainly focused on impacts of otter/bottom trawl gear on crustacean discard survival, and did not include American Lobster in the assessments. Studies on the survival rate of discarded American Lobster would increase the certainty of this assessment. |

**Risk Assessment – Midwater trawl and beaked whale habitat**

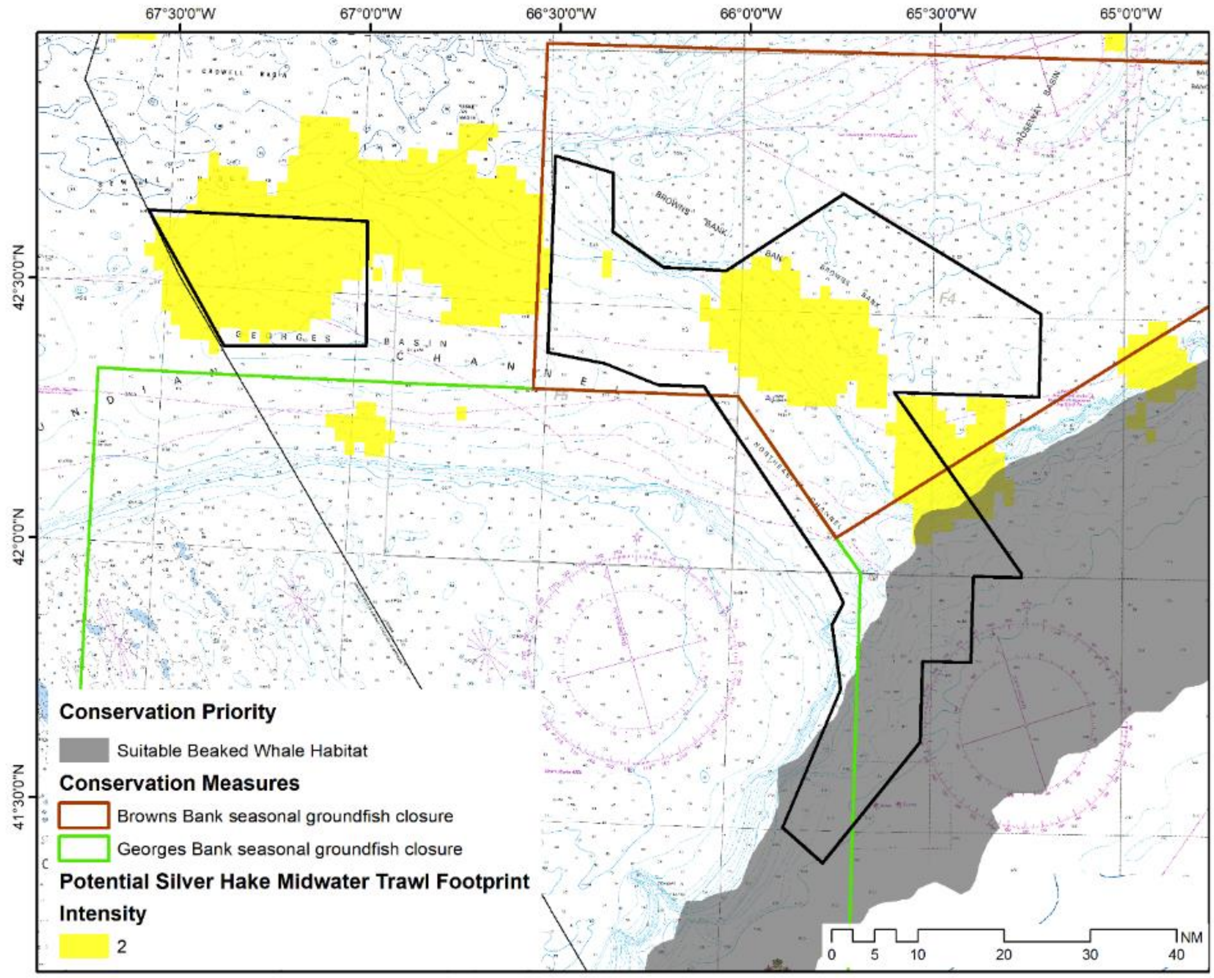


Figure 2.4.7-3. Overlap of extent of suitable beaked whale habitat with potential groundfish midwater trawl fishery footprint in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). Groundfish midwater trawl gear is not currently operated within the AOI and intensity data is not available. As such, the median intensity score, moderate (2), was assigned.

**Risk Statement:** There is a risk that entanglement in midwater trawls will lead to negative impacts to beaked whales in their suitable habitat within the AOI.

Table 2.4.7-4. Scoring for the risk posed by the midwater trawl fishery to beaked whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 4 x 1<br>= 8 (raw score) |
| Intensity | 2 | Midwater trawl gear is not currently operated within the AOI, hence intensity data is not available. As such, the median intensity score, moderate, was assigned. |
| Temporal | 4 | Beaked whales occur within the AOI year-round and the midwater trawl fishery can occur year-round in the area |

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| | | overlapping beaked whale habitat. Therefore, there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (4.6%) between the potential groundfish midwater trawl footprint and the extent of suitable beaked whale habitat within the AOI. |
| $Q_{Sensitivity}$ | 3 | Of the beaked whale species known to occur in and around the AOI (see Chapter 1, Section 1.4.3), more information is known about Sowerby's Beaked Whales and Northern Bottlenose Whales in terms of population status and threats. The information below therefore focuses mainly on these two species.<br><br>Entanglement in fishing gear is listed as a threat for both Sowerby's Beaked Whales (Special Concern – SARA) and Northern Bottlenose Whales, Scotian Shelf population (Endangered – SARA) (DFO 2016; DFO 2017*a*; DFO 2017*c*; DFO 2022).<br><br>Both Northern Bottlenose Whales and Sowerby's Beaked Whales are long-lived species that reproduce at a low rate, similar to other beaked whale species (DFO 2016; DFO 2017*c*). This low reproductive rate may limit a population's ability to adapt to or recover from disturbance (COSEWIC 2019). The Scotian Shelf population of Northern Bottlenose Whales is estimated at roughly 175 individuals (Feyrer 2021). Although the population is still considered Endangered and was declining up to 2004, recent estimates indicate this trend has since reversed and the population now appears to be increasing since at least 2010 (Feyrer 2021). However, this population has a potential biological removal (PBR: the maximum number of non-natural mortalities that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) of 0.3 individuals per year (DFO 2007*b*; DFO 2010*c*). This means that the level of allowable harm for this population is low (DFO 2016).<br><br>In addition to direct mortality from fishing gear entanglement, there is the possibility that whales break free from entanglement (potentially with gear attached) (Feyrer et al. 2021). Whales that survive the entanglement event but escape with injuries may still experience long-term health impacts, which can also result in population level impacts (Dolman and Brakes 2018). These can include stress responses (Pettis et al. 2004), compromised immune responses (Cassoff et al. 2011), and cumulative loss of body condition and constriction of body parts, with or without secondary infection that may impact health and fecundity even after gear is no longer attached (Moore and van der Hoop 2012).<br><br>There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). Scarring analysis |

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| | | conducted on Northern Bottlenose Whales found that the majority of anthropogenic scars (57%) were considered low to moderate severity, and 16% were considered severe injuries; however, scarring analysis does not account for cryptic mortalities (Feyrer et al. 2021). In general, ingestion of gear and entanglement with trailing gear are considered serious injuries for odontocetes (Angliss and DeMaster 1997; NMFS 2012). Depending on multiple factors such as the animal's body size relative to the gear and the species' sensitivity, loose gear may have the potential to become a serious injury (NMFS 2012). In addition, odontocetes may tire quickly as a result of their small body size, impacting their ability to reach the surface to breathe, and possibly leading to myopathy (NMFS 2012).<br><br>It is important to note that the midwater trawl fishery actively tends gear, with fishing vessels remaining with the deployed gear, which may mitigate some severe impacts and mortality through quicker interventions to release entangled animals (Tulloch et al. 2020).<br><br>Considering the population size, status and low reproduction rate of the more at-risk beaked whale populations that can occur within the AOI, entanglement in midwater trawl gear could result in a detectable change in population size. However, there is no available data that suggests entanglement within the AOI by this gear type would be exceeding the maximum sustainable level nor adversely impacting long-term recruitment dynamics. Taken together, a sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 3$<br>$= 9$ (raw score) |
| Likelihood | Rare | Beaked whales dive to deep waters where they forage for fish and squid (COSEWIC 2011; COSEWIC 2019) and therefore may interact with midwater trawl fishing gear while foraging. Additionally, Northern Bottlenose Whales are generally attracted to vessels, and in some areas demonstrate opportunistic associations with fishing vessels to feed on discards (e.g., Johnson et al. 2020).<br><br>Beaked whale entanglement incidents in fishing gear in Atlantic Canada are rarely observed. However, there have been some direct observations of entanglements (described below), and additional evidence of interactions through scarring analysis (Feyrer et al. 2021). Of the beaked whale species that occur within the AOI, information related to entanglements mainly exists for Northern Bottlenose Whales and Sowerby's Beaked Whales. |

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| | | There were ten reports of Northern Bottlenose Whale entanglement in fishing gear since 1981 impacting the Scotian Shelf population with three events attributed to trawl fisheries targeting Silver Hake (Hooker et al. 1997; Harris et al. 2013; Themelis et al. 2016; Feyrer et al. 2021). Additionally, two entangled Sowerby's Beaked Whales were observed in the Gully MPA in 2013, but it is not known from which fishery the gear originated (Narazaki 2013 as cited in DFO 2017*c*). A more recent assessment reporting instances of beaked whale entanglement within the western North Atlantic attributed ~23% of entanglement events to trawl fisheries (Feyrer et al. 2021). Additionally, midwater trawls may incidentally catch a higher amount of cetaceans than bottom trawls due to larger net sizes, higher speeds, and location in the water column (Fertl and Leatherwood 1997).<br><br>Given the low probability of these events being observed due to factors such as their offshore location (Whitehead and Hooker 2012; DFO 2022), the records of beaked whale entanglements described above are considered low estimates of actual occurrence. Entanglement scars have been observed on Northern Bottlenose Whales and Sowerby's Beaked Whales on the Scotian Shelf (Whitehead et al. 1997; DFO 2017*c*), suggesting that interactions with fishing gear occur more frequently than observed (DFO 2010*c*; Feyrer et al. 2021). Scarring evidence indicates Northern Bottlenose Whale interactions with fishing gear and propeller-vessel strikes occurs at a rate of 1.7 individuals per year (Feyrer et al. 2021).<br><br>While there is potential for beaked whale entanglement in midwater trawl gear within the AOI, based on available information, the likelihood was estimated as rare. |
| Overall risk | Moderate | Additional management measures may be considered to address risks from this pressure including operational modifications (e.g., reducing number of turns per tow, tow duration) or restrictions where this fishery overlaps with the suitable beaked whale habitat within the future MPA. Additionally, since this risk assessment is for a fishery that does not currently operate within the AOI, this analysis should be revised as more information, such as data on spatial footprint and bycatch, become available within the AOI assessment area. |
| Uncertainty | High | Due to the minimal use of midwater trawls within the region at the time of assessment, a proxy fisheries footprint was developed using predicted species distribution of Silver Hake, which was identified as a potential target species for this fishery. Intensity was also presumed to be moderate due to lack of available data. |

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| | | Since 2018, amendments to the Marine Mammal Regulations have required all accidental contact between marine mammals and fishing gear to be reported directly to DFO (Government of Canada 2018). However, entanglement events may go unwitnessed. As well, entanglement scarring for beaked whales does not generally provide a clear link to fishing gear type. The potential for larger animals to break free from the gear before being noticed and recorded by observers can further limit the comprehensiveness of this data source. As a result, observer data are limited in their ability to approximate rates of cetacean bycatch and entanglement.<br><br>Additionally, as noted above, mortality may not be immediate, as entangled animals may die of sublethal effects such as starvation or infection at some future date (Pettis et al. 2004; Moore and van der Hoop 2012) and some animals eventually sink when they die (Moore 2014). There is limited information on the known outcomes of various injuries for odontocetes (NMFS 2012). These factors obscure knowledge of entanglement-related mortality.<br><br>Beaked whale suitable habitat was defined using available data from visual detections, acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited. There is also uncertainty associated with the use of this area for Northern Bottlenose Whales in particular, given that it is toward the southern extent of their range. |

**Risk Assessment – Midwater trawl and deep-water corals**

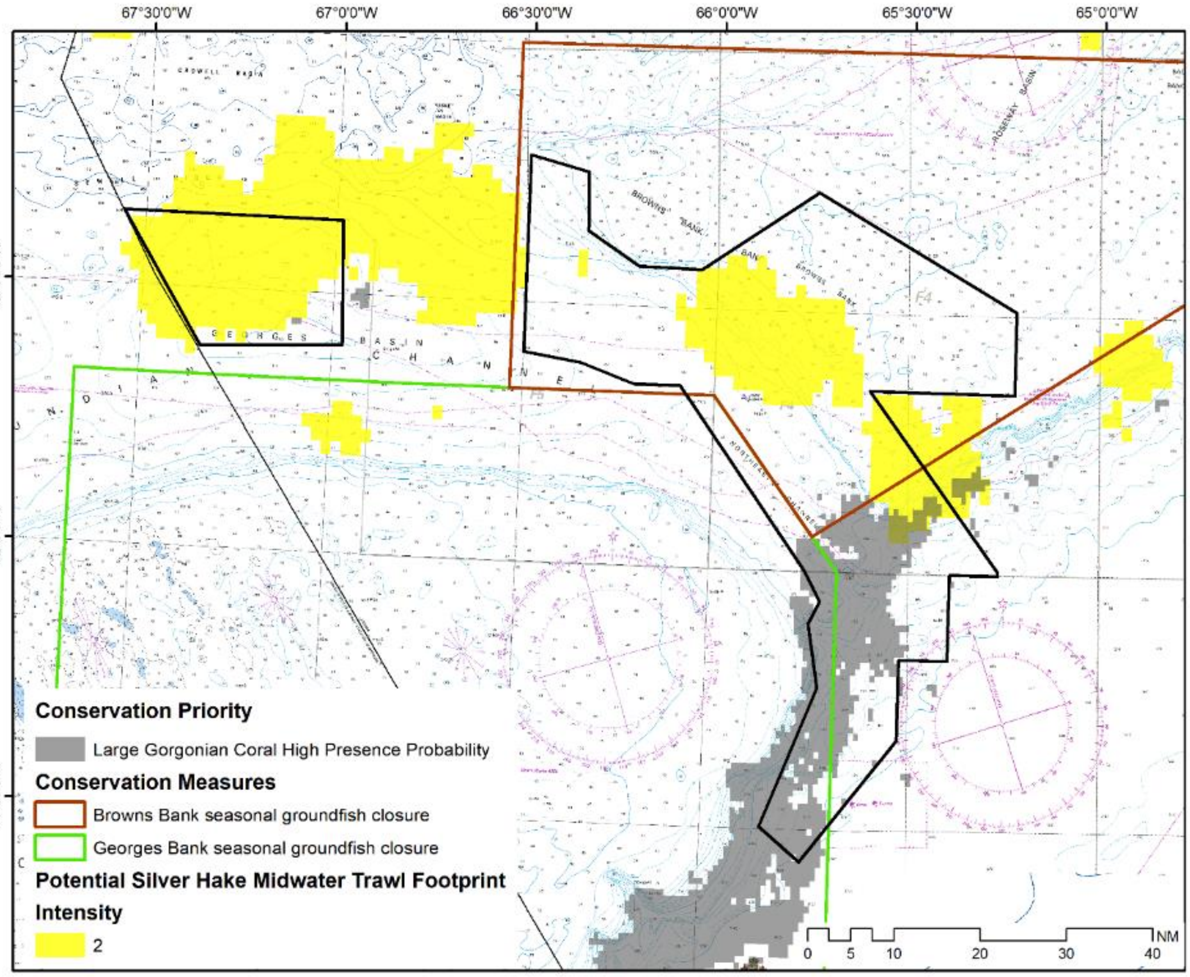


Figure 2.4.7-4. Overlap of predicted extent of large gorgonian corals with potential groundfish midwater trawl fishery footprint in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). Groundfish midwater trawl gear is not currently operated within the AOI and intensity data is not available. As such, the median intensity score, moderate (2), was assigned.

**Risk Statement:** There is a risk that bottom disturbance from midwater trawl gear (e.g., footropes) will lead to negative impacts on deep-water coral communities within the AOI.

Table 2.4.7-5. Scoring for the risk posed by the midwater trawl fishery to deep-water corals within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 4 x 1<br>= 8 (raw score) |
| Intensity | 2 | Midwater trawl gear is not currently operated within the AOI, hence current intensity data is not available. As such, the median intensity score, moderate, was assigned. |
| Temporal | 4 | Deep-water corals are present year-round and the midwater trawl fishery can occur year-round in the area overlapping deep-water |

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| | | corals. Therefore, there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (5.3%) between the potential groundfish midwater trawl footprint and the predicted extent of large gorgonian corals within the AOI. |
| $Q_{Sensitivity}$ | 5 | Corals are susceptible to fishing from both direct (removal and/or damage) and indirect impacts (smothering) (DFO 2010*b*). The effect of fishing gear on corals is dependent on a number of factors including: morphology/skeletal composition of the coral, coral reproduction and growth rate, methods and timing of deployment of gear, and the frequency with which the site is fished.<br><br>Interaction between midwater trawls and benthic habitats can occur via several elements of the gear, including trawl doors, auxiliary weights, cod-end, and footropes (DFO 2010*a*; NOAA 2014). However, as midwater trawl gear is not designed to make extensive contact with the seafloor (provided chafing gear is not used), gear damage is expected before substantial, widespread damage occurs to seafloor structures (Chuenpagdee et al. 2003; DFO 2010*a*). Experimental groundfish off-bottom trawls targeting Georges Bank Haddock documented seafloor contact via drop chains and footropes during operation (Chosid and Pol 2020). The study suggests that reduced bottom contact by midwater trawls, compared to bottom trawls, may allow additional areas to be opened to this gear type, but not areas with highly sensitive benthic ecosystems.<br><br>Gorgonian corals are long-lived and slow to recover from physical damage (Witherell and Coon 2001). Growth rates and life spans of corals vary by species; studies of gorgonian corals have calculated growth rates of 5-26 mm per year and lifespans of 100 to 200 years (Roberts et al. 2006 as cited in Campbell and Simms 2009). Some of the species of deep-water corals found in Nova Scotia may take decades to centuries to recover from impacts associated with fishing activities, if they recover at all (Sherwood and Edinger 2009; DFO 2010*b*).<br><br>Due to the sensitivity of deep-water corals to physical disturbance and the extremely slow recovery time, a sensitivity score of 5 was assigned. |
| $Q_{Consequence}$ | High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 5$<br>$= 15$ (raw score) |
| Likelihood | Unlikely | Although midwater trawls are designed to operate above the seafloor and reduce seafloor contact as compared to bottom trawls, studies indicate that current midwater trawl gear does not eliminate contact with benthic structures (DFO 2010*a*; NOAA 2014; Chosid and Pol 2020). The frequency of benthic contact for midwater trawl gear is not well defined, and is likely dependent on operation depth |

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| | | and gear configuration. A review of catch data from midwater trawls targeting Pacific Hake and Pacific Ocean Perch within the Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs found that 13% of tows contained benthic species that could only be caught if the gear was on the bottom at some point during the tow (Boutillier et al. 2013). Experimental groundfish off-bottom trawls targeting Georges Bank Haddock also documented seafloor contact via drop chains and footropes during operation, although the frequency of contact was not provided (Chosid and Pol 2020). Bycatch records for midwaters trawl fisheries in the US Pacific recorded coral/sponge bycatch in ~0.4% of tows (amounting to 38.4 kg) between 2000-2010 (Hourigan et al. 2017). Occasional contact with the seafloor occurs from midwater trawl gear, particularly when the target species are in close proximity to the seabed (McConnaughey et al. 2019).<br><br>Observer records from 1977 to 2014 in 4X and 4W (Tables 2.4.7-1 and 2.4.7-2) did not document any bycatch of corals in the midwater trawl fishery targeting Silver Hake or Cod/Haddock/Pollock and Redfish.<br><br>Taken together, this would suggest that midwater trawl gear may occasionally interact with corals, but that overall this interaction is expected to be unlikely. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) to address risks from this pressure, such as restricting this fishery in the predicted extent of large gorgonian corals within the future MPA. Since this risk assessment is for a fishery that does not currently operate within the AOI, this analysis should be revised as more information, such as data on spatial footprint and bycatch, become available within the AOI assessment area. |
| Uncertainty | Moderate | Due to the minimal use of midwater trawls within the region at the time of assessment, a proxy fisheries footprint was developed using predicted species distribution of Silver Hake, which was identified as a potential target species for this fishery. Intensity was also presumed to be moderate due to lack of available data.<br><br>While it is known that gorgonian corals are long-lived, easily damaged by fishing gear and slow to recover from damage (Witherell and Coon 2001), the frequency of seafloor contact by midwater trawl gear is not well documented. However, there is sufficient evidence from various midwater trawl fisheries that contact with the benthic environment does occur.<br><br>The presence probability map for deep-water corals within the AOI was developed using available data from research surveys. The identified coral area is predictive in nature due to limited survey coverage in the deeper waters. |

**Risk Assessment – Midwater trawl and significant concentrations of sponges**

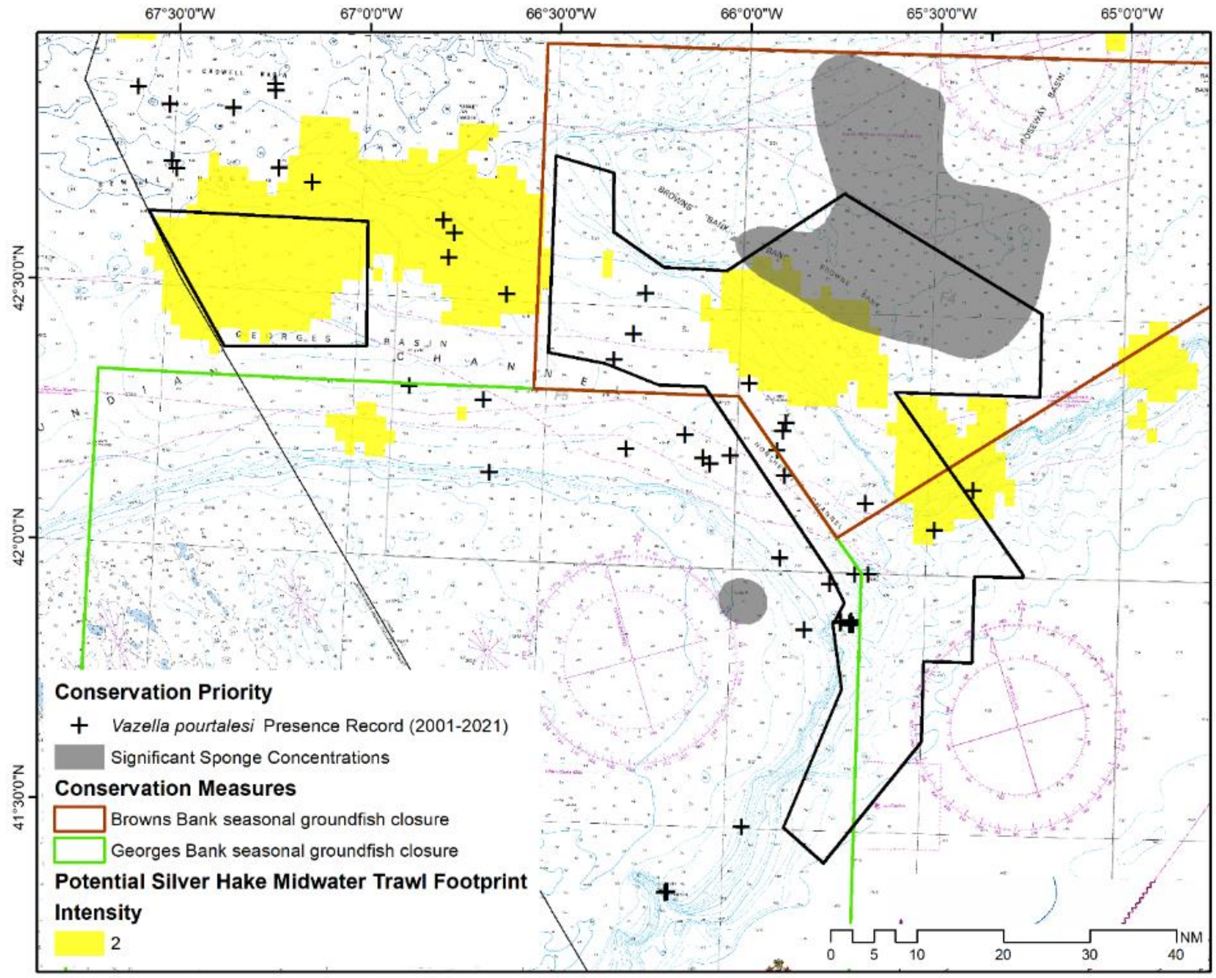


Figure 2.4.7-5. Overlap of predicted extent of significant concentrations of sponges and presence records for *Vazella pourtalesi* with midwater trawl fishery footprint in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). Groundfish midwater trawl gear is not currently operated within the AOI and intensity data is not available. As such, the median intensity score, moderate (2), was assigned.

**Risk Statement**: There is a risk that bottom disturbance from midwater trawl gear (e.g., footropes) will lead to negative impacts on significant concentrations of sponges within the AOI.

Table 2.4.7-6. Scoring for the risk posed by the midwater trawl fishery to significant concentrations of sponges within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 3 x 2<br>= 12 (raw score) |
| Intensity | 2 | Midwater trawl gear is not currently operated within the AOI, hence current intensity data is not available. As such, the median intensity score, moderate, was assigned. |

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| Temporal | 3 | Significant concentrations of sponges are present year-round. The midwater trawl fishery can occur year-round; however, the significant concentration of sponges occurs entirely within the Browns Bank seasonal spawning closure (February 1 to June 15). Considering this, there is potential temporal overlap for 7.5 months of the year. |
| Spatial | 2 | There is a localized spatial overlap (11.6%) between the potential groundfish midwater trawl footprint and important sponge areas within the AOI. |
| $Q_{Sensitivity}$ | 4 | Significant concentrations of sponges in the AOI include several species of sponges, with the family Polymastiidae (massive sponges) being prevalent (DFO 2020*b*). Note that *V. pourtalesi* sponges have also been detected in parts of the AOI; these hexactinellid glass sponges are also susceptible to physical damage (Morrison et al. 2020). Sponge dominated communities are considered indicator taxa for Vulnerable Marine Ecosystems (FAO 2009).<br><br>Clark et al. 2016 (modified from Hewitt et al. 2011) categorized the sensitivity of deep-sea benthic taxa to disturbance from mobile fishing gears and assigned erect branching or laminar sponges as highly sensitive, massive sponges as intermediate sensitivity, and encrusting sponges as tolerant.<br><br>Interaction between midwater trawls and benthic habitats can occur via several elements of the gear, including trawl doors, auxiliary weights, cod-end, and footropes (DFO 2010*a*; NOAA 2014). However, as midwater trawl gear is not designed to make extensive contact with the seafloor (provided chafing gear is not used), gear damage is expected before substantial, widespread damage occurs to seafloor structures (Chuenpagdee et al. 2003; DFO 2010*a*). Experimental groundfish off-bottom trawls targeting Georges Bank Haddock documented seafloor contact via drop chains and footropes during operation (Chosid and Pol 2020). The study suggests that reduced bottom contact by midwater trawls, compared to bottom trawls, may allow additional areas to be opened to this gear type, but not areas with highly sensitive benthic ecosystems.<br><br>Fishing gear contact with sponges can cause damage and removal of biomass; however, recovery is possible. Polymastiids have shown good recovery and survival following damage (Duckworth 2003). The study found similar rates of growth in damaged and undamaged sponges, and estimated that damaged sponges could survive and recover from a loss of up to 90% of the individual's biomass. The estimated time for regrowth ranged from 155 weeks (for 50% biomass removal) to 400 weeks (for 90% biomass removal) on a Polymastiid sponge. Other species showed faster |

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| | | recovery of 39 to 75 weeks for 50% and 90% biomass removal respectively..<br><br>Taken together, due to the potential sensitivity of sponges to physical disturbance combined with the estimated recovery time of possibly over 1 year, a sensitivity score of 4 was assigned. |
| $Q_{Consequence}$ | Very High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 4$<br>$= 16$ (raw score) |
| Likelihood | Unlikely | Although midwater trawls are designed to operate above the seafloor and reduce seafloor contact as compared to bottom trawls, studies indicate that current midwater trawl gear does not eliminate contact with benthic structures (DFO 2010*a*; NOAA 2014; Chosid and Pol 2020). The frequency of benthic contact for midwater trawl gear is not well defined, and is likely dependent on operation depth and gear configuration. A review of catch data from midwater trawls targeting Pacific Hake and Pacific Ocean Perch within the Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs found that 13% of tows contained benthic species that could only be caught if the gear was on the bottom at some point during the tow (Boutillier et al. 2013). Experimental groundfish off-bottom trawls targeting Georges Bank Haddock also documented seafloor contact via drop chains and footropes during operation, although the frequency of contact was not provided (Chosid and Pol 2020). Bycatch records for midwaters trawl fisheries in the US Pacific recorded coral/sponge bycatch in ~0.4% of tows (amounting to 38.4 kg) between 2000-2010 (Hourigan et al. 2017). Occasional contact with the seafloor occurs from midwater trawl gear, particularly when the target species are in close proximity to the seabed (McConnaughey et al. 2019).<br><br>Observer records from 1977 to 2014 in 4X and 4W (Tables 2.4.7-1 and 2.4.7-2) did not document any recorded bycatch of sponges in the midwater trawl fishery targeting Silver Hake or Cod/Haddock/Pollock and Redfish.<br><br>Taken together, this would suggest that midwater trawl gear may occasionally interact with sponges, but that overall this interaction is expected to be unlikely. |
| Overall risk | High | Additional management measures are required to address risks from this pressure, such as restricting this fishery where it overlaps with significant concentrations of sensitive sponge species within the future MPA. Since this risk assessment is for a fishery that does not currently operate within the AOI, this analysis should be revised as more information, such as data on spatial footprint and bycatch, become available within the AOI assessment area. |

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| Uncertainty | High | Due to the minimal use of midwater trawls within the region at the time of assessment, a proxy fisheries footprint was developed using predicted species distribution of Silver Hake, which was identified as a potential target species for this fishery. Intensity was also presumed to be moderate due to lack of available data.<br><br>Available literature on the impacts of midwater trawls on sponges are very limited, although information is available on benthic contact of midwater trawls in general.<br><br>Sponge coverage and composition in the AOI has been confirmed through scientific surveys. There is sufficient evidence based on CSAS advice, relevant international research, and survey findings in other similar areas in Atlantic Canada that gears that may make contact with benthic structure, like midwater trawl, can cause damage to sensitive benthic features such as sponges, and several spatial closures to have been implemented in areas of high coral and sponge concentration (e.g., Northeast Channel Coral Conservation Area) where all bottom contact fishing gear is prohibited.<br><br>Available information on sponge recovery and growth rates is limited. While there is some research on Polymastiid recovery, there are several other sponge species present in the significant sponge area for which no information on recovery is available. |

**Risk Assessment – Midwater trawl and highly suitable habitat for Cusk**

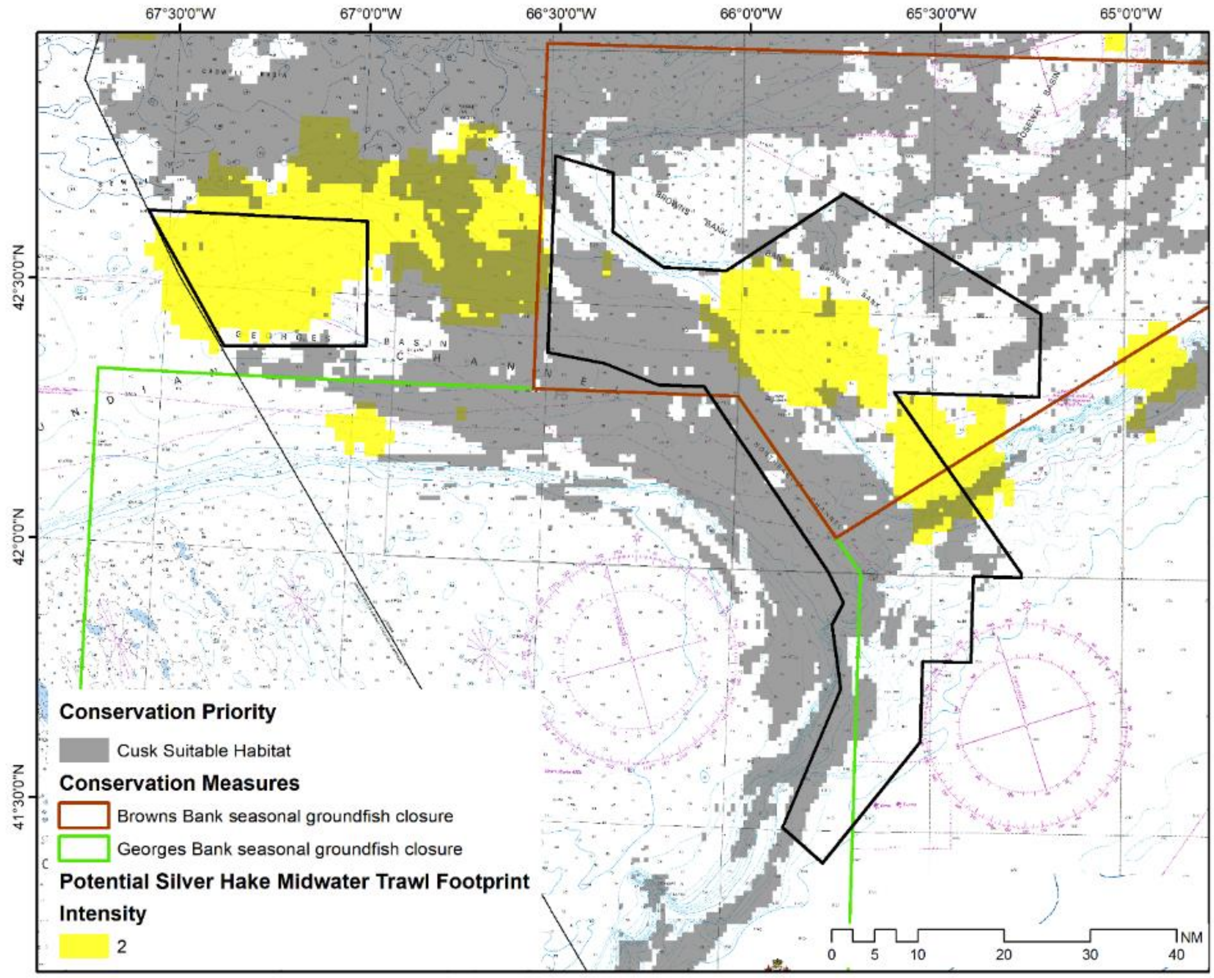


Figure 2.4.7-6. Overlap of predicted highly suitable Cusk habitat with potential groundfish midwater trawl fishery footprint in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). Groundfish midwater trawl gear is not currently operated within the AOI and intensity data is not available. As such, the median intensity score, moderate (2), was assigned.

**Risk Statement:** There is a risk that bycatch in midwater trawls will lead to negative impacts on the local population of Cusk in its suitable habitat within the AOI.

Table 2.4.7-7. Scoring for the risk posed by the midwater trawl fishery to Cusk within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 4 x 1<br>= 8 (raw score) |
| Intensity | 2 | Midwater trawl gear is not currently operated within the AOI, hence current intensity data is not available. As such, the median intensity score, moderate, was assigned. |
| Temporal | 4 | Cusk occur within the AOI year-round and the midwater trawl fishery can occur year-round in the area overlapping suitable cusk |

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| | | habitat, therefore there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 1 | There is minimal spatial overlap (7.3%) between the potential groundfish midwater trawl footprint and highly suitable Cusk habitat within the AOI. |
| $Q_{Sensitivity}$ | 2 | Fish species with a physoclistous swim bladder, such as Cusk, are likely to possess a lower survival rate when discarded due to their physiology (Cook et al. 2017). Cusk usually experience physical trauma when brought to the surface due to the expansion of gas in their swim bladders. Physical trauma includes: overexpansion or rupture of the swim bladder, stomach eversion, intestinal protrusion through the cloaca, external hemorrhaging, organ torsion, subcutaneous gas bubbles, ocular gas bubbles (Rummer and Bennet 2005; Hannah et al. 2008; Pribyl et al. 2009; Campbell et al. 2010; Rogers et al. 2011; Butcher et al. 2012 as cited in Chen and Runnebaums 2014). Additionally, Cusk are likely to remain positively buoyant when brought to the surface, which increases the probability of predation (Chen and Runnebaums 2014). Cusk that are released are therefore not likely to survive (COSEWIC 2012*a*).<br><br>Fishing mortality is the only known major source of anthropogenic mortality of Cusk (Harris and Hanke 2010). Cusk is a bycatch species in the groundfish fishery within 4VWX5 and can be legally landed and sold (DFO 2018*a*). Bycatch of Cusk is capped at 20 tons in the MG <65' fleet (DFO 2018*a*).<br><br>Recent DFO science advice places local (NAFO divisions 4VWX5Z) Cusk population biomass above the Limit Reference Point (DFO 2021*b*), and analyses using data from the Halibut Industry Survey suggests that the population abundance has been stable since 1999 (DFO 2014).<br><br>Taken together, the midwater trawl fishery could cause potential detectable changes in population size, but is only expected to have minimal impact on population dynamics. Therefore, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 2$<br>$= 6$ (raw score) |
| Likelihood | Unlikely | From 1977 to 2014, 819 midwater trawl fishing sets were observed by at-sea observers in 4X and 4W (Tables 2.4.7-1 and 2.4.7-2). Cusk was caught in approximately 5.4% of sets targeting Silver Hake, and in approximately 33.3% of sets targeting Cod/Haddock/Pollock and Redfish. Since most of the fishery overlapping the AOI is likely to target Silver Hake, a likelihood score of unlikely was assigned. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) to address risks from this pressure to Cusk, e.g., restricting |

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| | | this fishery in areas important to Cusk within the future MPA. Since this risk assessment is for a fishery that does not currently operate within the AOI, this analysis should be revised as more information, such as data on spatial footprint and bycatch, become available within the AOI assessment area. |
| Uncertainty | Moderate | Due to the minimal use of midwater trawls within the region at the time of assessment, a proxy fisheries footprint was developed using predicted species distribution of Silver Hake, which was identified as a potential target species for this fishery. Intensity was also presumed to be moderate due to lack of available data.<br><br>While the exact post-release mortality of Cusk has not been calculated, the peer-reviewed, science-based literature is clear that it is high, especially in situations where the Cusk are brought to the surface from significant depths.<br><br>The area of highly suitable habitat for Cusk was determined using the outputs of a habitat suitability model and is predictive in nature. |

**Risk Assessment – Midwater trawl and shallow-diving pursuit generalists (shearwaters)**

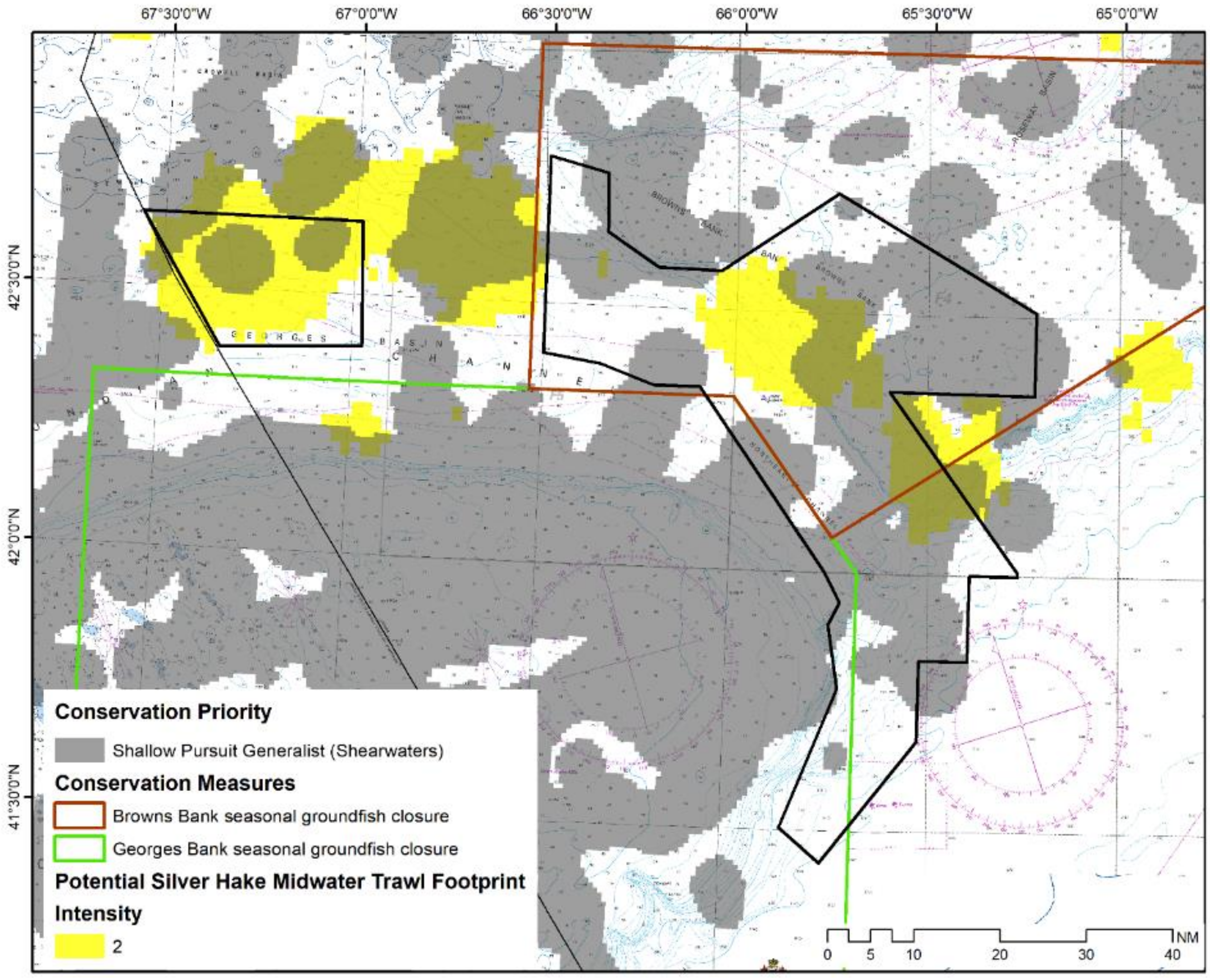


Figure 2.4.7-7. Overlap of predicted extent of shallow-diving pursuit generalists (shearwaters) with potential groundfish midwater trawl fishery footprint in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). Groundfish midwater trawl gear is not currently operated within the AOI and intensity data is not available. As such, the median intensity score, moderate (2), was assigned.

**Risk Statement:** There is a risk that bycatch in midwater trawls will lead to negative impacts on shearwaters in their foraging habitat within the AOI.

Table 2.4.7-8. Scoring for the risk posed by the midwater trawl fishery to shearwaters within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 3 x 2<br>= 12 (raw score) |
| Intensity | 2 | Midwater trawl gear is not currently operated within the AOI, hence current intensity data is not available. As such, the median intensity score, moderate, was assigned. |

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| Temporal | 3 | The midwater trawl fishery can occur year-round in areas that overlap with shearwater foraging habitat and shearwaters are present May through November. Therefore, there is potential temporal overlap for up to 7 months of the year. |
| Spatial | 2 | There is localized spatial overlap (25.8%) between the potential groundfish midwater trawl footprint and shearwater foraging habitat within the AOI. |
| $Q_{Sensitivity}$ | 2 | Shearwaters are shallow diving pursuit generalists that feed mainly on fish and squid. These birds can become entangled in trawl nets, particularly when nets are closer to the surface during hauling (Sullivan et al. 2006; Løkkeborg 2008). Birds can also be attracted to vessels due to fisheries discards, which can result in additional entanglement events (Anderson et al. 2011; Løkkeborg 2011). Additional mortality may also occur from collision with netsonde or warp cables (Sullivan et al. 2006; Løkkeborg 2011), although birds with shorter wingspans, such as Shearwaters, are possibly less susceptible (Melvin et al. 2011).<br><br>Compared to other seabird species, Shearwaters reproduce slowly, so loss of adults could have impacts to a population (Anderson et al. 2011). Of the species shown to reach significant concentrations within the AOI, only one species of Shearwater, the Sooty Shearwater, is listed as near threatened by the IUCN (IUCN 2020). The other two species, Great Shearwater and Cory's Shearwater, have been listed as Least Concern (DFO 2020*b*).<br><br>However, given the relatively healthy global populations of Great and Sooty Shearwaters, changes to population dynamics for these species as a result of this interaction within the AOI is not anticipated. Therefore, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 2$<br>$= 8$ (raw score) |
| Likelihood | Rare | A summary of all observer data from 1998-2011 within Atlantic Canada observed 153,596 midwater trawls and reported a total bycatch of 65 shearwaters (Hedd et al. 2015). It must be noted that this study found that the majority of bycatch was documented in the northern shrimp fishery on Flemish Cap. Additionally, shearwaters have been documented in bycatch reports from the Alaskan groundfish pelagic trawl fishery (Krieger and Eich 2020).<br><br>Observer records from 1977 to 2014 in 4X and 4W (Tables 2.4.7-1 and 2.4.7-2) did not document any recorded bycatch of Great Shearwaters or Sooty Shearwaters in the midwater trawl fishery targeting Silver Hake or Cod/Haddock/Pollock and Redfish.<br><br>Taken together, shearwater bycatch in groundfish midwater trawl fisheries is expected to be rare (Løkkeborg 2008; Hedd et al. 2015). |

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| Overall risk | Moderate | No additional management measures suggested given the low sensitivity score. However, since this risk assessment is for a fishery that does not currently operate within the AOI, this analysis should be revised as more information, such as data on spatial footprint and bycatch, become available within the AOI assessment area. |
| Uncertainty | High | Due to the minimal use of midwater trawls within the region at the time of assessment, a proxy fisheries footprint was developed using predicted species distribution of Silver Hake, which was identified as a potential target species for this fishery. Intensity was also presumed to be moderate due to lack of available data.<br><br>Further, as a result of low current activity of groundfish midwater trawls in the vicinity of the AOI, seabird entanglement data is limited. As such, broader seabird bycatch for midwater trawls within Atlantic Canada (1998-2011) and the Alaska groundfish pelagic trawl fishery were also considered to understand potential bycatch risk within the AOI.<br><br>Important marine bird foraging areas were identified using available data from offshore seabird surveys. Survey coverage has been limited, and while identified foraging areas are based on occurrences, they contain a predictive component.<br><br>As well, shearwaters complete extensive migrations and have a large habitat range, therefore it is difficult to determine how one activity in one location may impact the population. |

## 2.5 SUMMARY OF FISHERIES RESULTS

The risks presented by commercial fishing activity in the Fundian Channel-Browns Bank AOI were determined from available catch and observer data, literature and expert opinion. Table 2.5-1 contains the risk scores for all fishing activities and conservation priorities assessed in the AOI.

Table 2.5-1. Summary of the risk levels for each interaction assessed for commercial fisheries; grouped by conservation priority.

| Conservation Priority | Pressure | Exposure | Sensitivity | Likelihood | Risk Level |
|---|---|---|---|---|---|
| **Large mature female lobster** | Groundfish gillnet (bycatch/ entanglement) | 2 | 1 | Moderate | Low |
| | Groundfish longline (bycatch/ entanglement) | 2 | 1 | Rare | Low |
| | Midwater trawl (bycatch/ entanglement) | 4 | 1 | Rare | Low |
| **Beaked whale habitat** | Groundfish gillnet (bycatch/ entanglement) | 2 | 3 | Rare | Moderate |
| | Groundfish longline (bycatch/ entanglement) | 2 | 3 | Rare | Moderate |
| | Pelagic longline (bycatch/ entanglement) | 5 | 3 | Rare | Moderately High |
| | Buoy gear (bycatch/ entanglement) | 3 | 2 | Rare | Moderate |
| | Midwater trawl (bycatch/ entanglement) | 3 | 3 | Rare | Moderate |
| **Blue Whale foraging area** | Lobster pot (bycatch/ entanglement) | 4 | 3 | Rare | Moderately High |
| | Hagfish trap (bycatch/ entanglement) | 1 | 3 | Rare | Low |
| **Deep-water corals** | Lobster pot (bottom disturbance) | 3 | 5 | Almost certain | High |
| | Hagfish trap (bottom disturbance) | 1 | 5 | Almost certain | Moderately High |
| | Groundfish gillnet (bottom disturbance) | 4 | 5 | Almost certain | High |
| | Groundfish longline (bottom disturbance) | 2 | 5 | Almost certain | High |
| | Midwater trawl (bottom disturbance) | 3 | 5 | Unlikely | Moderately High |
| **Significant Sponge Concentrations** | Groundfish longline (bottom disturbance) | 2 | 4 | Almost certain | Moderately High |
| | Midwater trawl (bottom disturbance) | 4 | 4 | Unlikely | High |
| **Highly suitable habitat for Cusk** | Lobster pot (bycatch/ entanglement) | 3 | 2 | Unlikely | Moderately High |
| | Groundfish gillnet (bycatch/ entanglement) | 3 | 2 | Moderate | Moderately High |
| | Groundfish longline (bycatch/ entanglement) | 3 | 2 | Moderate | Moderately High |
| | Midwater trawl (bycatch/ entanglement) | 3 | 2 | Unlikely | Moderately High |
| **Foraging ground for most guilds of marine birds** | Groundfish gillnet (bycatch/ entanglement) | 3 | 2 | Rare | Moderate |
| | Groundfish longline (bycatch/ entanglement) | 1 | 2 | Rare | Low |
| | Pelagic longline (bycatch/ entanglement) | 4 | 2 | Rare | Moderate |
| | Midwater trawl (bycatch/ entanglement) | 4 | 2 | Rare | Moderate |

The use of marine vessels in fisheries results in additional pressures that were not assessed in this chapter. Pressures that are applicable to fisheries but were assessed in the Marine Transportation Chapter are as follows:

- Vessel strikes
- Artificial light
- Noise from small motorized vessels
- Small operational oil spills

## 2.6 REFERENCES


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# 3.0 MARINE TRANSPORTATION

## 3.1 SECTOR OVERVIEW

Fundian Channel-Browns Bank AOI traffic patterns are dominated by three types of vessels. From available data, cargo ships contribute the most to vessel density patterns, transporting goods among ports on the east coast of North America and abroad. Tankers also pass through the AOI, predominantly along the same path as cargo ships. Fishing vessels deploy gear within the AOI and also transit through the area to and from Georges Bank. Vessel traffic patterns are described further below.

Vessel traffic patterns within the AOI

An analysis of vessel traffic patterns within the Fundian Channel-Browns Bank AOI was conducted using available Automatic Identification System (AIS) data. AIS is an automated system for vessel tracking that relies on ship-borne VHF transponders that transmit information to receivers on shore stations, satellites, and other ships (Canadian Coast Guard 2019). AIS is mandatory for all passenger vessels (carrying 12 or more passengers), vessels of ≥300 gross tonnes on international voyages, and vessels of ≥500 gross tonnes on domestic voyages. The information transmitted via AIS includes dynamic messages (i.e., automatically generated data on vessel speed, location, and direction of travel) and static messages that are manually entered by the vessel operator and provide details on the vessel itself (e.g., vessel name, dimensions, and type). Small pleasure craft and fishing vessels are not required to carry AIS transponders, but some do for safety purposes (Konrad 2020).

For the assessment of risks posed by marine transportation-related pressures to conservation priorities for the AOI, vessel density maps were created from available AIS data in the area for one representative year, from March 1, 2017 to February 28, 2018; previous AIS studies (e.g., Simard et al. 2014) demonstrate similar patterns of vessel use in the study area. Maps include traffic patterns for all vessels combined (Figure 3.1-1) and maps by vessel type (see Figure 3.1-2 to Figure 3.1-4) for the three most common classifications (i.e., tankers, cargo ships, and fishing vessels).

Cargo ships and tankers were the first and third most commonly classified vessel types, respectively, found within the AOI during the assessment period. Even with the incomplete AIS coverage for fishing vessels, they were the second most commonly classified vessel type in the AOI. All other AIS vessel categories were present in low densities (Table 3.1-1). Tanker density displayed little monthly variation, while cargo ship density peaked in February and March and was fairly consistent during the remainder of the year (Figure 3.1-5). Fishing vessel activity was notably higher in June and July, with a smaller peak in March. There was a slight decrease in total vessel activity during the night, though cargo ship activity decreased by almost 40% (Figure 3.1-6).

Note that there was a discrepancy between classified vessel types and total activity captured in the AIS dataset. This is likely due to vessels that did not register a vessel type in their outgoing static AIS message (i.e., the "vessel type" field was left blank or entered as a non-numeric code such as "NA"). Larger vessels, such as tankers/cargo ships and passenger vessels demonstrate high levels of consistency between their listed vessel type and actual vessel type (~99% and 79% identified accurately, respectively; Konrad 2020) and therefore the patterns demonstrated by those classified vessel types are considered reliable. Other vessels, such as fishing vessels, are commonly misclassified in the AIS data (only 33% identified accurately; Konrad 2020). Therefore, vessel densities by vessel type may be underestimated for certain classifications, including fishing vessels. Because of this, consideration of analyses and maps of slow-moving vessels (described further below) may further inform inferences about vessel traffic patterns for fishing vessels, which tend to operate at slower speeds for gear deployment and retrieval.

Vessel density maps by speed (Figure 3.1-7 and Figure 3.1-8) were also created to inform the analyses of vessel strikes and noise interactions. The "fast" category included vessels travelling >10 and ≤50 knots, while "slow" vessels were defined as traveling at ≥3 and ≤10 knots. The threshold for fast vessels (i.e., >10 knots) was chosen based on current speed restrictions enacted in the Gulf of St. Lawrence to mitigate the risk of vessel strikes on North Atlantic Right Whales (Transport Canada 2020*a*). This was based on studies by Vanderlaan and Taggart (2007) that suggested lower speeds reduced the probability of a lethal strike. Laist et al. (2001) also documented that severe injury or mortality in large whales was not seen for vessel strikes occurring below 10 knots. However, it should also be noted that more recent investigation has suggested that lethal strikes can occur at speeds lower than 10 knots depending on the orientation and location of impact and the morphological characteristics (e.g., blubber thickness) of the whale (Kelley et al. 2021). Three knots was selected as the lower bound of the "slow" category to eliminate moored vessels and drifting AIS-equipped buoys, and the upper 50 knot bound of the "fast" category was included to remove higher speeds, as these reports are assumed to be erroneous (Konrad 2020). The majority of tankers and cargo vessels transited through the AOI at speeds >10 knots (Figure 3.1-9), while fishing vessels traveled at slower speeds.

Vessel traffic patterns varied by vessel type. Cargo ships travelled predominantly along a corridor adjacent to the shelf edge across the AOI, though they occurred in lower densities throughout the whole area (Figure 3.1-2). Tankers predominantly followed the same tracks as cargo ships, though in lower densities (Figure 3.1-3). Available data indicate that fishing vessels carrying AIS transponders most often transited the northern half of the Fundian Channel portion of the AOI, presumably to reach fishing grounds on Georges Bank (Figure 3.1-4), though fishing vessels also frequent Browns Bank and the edge of the Scotian Shelf.

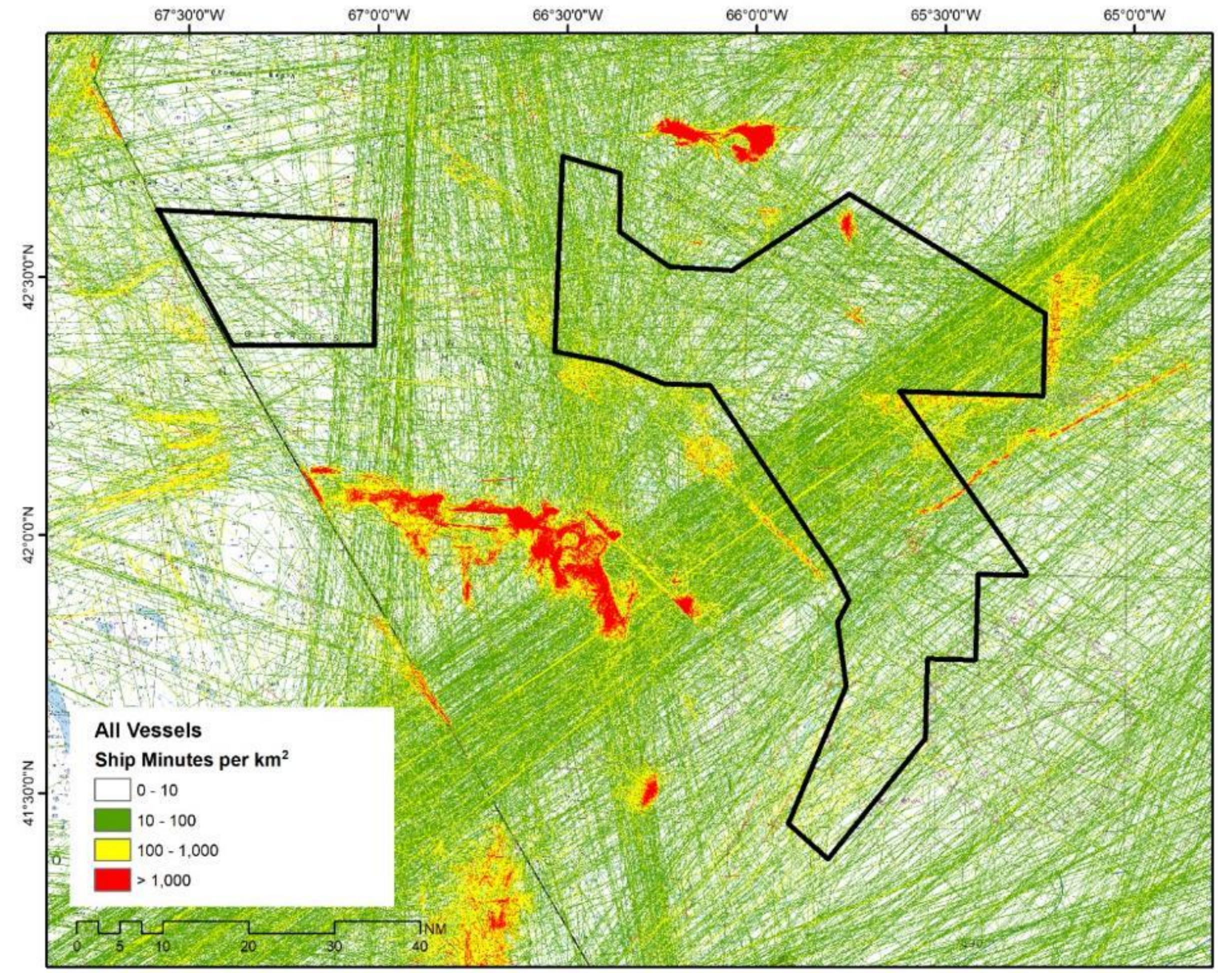


Figure 3.1-1. Vessel density for all vessel types in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available Automatic Identification System (AIS) data.

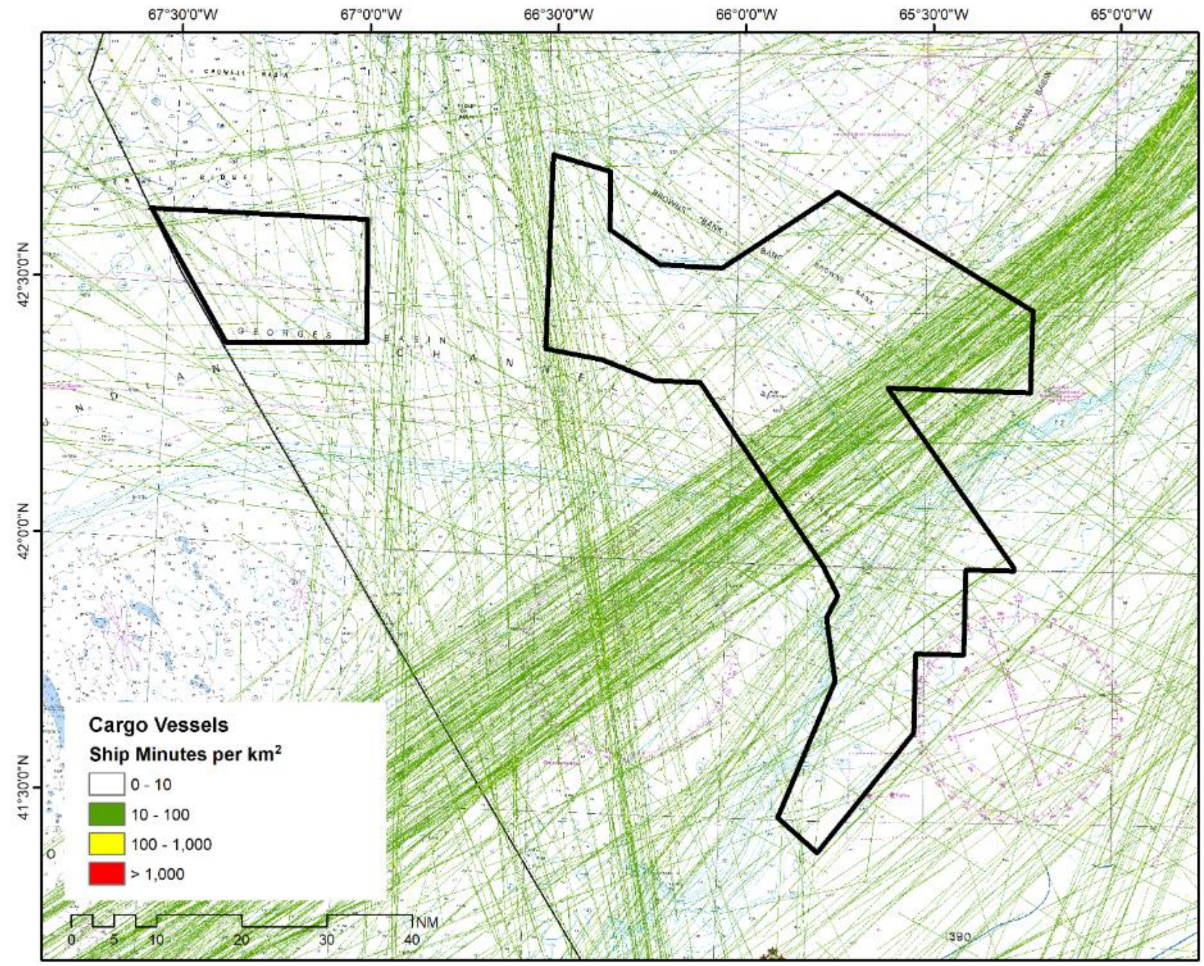


Figure 3.1-2. Cargo vessel density in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available Automatic Identification System (AIS) data.

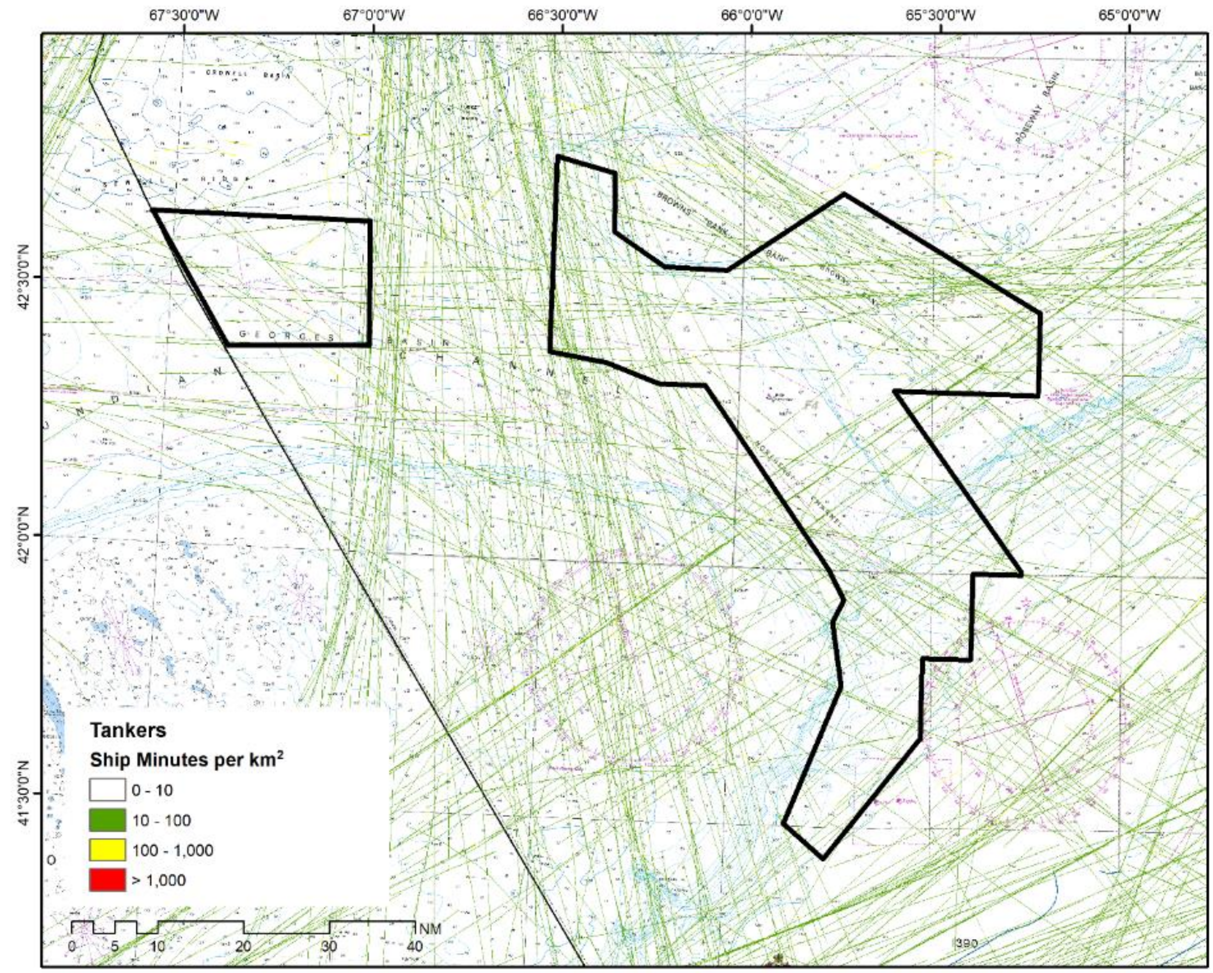


Figure 3.1-3. Tanker density in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available Automatic Identification System (AIS) data.

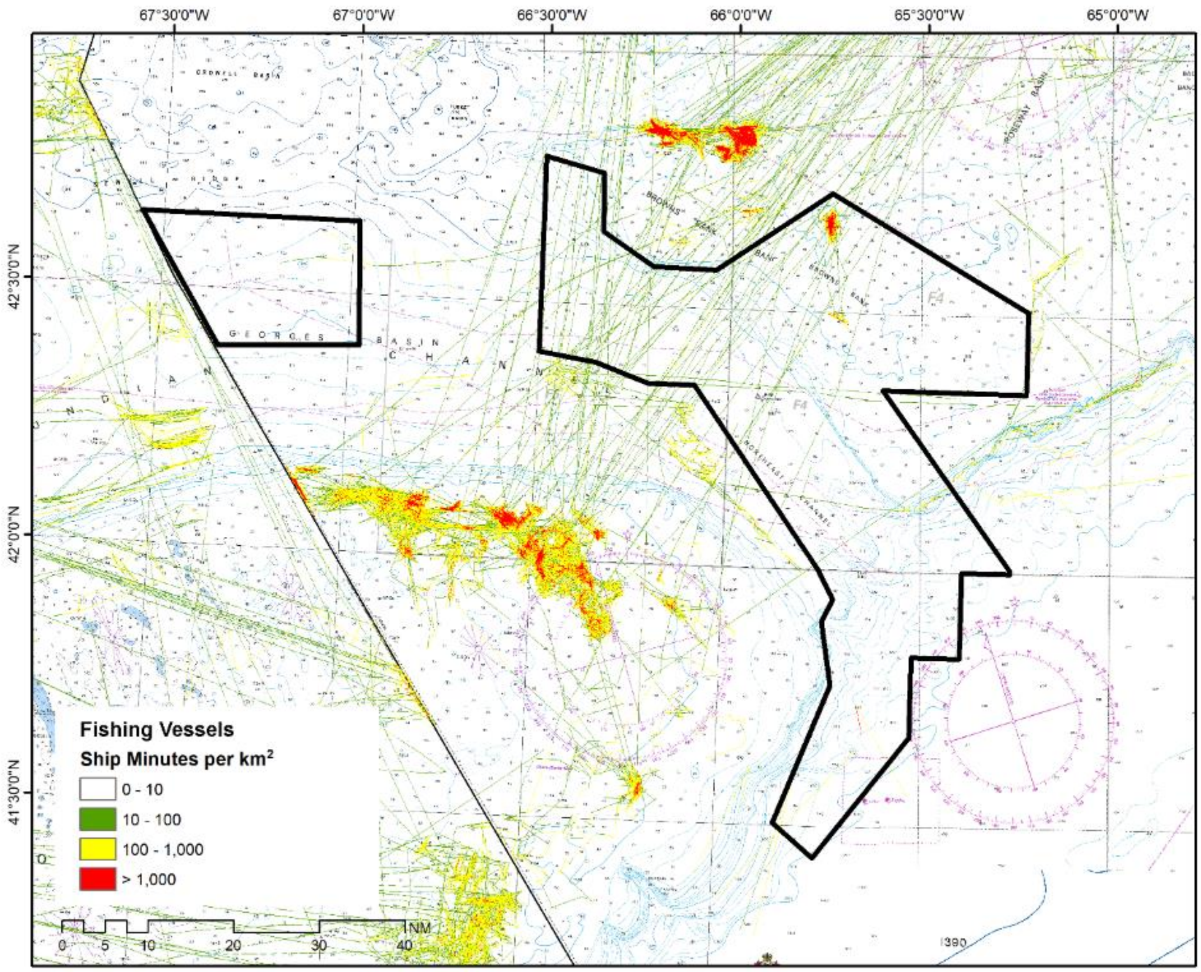


Figure 3.1-4. Fishing vessel density in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available Automatic Identification System (AIS) data. Note: fishing vessels are not required to carry AIS transponders and are often misclassified; thus, an underestimate of density is expected.

Table 3.1-1. Total vessel minutes by classified vessel type in the Fundian Channel-Browns Bank Area of Interest from March 1, 2017 to February 28, 2018. Available data from the Automatic Identification System (AIS) were used. Vessel minutes per day were estimated without considering seasonal variability. Vessel classifications taken from International Maritime Organization guidance. Although all AIS categories were analyzed, those with no activity were excluded from this table. Note: fishing vessels are not required to carry AIS transponders and are often misclassified so vessel activity is expected to be underestimated for this class.

| Code | AIS categories | Vessel type classification | Total vessel minutes | Vessel minutes per day |
|---|---|---|---|---|
| 1-9 | 1-9 | Not used | 340 | <1 |
| 10-19 | 10-19 | "Reserved for future use" | 44 | <1 |
| 30 | 30 | Fishing (also includes fish carrier and fish farm support vessel) | 37,106 | 102 |
| 33 | 33 | Dredging or underwater ops (buoy tending, pipe burying vessel, ice breaking, and research) | 305 | <1 |
| 35 | 35 | Military ops (also includes naval training ships) | 50 | <1 |
| 38-39 | 38, 39 | "Reserved for future use" | 9,816 | 27 |
| 51 | 51 | Search and rescue vessel | 257 | <1 |
| 52 | 31, 32, 52 | Tug/towing (also includes "salvage ship") | 228 | <1 |
| 53 | 53 | Port tender (attending and off-shore supply vessels, and similar support craft) | 44 | <1 |
| 60 | 40-49, 60-69 | Passenger (passenger ferries, high-speed craft, and "Passenger/Ro-ro Ship") | 2,112 | 6 |
| 70 | 70-79 | Cargo (also includes "heavy load carrier – semi-submersible") | 49,510 | 136 |
| 80 | 80-89 | Tanker | 21,296 | 58 |
| 90 | 90-99 | Other | 3,113 | 9 |
| 0 | Unclassified | Unclassified vessels | 7,377 | 20 |

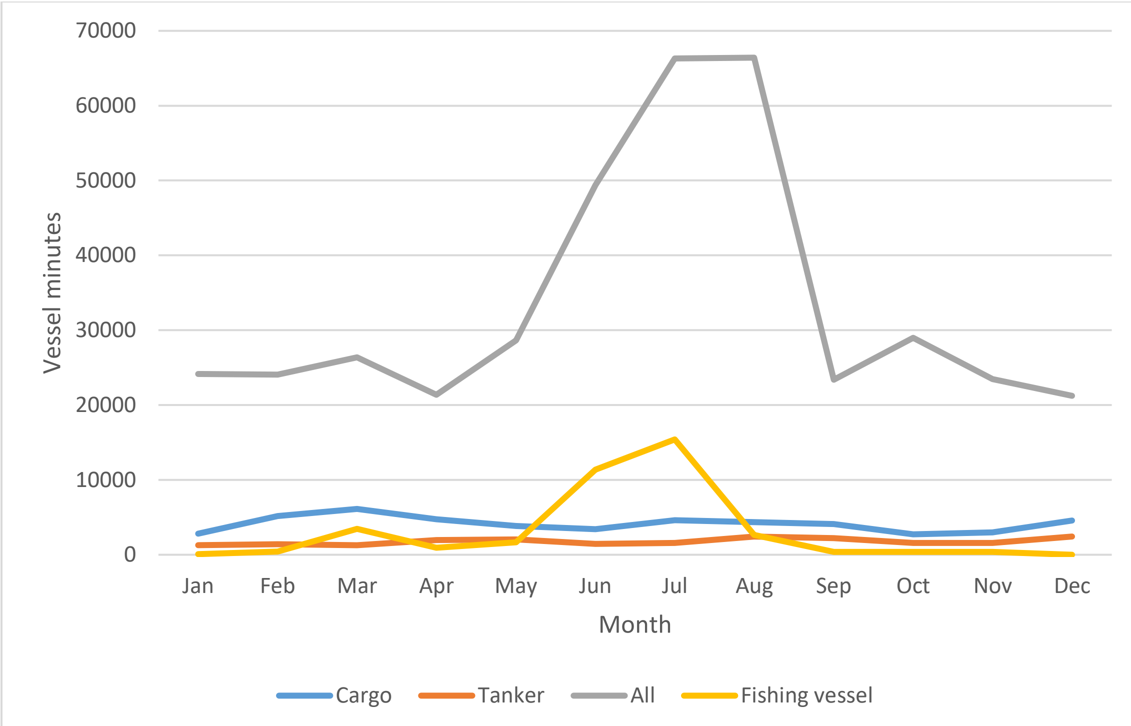


Figure 3.1-5. Total vessel minutes by month from March 1, 2017 to February 28, 2018 in the Fundian Channel-Browns Bank Area of Interest. The three most common vessel types and all vessel types together are shown. Available Automatic Identification System (AIS) data were used. Note: fishing vessels are not required to carry AIS transponders and are often misclassified, so fishing vessel activity is expected to be underestimated.

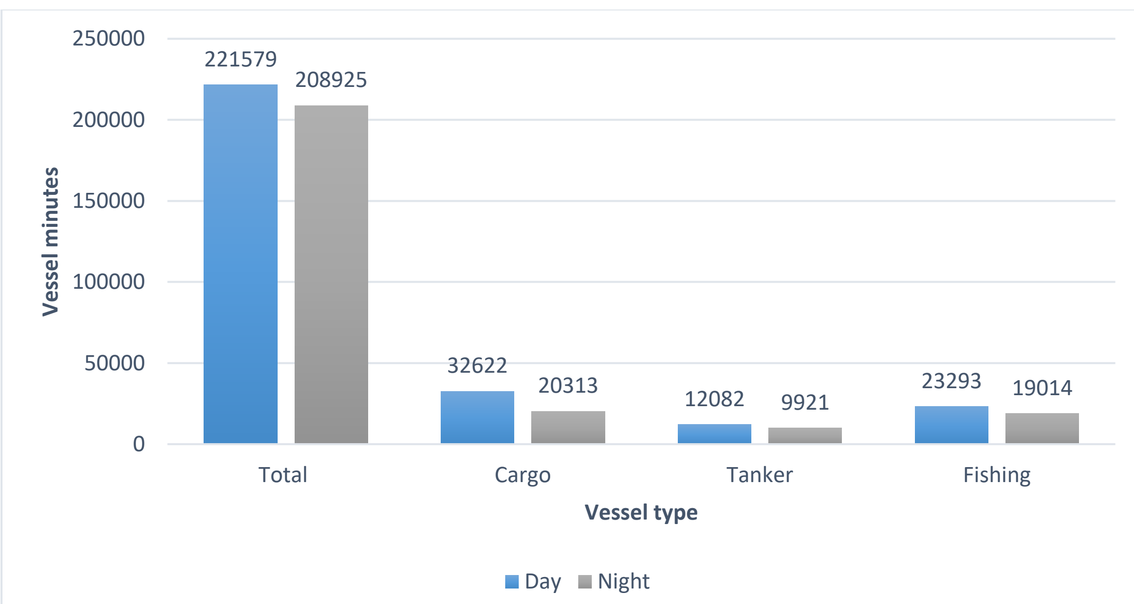


Figure 3.1-6. Total vessel minutes by day/night from March 1, 2017 to February 28, 2018 in the Fundian Channel-Browns Bank AOI. The three most common vessel types and all vessel types together are shown. Available Automatic Identification System (AIS) data were used. Note: fishing vessels are not required to carry AIS transponders and are often misclassified, so fishing

vessel activity is therefore expected to be underestimated. Sunrise and sunset times from NOAA's sunrise/sunset calculator (https://www.esrl.noaa.gov/gmd/grad/solcalc/sunrise.html) for the coordinates 42.5°N, 66°W were taken on the 15th of each month and used to determine the length of the day for that month. Vessel minutes were then grouped into day or night categories using the day length estimates for each month.

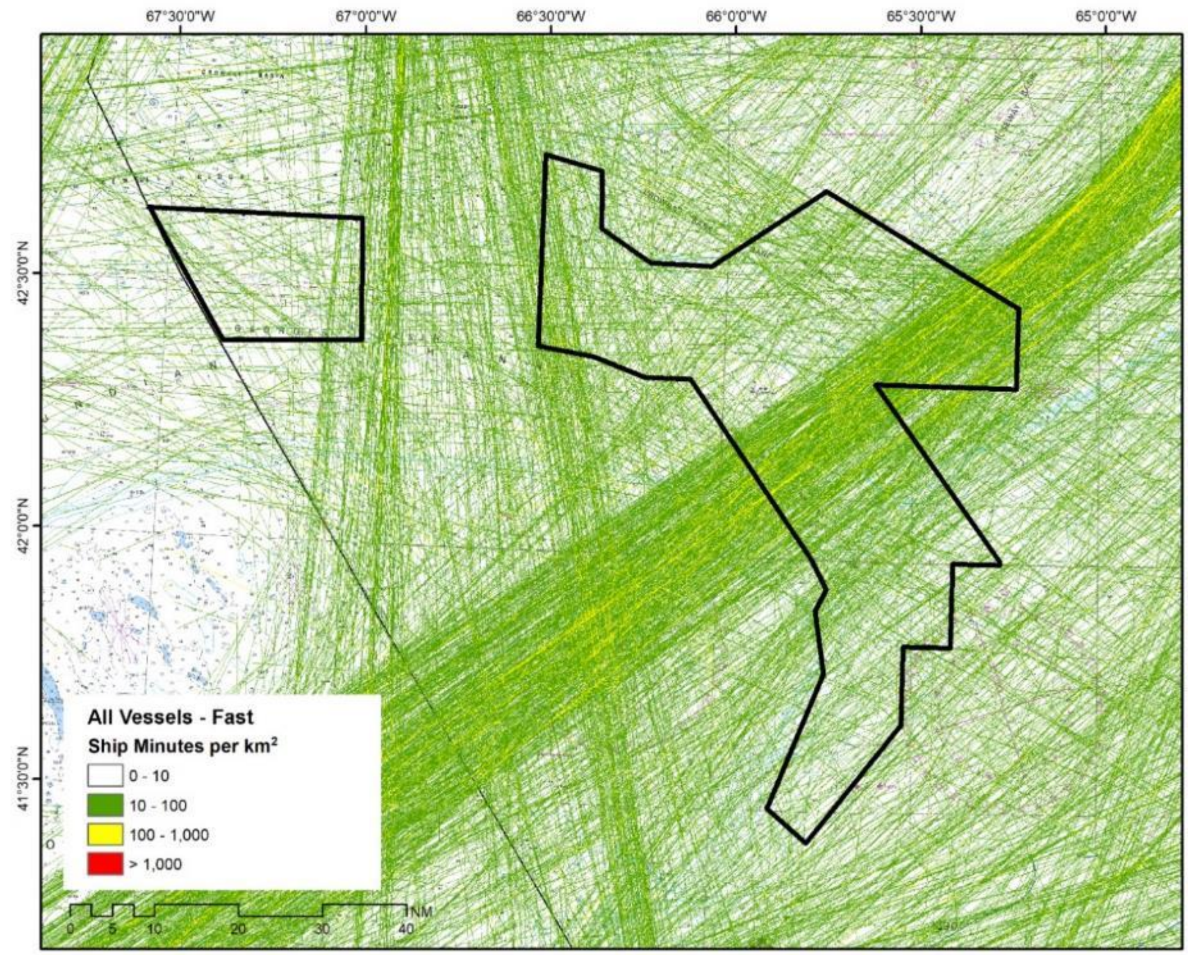


Figure 3.1-7. Vessel density for those travelling >10 knots in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available automatic identification system (AIS) data.

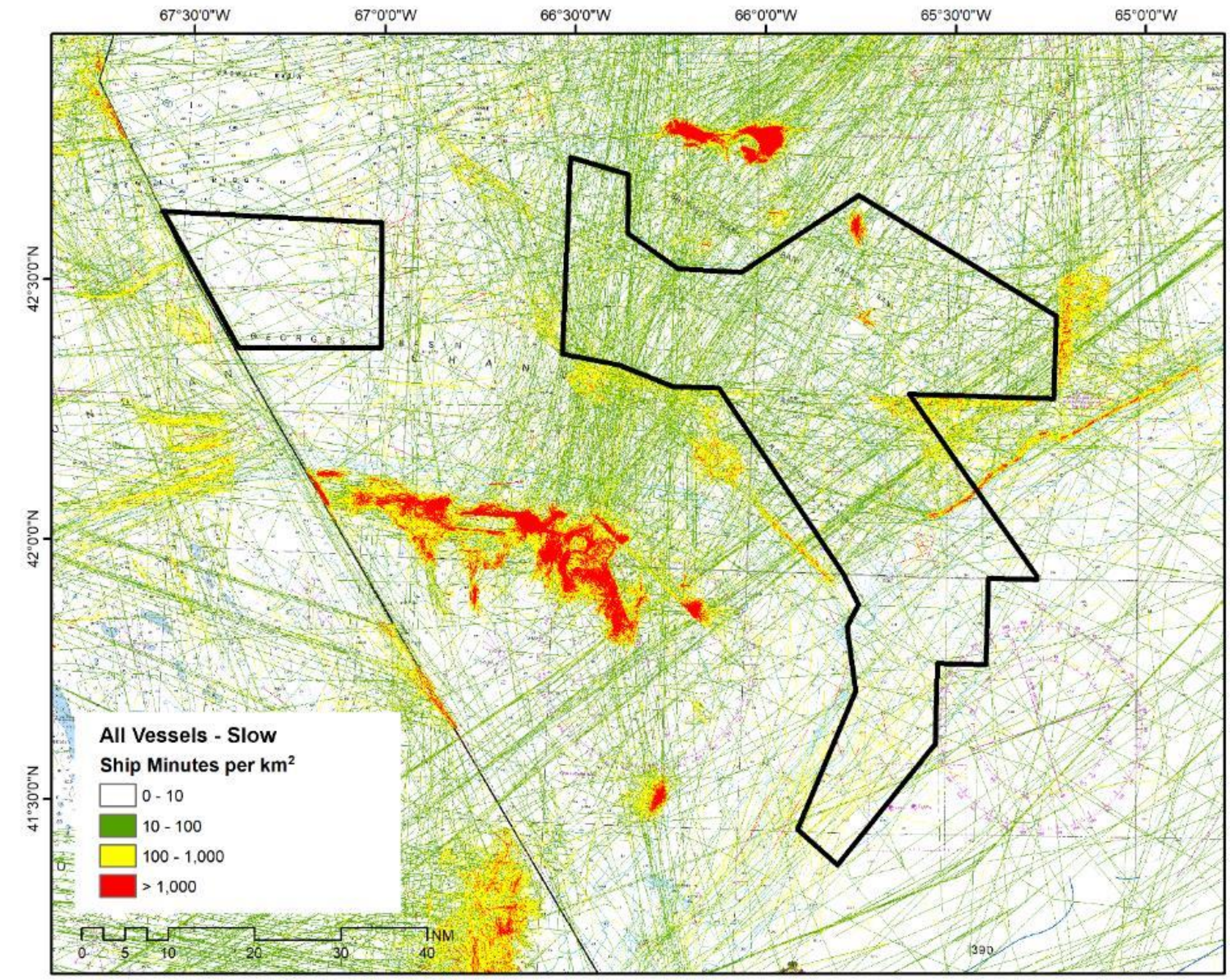


Figure 3.1-8. Vessel density for those travelling ≥3 and ≤10 knots in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available automatic identification system (AIS) data.

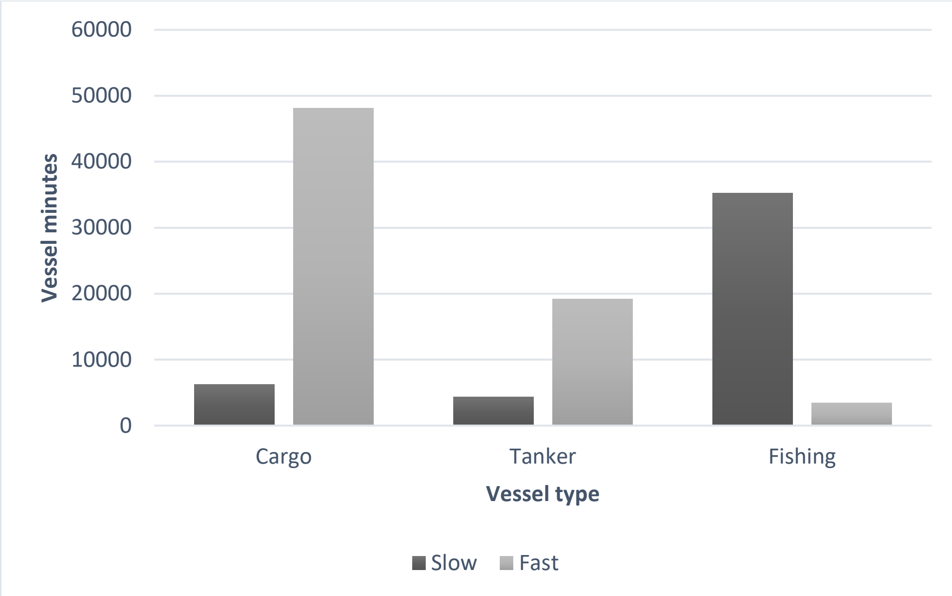


Figure 3.1-9. Vessel minutes by vessel type and speed in the Fundian Channel-Browns Bank Area of Interest from March 1, 2017 to February 28, 2018 using available Automatic Identification System (AIS) data. "Slow" vessels travelled at speeds ≥3 and ≤10 knots while "fast" vessels travelled at speeds >10 knots. Note: fishing vessels are not required to carry AIS transponders and are often misclassified, so fishing vessel activity is therefore expected to be underestimated.

Existing management measures

Transport Canada is the federal government department that regulates marine transportation in Canada. This department is responsible for overseeing and regulating navigation, marine pollution, government ports and harbours, and recreational boating, among others. The *Canada Shipping Act* is the umbrella act for marine activities and regulates the greatest number of marine transportation-related aspects. Provisions regarding vessel traffic-related activities, such as vessel speed, presence, and navigation are regulated through the *Canada Shipping Act* and the regulations that derive from it. The *Canada Marine Act* encompasses regulations for commercial ports overseen by individual authorities and includes provisions for safety and environmental protection.

Provisions under the *Canada Shipping Act* the *Fisheries Act* the *Canadian Environmental Protection Act*, and related regulations and guidelines have been developed to reduce and control vessel-sourced discharges (e.g., bilge water, fuel oil sludge, slop tank releases, sewage, solid wastes, ballast water, and accidental oil spills) into waters under Canadian jurisdiction. For example, the "Pollution Prevention Guidelines for the Operation of Cruise Ships under Canadian Jurisdiction" outlines legislative requirements and best practices in environmental protection for the cruise ship industry in the Canadian context. Furthermore, the *Vessel Pollution and Dangerous Chemicals Regulations* include requirements for anti-fouling systems for vessels that engage in international voyages. However, there are currently no hull fouling regulations specific to domestic vessels (Adams et al. 2014).

While no official regulations are in place to control the effects of underwater noise generated by ships in Canadian waters, guidance does currently exist. In 2014, the International Maritime Organization (IMO) approved a series of non-mandatory guidelines to reduce underwater noise from commercial shipping, including considerations on how to design quieter propellers and hulls, operational and maintenance considerations such as cleaning propellers, and suggestions on reducing speed (IMO 2014). Transport Canada then took measures to better understand the scope of the problem by contracting the Green Marine Management Corporation to assess the issue of underwater noise in domestic waters and by creating a formal working group. In 2019, Transport Canada hosted an international workshop entitled "Quieting Ships to Protect the Marine Environment", from which a final report was drafted containing a series of recommended actions that may help address the impact of noise from ships (see Bahtiarian 2019). Little official guidance currently exists with regards to smaller vessels such as fishing boats.

To protect sensitive species or areas, voluntary measures such as Areas to be Avoided (ATBA) (e.g., the Roseway Basin ATBA, see section 3.4.1) or vessel slow-downs can be used to mitigate impacts from vessel activities. The IMO has also adopted the use of Particularly Sensitive Sea Areas (PSSAs) which are spaces declared to have certain significant ecological, social, cultural, economic, or scientific importance and may be vulnerable to negative impacts from ships. To protect established PSSAs, special voluntary routing measures can be enacted to protect the area (IMO 2019). There are currently no such measures in place for waters within the AOI. The Canadian Coast Guard publishes an annual Notice to Mariners (NOTMAR) (Canadian Coast Guard 2021) which offers best practices and guidance on maritime issues. This guidance will be discussed further in section 3.4.1 as it pertains to vessel operations around marine mammals, including in marine protected areas.

## 3.2 SCOPE OF THE MARINE TRANSPORTATION RISK ASSESSMENT

For the purposes of this evaluation, marine transportation-related pressures to be assessed are vessel collisions/disorientation, noise, small-volume operational oil spills, and large oil spills.

Raw sewage and greywater discharge from vessels may pose risks to various ecosystem components within the AOI, including potential for smothering, excess nutrient load, and exposure to toxins (Science Advisory Panel 2002; Holeton et al. 2011). However, Section 86 of the *Vessel Pollution and Dangerous Chemicals Regulations* requires all vessels that have toilets on board to have a holding tank or an approved marine sanitation device. Section 96 of these Regulations prescribes the requirements for authorized discharges of sewage from these holding tanks/treatment devices, including treatment requirements and permissible distances from shore. Specifically, untreated sewage can only be released by a small vessel (<400 gross tonnage, or not certified to carry more than 15 passengers) if it is at least 3 nautical miles from shore moving at the fastest feasible speed. The distance increases to 12 nm from shore with speeds ≥4 knots for larger vessels (≥400 gross tonnage, or certified to carry more than 15 passengers). Section 131.1 prohibits greywater discharge from any vessel if the discharge deposits solids in the water or creates a sheen on the water. Additionally, a new passenger vessel carrying >500 passengers must pass greywater through an appropriate marine sanitation device or discharge greywater >3 nm from land. Thus, the authorized release of sewage and greywater within the AOI can only occur under conditions designed to ensure adequate dilution of discharge. Given the measures already in place, the relatively low density of vessel traffic, and oceanographic conditions in the AOI, this pressure will not be assessed further.

In an effort to reduce harmful air emissions from vessels the *Vessel Pollution and Dangerous Chemicals Regulations* limits the sulphur content of marine fuels to 0.5% as of January 1, 2020. Alternatively, vessels can employ exhaust gas cleaning systems, or scrubbers, to ensure an equivalent reduction in sulphur content in emitted exhaust. These systems use large volumes of seawater in their operation, and the output is cleaning residue and wash water. Though the residue must be offloaded at a shore facility, the wash water can be discharged at sea and can contain pollutants such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals, which can be harmful to the marine environment (Lange 2015). However, in accordance with the *Vessel Pollution and Dangerous Chemicals Regulations*, wastewater pH, turbidity, and pollutant concentrations are limited to align with acceptable levels outlined in the IMO resolution MEPC 184(59) guidelines or the more recent MEPC 259(68) for vessels built after May 15, 2015. Thus, the authorized release of scrubber wash water can only occur under conditions designed to ensure adequate dilution. Considering this, in conjunction with the dynamic oceanographic conditions of the AOI, this pressure is expected to have negligible impacts and will not be assessed further.

Non-indigenous species can have myriad effects on an ecosystem including competition for space, prey, and other resources, disruption of food webs, and introduction of parasites and pathogens (Lambert et al. 1992; Tan et al. 2002; Daniel and Therriault 2007). Marine transportation may serve as a vector for the spread of non-indigenous aquatic species, including through fouling (e.g., of the hull or sea chest) and ballast water releases (Lacoursiere-Roussel et al. 2012).

Ballast water is carried in tanks onboard vessels and is taken up or discharged at port to ensure stability under varying loads and conditions at sea and has the potential to carry organisms and pathogens between locations (Government of Canada 2019). To reduce the spread of invasive species through ballast water, options include treatment or exchange. Ballast water treatment serves to eliminate non-indigenous species before the water is discharged into the environment. In accordance with the IMO Convention D-2 standard (IMO n.d.), treatment may include ultraviolet irradiation, filtration, and/or chemical additives – with multiple methods potentially employed as part of a single treatment plan (Dobroski et al. 2007; DFO 2019). Ballast water exchange in accordance with the IMO convention D-1 standard involves the replacement of low-salinity coastal water taken up at port with high-salinity water taken up offshore; as coastal species are unlikely to survive in the open ocean and vice-versa, ballast exchange can effectively reduce the spread of invasive species through this vector. IMO regulations that came into force in 2017 require ballast water treatment systems to be in place aboard all vessels registered to signatory countries that travel internationally by 2024 (*International Convention for the Control and Management of Ships' Ballast Water and Sediments*). Until treatment systems are in place onboard all vessels in 2024, ballast water exchange will still be the predominant management method.

Canada's *Ballast Water Regulations* came into force in 2021 and align with the IMO convention. The regulations outline cascading sets of conditions – where the preferred conditions cannot be met, subsequent conditions are outlined. After 2024, ballast water treatment as outlined above will be mandatory. Until then, the baseline conditions state that vessels must exchange ballast in water at least 200 nm from shore where depths reach at least 2,000 m. Where this is not possible due to safety or logistical concerns, the *Ballast Water Regulations* outline two subsequent sets of parameters by reference to the IMO convention: exchange at least 200 nm from land and in water at least 200 m deep and, where that is not possible, at least 50 nm from land and in water 200 m deep. Finally, where the sets of conditions outlined above cannot be met, exchange may be conducted in an alternate ballast water exchange zone (ABWEZ) as designated in TP 13617E (Transport Canada 2021). The Eastern Canada ABWEZ encompasses the area south of 43°30' north latitude where water is 1,000 meters deep (grey polygon, Figure 3.2-1). Specifically, in the vicinity of the FCBB AOI, the TP 13617E directs vessels traveling to or from Nova Scotia or following a shelf break path to conduct exchanges in water at 1,000 m deep away from the entrance to the Northeast (Fundian) Channel. Further, vessels traveling to and from the Bay of Fundy, crossing the Gulf of Maine, or using a coastal route along the Scotian Shelf must conduct exchanges in the Gulf of Maine in waters deeper than 100 m (magenta polygon, Figure 3.2-1).

Given the minimal overlap between the ABWEZ and the AOI, the deep waters in which the overlap occurs, the circulation patterns that would contribute towards removal of any organisms from the AOI (Brickman et al. 2004), and the stricter ballast water management regulations that will be coming into force in 2024 (IMO n.d.), the potential number of foreign organisms dispelled into the AOI is expected to be minimal and ballast water exchange will not be assessed further.

Multiple factors limit the likelihood of hull fouling as a substantive vector for non-indigenous species establishment for this offshore AOI: the transient nature of vessels traversing the area means there is limited time for organisms to detach and/or expel gametes that can then become established; environmental differences (e.g., water depth, suitable substrate) between the location of attachment of fouling organisms (i.e., coastal ports) and the offshore AOI reduces survivability; and anti-fouling measures (e.g., regular hull cleaning) designed to reduce drag and improve transit efficiency also reduce the number of fouling organisms exposed to the AOI environment. Altogether, hull fouling is not expected to pose a measurable risk to conservation priorities for the AOI and will not be assessed further.

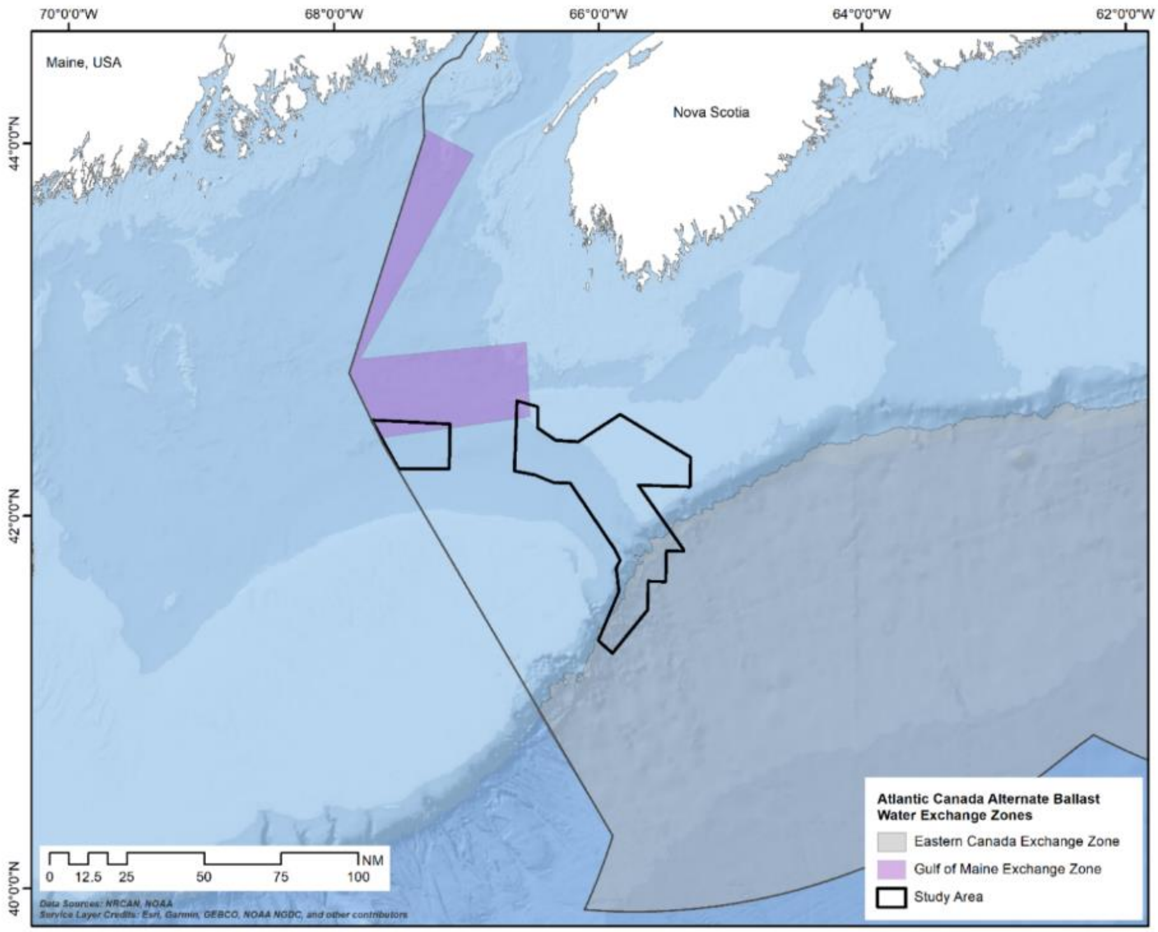


Figure 3.2-2. Alternate Ballast Water Exchange Zones (ABWEZ) near the Fundian Channel-Browns Bank Area of Interest (adapted from: Transport Canada 2021).

Various response measures are available in the event of a large oil spill including booming and skimming, in-situ burning, decanting, and the application of chemical dispersants (Lee et al. 2015). The *Canada Oil and Gas Operations Act* authorizes dispersant use in oil spill response if there is evidence that application will provide a net environmental benefit. These response measures may modify the fate and behaviour of oil, which may change exposure and/or sensitivity of different ecosystem components during a spill (Lee et al. 2015). Weather, oceanographic, logistical, and temporal considerations limit the scenarios in which response measures can be successfully deployed (e.g., in-situ burning may not be a response option considered for spills close to human habitation due to air quality impacts) though in general the location of this AOI does not preclude their use. Response measures may be considered in a future environmental response plan for the AOI; however, the analysis presented here will focus on the impacts of the oil in a no-intervention scenario and will not consider alternative response measures.

<u>Potential for interaction</u>

The potential for interactions between marine transportation activities and conservation priorities for the AOI are identified in Table 3.2-1. Where multiple conservation priorities within an assemblage (e.g., groundfish, cetaceans, or marine birds) have a known potential for interaction with a specified pressure, the risk assessment only analyzed the interaction for the most sensitive species or ecosystem component of the group, as determined by review of the literature and expert opinion.

Table 3.2-1. Potential for interaction between marine transportation pressures and conservation priorities for the Fundian Channel-Browns Bank AOI. Dark blue shading indicates that an exposure pathway exists and effects are known to occur, light blue indicates that an exposure pathway exists and effects may occur, and white indicates a lack of interaction. An asterisk identifies interactions selected to undergo the risk assessment.

| Conservation Priority | Vessel Interactions | | Vessel-based noise | | Oil spills | |
|---|---|---|---|---|---|---|
| | Vessel Collisions | Artificial light (disorientation /collisions) | Propellers, machinery | Echosounders | Small, operational oil spills (mL - L) | Large (79,000 $m^2$) heavy fuel oil spill |
| Large mature female lobster | | | | | | * |
| Cetaceans: Beaked whale habitat | | | * | * | | * |
| Cetaceans: Blue Whale foraging area | * | | * | * | | |
| Sensitive benthic sp: Deep-water corals | | | | | | * |
| Sensitive benthic sp: Significant sponge concentrations | | | | | | |
| Groundfish: Juvenile Atlantic Halibut habitat | | | | | | |
| Groundfish: Atlantic Cod habitat | | | * | | | * |
| Groundfish: Atlantic Wolffish habitat | | | | | | |
| Groundfish: Thorny Skate habitat | | | | | | |
| Groundfish: Winter Skate habitat | | | | | | |
| Groundfish: White Hake habitat | | | | | | |
| Groundfish: Cusk habitat | | | | | | |
| Marine birds: Shallow-diving pursuit generalists | | | | | | |
| Marine birds: Surface-seizing planktivores/piscivores | | * | | | | |
| Marine birds: Surface shallow-diving piscivores | | | | | | |
| Marine birds: Pursuit-diving piscivores | | | | | * | * |
| Marine birds: Pursuit-diving planktivores | | | | | | |
| Area of high productivity (plankton) | | | | | | * |

*Vessel interactions (collisions)*: The occurrence of large vessels and cetaceans in the same space can lead to collisions that can result in injury or mortality (Laist et al. 2001); this is considered a threat to recovery for at-risk cetaceans in Atlantic Canada (COSEWIC 2006; Beauchamp et al. 2009; DFO 2010). Baleen whales are considered more susceptible to this stressor than beaked whales due to their large size and lower maneuverability (Beauchamp et al. 2009; DFO 2017*a*); therefore, Blue Whales were selected for assessment.

*Vessel interactions (artificial light-induced disorientation and collisions)*: Although vessels transiting the AOI will use navigational lights as a regular component of night operations, their comparatively low brightness and transient nature are not expected to lead to noticeable impacts on the AOI's conservation priorities. In contrast, brighter lighting associated with nighttime deck operations (e.g., fishing vessels preparing gear) may be a source of potential negative effects (Montevecchi 2006). While artificial light has been shown to affect the movement and behaviour of planktonic organisms in laboratory and in-situ studies (Sameoto et al. 1985; Cohen and Forward 2002) bright deck lighting from vessels operating within the AOI would not be expected to pose detectable impacts to phytoplankton populations, so this interaction was not assessed. Seabirds have a known attraction to light (Montevecchi 2006; Rodriguez et al. 2015), light-induced vessel collisions are a known source of direct mortality and disorientation/contact could negatively impact survival, even if the collision is not immediately lethal (Ryan 1991; Black 2005; Kingsley 2006; Bocetti 2011). Storm-petrels (surface seizing plank/piscivores) exhibit behaviours (i.e., returning to coastal burrows at night) that increase their susceptibility to collisions/disorientation, and events causing the death of hundreds of these birds have been recorded (Black 2005); therefore, this species was selected for assessment.

*Vessel-based noise (propellers, machinery)*: Blue Whales and beaked whales rely on the production and perception of sound to carry out important biological functions (MacLeod and D'Amico 2006; Oleson et al. 2007; Di Iorio 2009) and these functions can be negatively impacted by anthropogenic noise, including noise generated by vessels through engine operation, onboard machinery, and propeller action (Erbe et al. 2019). Underwater noise can lead to physiological and behavioural effects such as elevated stress levels (Rolland et al. 2012) and changes in vocalization (Di Iorio 2009; Melcón et al. 2012). Baleen whales, such as Blue Whales, are thought to be particularly susceptible to impacts from vessel noise because their vocalizations occupy the same low-frequency (<1 kHz) sound range as ships (McKenna et al. 2009) and therefore may be more sensitive to sounds within that range (Erbe et al. 2019). This interpretation relies on the assumption that vocalization range is at least partially indicative of hearing range, an approach that must be used with caution, as many mammal species have best hearing at frequencies above the lower end of their vocalization range (Southall et al. 2019*a*). It is therefore acknowledged that for all species, vocalization range is not entirely indicative of hearing range and cannot be used as a perfect proxy. There is also evidence that vessel noise emitted at higher frequencies can be disruptive to odontocetes (toothed whales) (e.g., Lesage et al. 1999; Aguilar Soto et al. 2006; Dyndo et al. 2015; Wisniewska et al. 2018). Newer understanding of toothed whale hearing suggests that beaked whales, a family of toothed whales, may have good hearing at lower frequencies (<5 kHz) (Southall et al. 2019*a*). Consequently, based on spatial overlap and susceptibility to noise impacts, both Blue Whales and beaked whales were both selected for assessment.

While less is known about the effects of anthropogenic noise on fish, studies show that fishes can experience a wide variety of negative impacts as a result of exposure to noise, including loss of communication space (Putland et al. 2018), behavioral changes (Magnhagen et al. 2017), injury (McCauley et al. 2003), elevated stress levels (Wysocki et al. 2006), and reduced growth and development (Nedelec et al. 2015). Among the groundfish in the AOI, Atlantic Cod were selected for assessment due to the species' known use of and reliance on sound for important biological functions (Rowe and Hutchings 2004) and their potential sensitivity to vessel traffic noise (Stanley et al. 2017). It is acknowledged that other fish species are also likely to be sensitive to anthropogenic noise (e.g., Scholik and Yan 2002; Wilson and Dill 2002), particularly other members of the Gadoid family of fishes, such as Cusk. However, the wide sensitivity to sound that Cod possess relative to other species (Popper and Hawkins 2019), combined with the degree of impact that may result due to interference from anthropogenic noise (see Rowe and Hutchings 2008) provided the rationale for the selection of Atlantic Cod for this analysis. Furthermore, the results of an assessment on Atlantic Cod are also likely to apply to other sound-dependent species like Cusk.

*Vessel-based noise (echosounders)*: Beaked whales are generally thought to be particularly sensitive to acoustic disturbance (Cox et al. 2006; Tyack et al. 2011; DeRuiter et al. 2013; Miller et al. 2015) and evidence suggests that sonar pulses can be highly disruptive to marine mammals, particularly toothed whales (Tyack et al. 2011; DeRuiter et al. 2013). The majority of existing studies on beaked whale sensitivity to sonar are largely based on military mid-frequency active (MFA) sonar, but more recent evidence indicates behavioral responses by beaked whales to scientific echosounders (Cholewiak et al. 2017). Beaked whales were therefore selected for assessment of the effect of echosounders. When discussing potential impacts of noise, it is important to note that vocalization range may not be entirely indicative of the full spectrum of an animal’s hearing sensitivity and by extension, the likelihood that an animal will react to a given sound. This is illustrated by the fact that Blue Whales, which use very low-frequency sounds (Mellinger and Clark 2003), have been shown to respond to MFA sonar (Goldbogen et al. 2013; Friedlaender et al. 2016; Southall et al. 2019*b*), which is above the general communication range of Blue Whales. Consequently, both beaked whales and Blue Whales were selected for assessment for the risk of impacts from echosounders.

The impacts of sonar on fishes have been studied to a limited extent and focus largely on MFA sonar. The effects are thought to be dependent on the particular hearing capabilities and physical sound-perceiving structures possessed by the species of study, but in general sonar operates largely within frequencies that are not detectable by fish (Popper and Hawkins 2019). Based on this information, fish were not assessed against the impacts of echosounder noise.

*Oil spills (small operational and large accidental spills)*: Vessel-sourced small-volume operational oil spills and large accidental spills present a threat to many aspects of the marine environment. Regular operation of vessels may lead to spills (e.g., bilge water and small fuel leaks) that are generally small volume but occur frequently (i.e., chronic) while large accidental spills can occur as a result of rarer events such as collisions, groundings, structural failure, or other instances of vessels in distress at sea (Haggarty et al. 2003; GESAMP 2007). Impacts to marine and coastal ecosystems will depend on volume, location, type of oil spilled, and environmental factors, such as time of year and weather conditions (Spaulding et al. 1983; DFO 2011; GENIVAR 2013). For this assessment, two scenarios were analyzed: 1) frequent but small-volume operational oil spills, and 2) a large heavy fuel oil spill from a tanker transiting the AOI. Small-volume oil spills due to normal vessel operation have been estimated to be the largest source of anthropogenic oil in the marine environment (GESAMP 2007). Though low volumes and high mixing rates mean that most conservation priorities for the AOI are not exposed to significant oil levels via operational spills, seabirds are particularly susceptible to even very low concentrations of oil, and alcids are especially sensitive due to the amount of time they spend in the water (Irons et al. 2000; Wiese and Robertson 2004; Lieske et al. 2019). As a result, this foraging guild was selected for assessment. For the large heavy fuel oil spill scenario, Atlantic Cod were chosen as the representative groundfish species due to their depleted status and paucity of information regarding the sensitivity of other groundfish species. Deep-water corals were selected to assess impacts to sensitive benthic habitats. Beaked whales were chosen for assessment and will also be used as a proxy for assessing impacts to Blue Whales. The sensitivity of alcids to large oil spills is well-characterized (Mead and Baillie 1981; Piatt and Ford 1996) and thus they were chosen to undergo assessment. Impacts to phytoplankton and zooplankton communities in the area of high productivity were also assessed as plankton are an integral link in marine food webs; as well, the planktonic larval stage of many fish and invertebrates is often considered the most sensitive life history stage to the toxicological effects of oil (Hutchinson et al. 1998). Plankton was assessed during the period of highest chlorophyll a abundance (September to April) (Johnson et al. 2017), as oil spills during this time period are anticipated to have the highest potential impacts (Varela et al. 2006).

## 3.3 METHODS

Consequence

$Q_{Exposure}$

Vessel density maps were created using available AIS data and used to inform spatial overlap and intensity scores. Maps depict the cumulative number of minutes spent by the specified vessel type(s) (i.e., "vessel minutes") per $km^2$. These data are displayed on a logarithmic scale in four classes corresponding to the four levels used for scoring intensity (i.e., negligible = 0; low = 1; medium = 2; and high = 3). Data spanned March 1, 2017 to February 28, 2018. As described above, AIS data were not comprehensive for all vessel types; for example, fishing vessels are not required to carry AIS transponders and are often misclassified, so fishing vessel activity is expected to be underestimated. Thus, for analyses that include these vessel classes, the density maps were used to help characterize the general spatial and temporal patterns of vessel traffic, but densities may be misrepresented. For cases where a pressure could be assumed to occur on or close to a vessel's path (e.g., small operational oil spills and vessel collisions) areas of predominant vessel activity were considered when estimating potential for overlap between the pressure and conservation priority. No modeling outputs were available to quantify the acoustic footprint of transiting vessels within the AOI; exposure scores for noise were therefore limited to the physical overlap of vessel tracks with the conservation priority being assessed. Where a pressure could extend far beyond the path of a vessel (e.g., large oil spills from a tanker) expert opinion and publicly available resources (e.g., mass balance modelling – see below) were used to estimate the exposure score. Estimates of intensity considered the density of vessel traffic (e.g., for noise) and the characteristics of the specific pressure (e.g., persistence of oil). Temporal exposure was determined with consideration for the seasonal nature of conservation priorities.

The U.S. National Oceanic and Atmospheric Administration's (NOAA) ADIOS (Automated Data Inquiry for Oil Spills) mass balance model was used to inform potential level of exposure from accidental ship-sourced heavy fuel oil spills. ADIOS combines the physical properties of oil (i.e., pour point, viscosity, and American Petroleum Institute [API] gravity) with environmental data (e.g., wind speed, sea surface temperature) to estimate the degree of oil weathering, such as evaporation, dispersion, and changes in viscosity and density (Samuels et al. 2013); the model can be run for a maximum of five days post-spill. Environmental data inputs were collected from multiple sources and verified through expert opinion (Table 3.3-1): wind speed and wind direction from DFO's Marine Environmental Data Service database; current speed and current direction from Brickman and Drozdowski (2012); sea surface temperature from DFO (2018); and salinity from the Northwest Atlantic Fisheries Organization (2008). Wave height was calculated by the ADIOS software based on wind speed. Data were taken from recordings in the vicinity of the entrance to the Fundian Channel. Fate and behaviour models were run using average values for both summer (July) and winter (December) environmental conditions to compare between seasons (Table 3.3-2). Open ocean sediment load values were taken from Brewer et al. (1976). Though the oil budget was similar between seasons, winter conditions resulted in less evaporation (likely due to colder temperatures) and more dispersion into the water column (likely due to stronger wind speeds), resulting in a greater totality of oil remaining on the surface and in the upper water column. As greater potential exposure is consistent with a plausible worst-case scenario, winter conditions were chosen to inform the assessments of conservation priorities that spend a significant amount of time near the water-air interface. ADIOS is intended to inform spill response measures that occur at the air-water interface by estimating the fate and behaviour of surface slicks. The model does not offer reliable estimates of oil reaching the benthos; thus, it was only used to inform the assessments of conservation priorities that occur in surface water. No oil spill trajectory modelling was available. Along with the outputs from ADIOS, generalized heavy fuel oil fate and behaviour, oceanographic conditions, and expert opinion were used to estimate exposure, including for the benthos.

For the heavy fuel oil spill scenario, factors such as spill location, quantity of oil released, and type of oil product were selected based on incidents that are likely to occur in the AOI and result in a plausible worst-case spill scenario (though average values were used for environmental conditions). Specifically, the hypothetical spill involved the loss of the entire capacity (~79,000 $m^3$) of a tanker carrying Bunker C fuel oil transiting the AOI. Heavy fuel oil products are a plausible source of a spill in the AOI as they are commonly handled as cargo at the nearby major ports (Statistics Canada 2011) of Saint John and Port Hawkesbury and is also the dominant fuel used by larger vessels (Ryan et al. 2019). Spill location was the north side of the Fundian Channel which demonstrates persistent flow onto the shelf and towards the bulk of the AOI.

Table 3.3-1. Environmental data inputs for NOAA's Automated Data Inquiry for Oil Spills (ADIOS) model used to inform a spill scenario in the Fundian Channel-Browns Bank Area of Interest. Wind speed and wind direction from DFO's Marine Environmental Data Service database; current speed and current direction from Brickman and Drozdowski (2012); sea surface temperature from DFO (2018); salinity from the Northwest Atlantic Fisheries Organization (2008); and open ocean sediment load values from Brewer et al. (1976). All environmental data inputs with the exception of sediment load were average values taken from readings at the entrance to the Fundian Channel.

| **Parameter** | **Unit** | **Model inputs** | |
|---|---|---|---|
| | | **Summer** | **Winter** |
| Water temperature | °C | 17 | 3 |
| Wind speed | m/s | 5 | 10 |
| Wind direction | Degree | 186 | 258 |
| Current speed | m/s | 0.12 | 0.18 |
| Current direction | Degree | 220 | 220 |
| Salinity | ppt | 32 | 32 |
| Sediment load | $g/m^3$ | 1 | 1 |

Table 3.3-2. Outputs by season and time post-spill from NOAA's Automated Data Inquiry for Oil Spills (ADIOS) model used to inform a spill scenario in the Fundian Channel-Browns Bank Area of Interest. Environmental data inputs collected from various sources: wind speed and wind direction from DFO's Marine Environmental Data Service database; current speed and current direction from Brickman and Drozdowski (2012); sea surface temperature from DFO (2018); salinity from the Northwest Atlantic Fisheries Organization (2008); and open ocean sediment load values from Brewer et al. (1976). All environmental data inputs with the exception of sediment load were taken from readings at the entrance to the Fundian Channel.

| Season | Time post-spill (hours) | Oil budget (percentage) | | |
|---|---|---|---|---|
| | | Evaporated | Dispersed | Remaining on surface |
| Summer (July) | 12 | 1 | 0 | 99 |
| | 24 | 2 | 0 | 97 |
| | 48 | 4 | 1 | 95 |
| | 120 | 6 | 5 | 89 |
| Winter (December) | 12 | 1 | 0 | 99 |
| | 24 | 2 | 1 | 97 |
| | 48 | 3 | 3 | 94 |
| | 120 | 5 | 9 | 86 |

$Q_{Sensitivity}$

The sensitivities of the conservation priorities to marine transportation-related pressures were determined through review of available literature and expert opinion.

Likelihood levels

For marine transportation-related risk analyses, levels of likelihood were determined by considering the probability of the pressure interacting with the conservation priority, based on existing data, literature and expert opinion, with consideration for level of exposure.

## 3.4 RISK ASSESSMENT FOR MARINE TRANSPORTATION IN THE FUNDIAN CHANNEL-BROWNS BANK AOI

### 3.4.1 Vessel interactions (collisions and artificial light-induced disorientation/collisions)

Collisions may occur where vessel traffic overlaps with areas important for susceptible species. Baleen whales are especially susceptible to injury and death from strikes due to their large size and lower maneuverability (Laist et al. 2001; DFO 2017*a*). Minimizing use of areas during times that susceptible species aggregate is a potential mitigation measure (Laist et al. 2001); for example, there is evidence that the Roseway Basin ATBA (discussed further below) has reduced lethal vessel strike risk to North Atlantic Right Whales by 82% (Vanderlaan and Taggart 2009). Reducing speed (e.g., below 10 knots) is another method to mitigate risk, as the calculated probability of a lethal vessel strike to North Atlantic Right Whales decreased with lower speed (Vanderlaan and Taggart 2007) and severe injury or mortality was not seen in documented vessel strikes on large whales below 10 knots (Laist et al. 2001). Recent modelling focused on North Atlantic Right Whales (Kelley et al. 2021) has proposed an even more precautionary critical speed threshold for both small (45 tonnes) and large (>300 tonnes) vessels of 6.6 and 4.5-4.7 knots respectively (where probability of a lethal strike is 50%). The study notes that the smaller vessels have a greater ability to avoid collisions due in part to their increased maneuverability.

Seabirds are also at risk of disorientation and/or collisions with vessels, mainly due to their attraction to lighted structures at night (Montevechi 2006), with the risk increasing as visibility deteriorates. Collision events involving a small number of birds are thought to occur frequently, while large mortality events, involving hundreds of birds, occurring more rarely (Dick and Donaldson 1978; Black 2005; Kingsley 2006). During migration, mass strandings of land birds are also known to occur, often leading to mass mortality (Montevecchi 2006; Bocetti 2011). The assessment will focus on risks posed by vessels using bright lighting associated with nighttime deck operations, as dimmer navigational lighting is not expected to be a strong attractant for birds.

<u>Existing management measures</u>

The *Marine Mammal Regulations* under the *Fisheries Act*, updated in 2018, prohibits the disturbance of marine mammals and outlines minimum distance requirements when viewing or approaching. For most whales, dolphins, and porpoises, these minimal distances are set at 100 m, though certain at-risk species (e.g., Beluga Whales [*Delphinapterus leucas*] in the St. Lawrence Estuary) can require a larger (400 m) buffer. Of note, these distance requirements do not apply to vessels in transit. The *Species at Risk Act* (SARA) prohibits killing, harming, harassing or capturing a listed marine mammal as well as any actions that damage or destroy their residence.

Although no spatial protection measures for marine mammals currently exist in the AOI, measures such as dynamic shipping zones, seasonal speed restrictions, and traffic separation schemes exist elsewhere in internal Canadian waters to protect cetaceans from vessel strikes. In Atlantic Canada, the Roseway Basin ATBA is a voluntary spatial measure adopted by the IMO for the purpose of protecting North Atlantic Right Whales (*Eubalaena glacialis*). This measure recommends vessels of >300 gross tonnage avoid the area from June 1 to December 31, when Right Whales are expected to be present, to reduce the risk of collisions.

The Canadian Coast Guard publishes an annual Notices to Mariners, which includes guidance and best practices to safeguard marine mammals, including within MPAs (Canadian Coast Guard 2021). For example, Section A2 notice 5 recommends developing awareness of critical habitat areas and slowing down to less than 7 knots when within 400 m of a marine mammal. Notice 5A provides specific guidance for vessel operations around marine mammals in MPAs. For example, in the Gully MPA, the guidance includes direction to avoid the area when possible, and to reduce speed to <10 knots and post a lookout if travel through the MPA is required.

Requirements for the operation of vessel lights are outlined in the *Collision Regulations* under the *Canada Shipping Act*. These regulations stipulate the need for navigation lights during periods of darkness or reduced visibility, and that the vessel be equipped with the proper lights for its size and purpose, in addition to other requirements. Particularly, the *Collision Regulations* (Rule 20) prohibits the use of non-essential (e.g., non-navigational) lighting, “except such lights as cannot be mistaken for the lights specified in these Rules or do not impair their visibility or distinctive character, or interfere with the keeping of a proper look-out”. No references are made to potential impacts to local wildlife due to vessel lights (navigational or operational), nor are any specific regulations given in this regard.

**<u>Risk assessment – Vessel collisions and Blue Whale foraging area</u>**

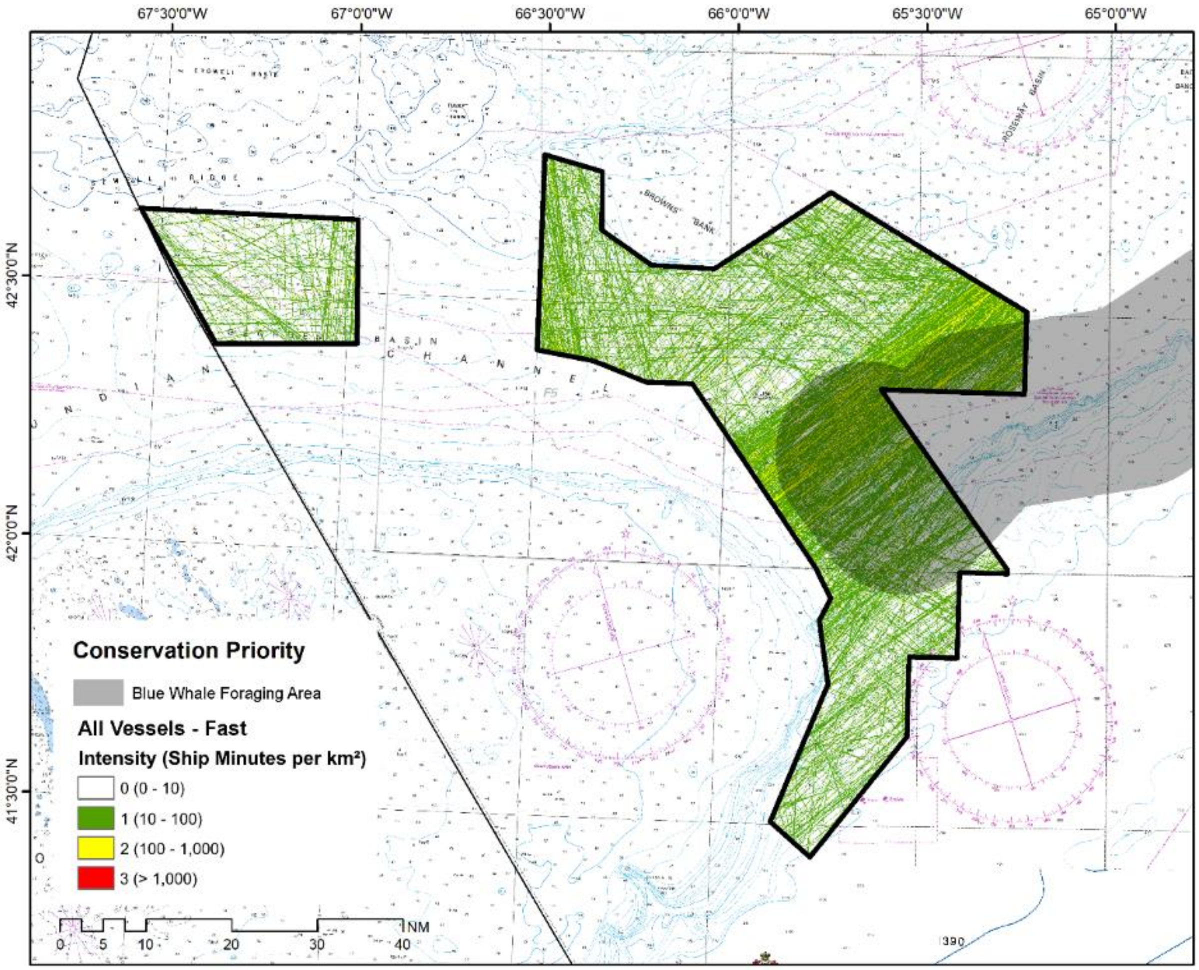


Figure 3.4.1-1. Overlap of Blue Whale foraging area and all vessel traffic travelling >10 knots in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) using available Automatic Identification System (AIS) data from March 1, 2017 to February 28, 2018. For intensity calculations vessel traffic intensity was classified into negligible (0), low (1), medium (2), or high (3) intensity categories.

**Risk statement**: There is a risk that vessel collisions will lead to negative impacts on Blue Whales in an important foraging area within the AOI.

Table 3.4.1-1. Scoring for the risk posed by vessel collisions to Blue Whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 3<br>= 12 (raw score) |
| Intensity | 1 | Overlap is predominantly characterized by low density vessel traffic and this stressor does not persist once the vessel has left the area, resulting in an intensity exposure score of 1. |

| | | |
|---|---|---|
| Temporal | 4 | Although temporal distribution patterns are not well described, Blue Whales are present in Canadian waters year-round (Lesage et al. 2018). Large vessel traffic is present throughout the year. Therefore, there is potential temporal overlap for up to 12 months of the year. |
| Spatial | 3 | Vessels travelling >10 knots overlap with >50% of Blue Whale foraging area within the AOI, resulting in a spatial exposure score of 3. |
| $Q_{Sensitivity}$ | 3 | Baleen whales are thought to be more susceptible to vessel strikes than other types of cetaceans due to their large size and limited maneuverability (DFO 2017*a*); their propensity for spending time at the surface feeding or resting increases their chance of a collision (DFO 2017*a*; Nanayakkara and Herath 2017). The COSEWIC (2002) status assessment and other studies (e.g., Laist et al. 2001; COSEWIC 2012) have identified vessel strikes as a source of human-induced mortality for Blue Whales.<br><br>In an evaluation of known vessel strikes on large whales between 1975 and 2002, Jensen and Silber (2003) reported that 84% of large whales struck suffered injury or death. Furthermore, laboratory hydrodynamic experiments suggest the lethal zone extends beyond the actual physical boundaries of the ship (Silber et al. 2010). The draft of large commercial ships may range from 8-18 m, with the lethal zone extending 1-2 x the depth, and horizontally extending an additional ½ beam width beyond the sides of the vessel. Additionally, recent modelling (Kelley et al. 2021) calculated that both small (45 tonnes) and large (>300 tonnes) vessels can produce the necessary force for a lethal strike, suggesting lower safe speed thresholds and indicating that large vessels are not the only category of vessels capable of causing mortality. Small and large vessels were calculated to produce a probability of a lethal strike >0.5 at 6.6 and 4.5-4.7 knots respectively, compared with the 10 knots threshold identified by Laist et al. (2001) where they found no documented mortalities. Modelling on the at-risk Northeastern Pacific population found that mortality due to collisions was 7.8x higher than recommended for population viability (Rockwood et al. 2017). Given the information above, our analysis that investigated risk posed by vessels travelling >10 knots may not capture all vessel activity that could pose a risk to Blue Whales. However, given the high spatial and temporal scores already assigned, we would not expect the inclusion of additional slower-moving vessels to affect the final exposure score.<br><br>The Northwest Atlantic Blue Whale population was assessed as Endangered by COSEWIC and listed under SARA, with most recent minimum population estimates of ~402 individuals (NOAA |

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| | | 2020) and indications of low recruitment and calving rates (Beauchamp et al. 2009). There is insufficient information to determine population trends for North Atlantic Blue Whales (NOAA 2020). The potential biological removal (PBR) (i.e., the maximum number of removed individuals per year that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) for the Western North Atlantic population of Blue Whale was estimated at 0.8.<br><br>Due to the small size of the Blue Whale population, the loss of even a small number of individuals can have an impact on the population's health (Beauchamp et al. 2009; DFO 2018). The SARA Blue Whale Recovery Strategy identified collisions with vessels as a threat of medium concern to the population (Beauchamp et al. 2009), whereas the most recent NOAA stock assessment for this population notes that the total level of human-caused mortality and serious injury is believed to be insignificant and approaching zero (NOAA 2020). Currently, there is no available data to suggest that collisions within the AOI would impact long term recruitment dynamics for this population. In light of this, while also acknowledging the differing assessments of the risk that vessel collisions pose to Northwest Atlantic Blue Whales mentioned above, a precautionary sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 3$<br>$= 12$ (raw score) |
| Likelihood | Rare | Although there is evidence that Blue Whales are able to react to approaching vessels, McKenna et al. (2015) suggested that the response had limited effectiveness for avoiding a collision, as all of the observed encounters resulted in either the whale crossing the path of the vessel or diving closer on a horizontal plane. The slow rate (0.3-0.4 m/s; Williams et al. 2000) at which diving Blue Whales gain depth, the shallow depth of the response dive, and the lack of avoidance behaviour (McKenna et al. 2015) may limit the ability of Blue Whales to clear the lethal zone of a vessel, especially for fast-moving vessels. It has also been suggested that whales may habituate to the continuous and ubiquitous vessel noise produced by the global shipping fleet, reducing the likelihood of an avoidance dive (Nowacek et al. 2004; McKenna et al. 2015).<br><br>It is posited that the majority of collisions with large whales, including Blue Whales, are unaccounted for due to their negative buoyancy (Reisdorf et al. 2012) which causes carcasses to sink and avoid detection (Rockwood et al. 2017). Therefore, it is suggested |

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| | | that the actual impact of vessel strikes is underestimated (Laist et al. 2001; Sears and Calambokidis 2002; Jensen and Silber 2003).<br><br>While there is potential for vessel collisions with Blue Whales within the AOI, based on available information, the likelihood is estimated as rare. |
| Overall risk | Moderately High | Additional management actions should be considered (where feasible) in collaboration with Regulators, including voluntary avoidance or speed reduction in high risk areas within the future MPA. |
| Uncertainty | High | Many collisions go unreported due to the large size of many vessels involved in collisions which make detection of an impact difficult (Jensen and Silber 2003). Additionally, large whale carcasses often sink, avoiding detection (Rockwood et al. 2017) and little is known about long-term impacts from non-lethal strikes which may impact health and eventually result in death after the collision occurred (Jensen and Silber 2003). As well, conditions (e.g., vessel size and speed, morphological differences among whale species) that result in a lethal strike are debated (Laist et al. 2001; Vanderlaan and Taggart 2007; Kelley et al. 2021). Thus, mortality and injury rates due to vessel strikes are unknown. In some cases it is difficult to determine the cause of death of stranded whales due to decomposition and/or logistics, further confounding mortality assessments (Reimer et al. 2016). Many life history characteristics of Northwest Atlantic Blue Whales are not well determined including population size, generation time, distribution, and natural mortality (Sears and Calambokidis 2002). |

**Risk assessment – Light-induced vessel collisions/disorientation and surface-seizing planktivores/piscivores (storm-petrels)**

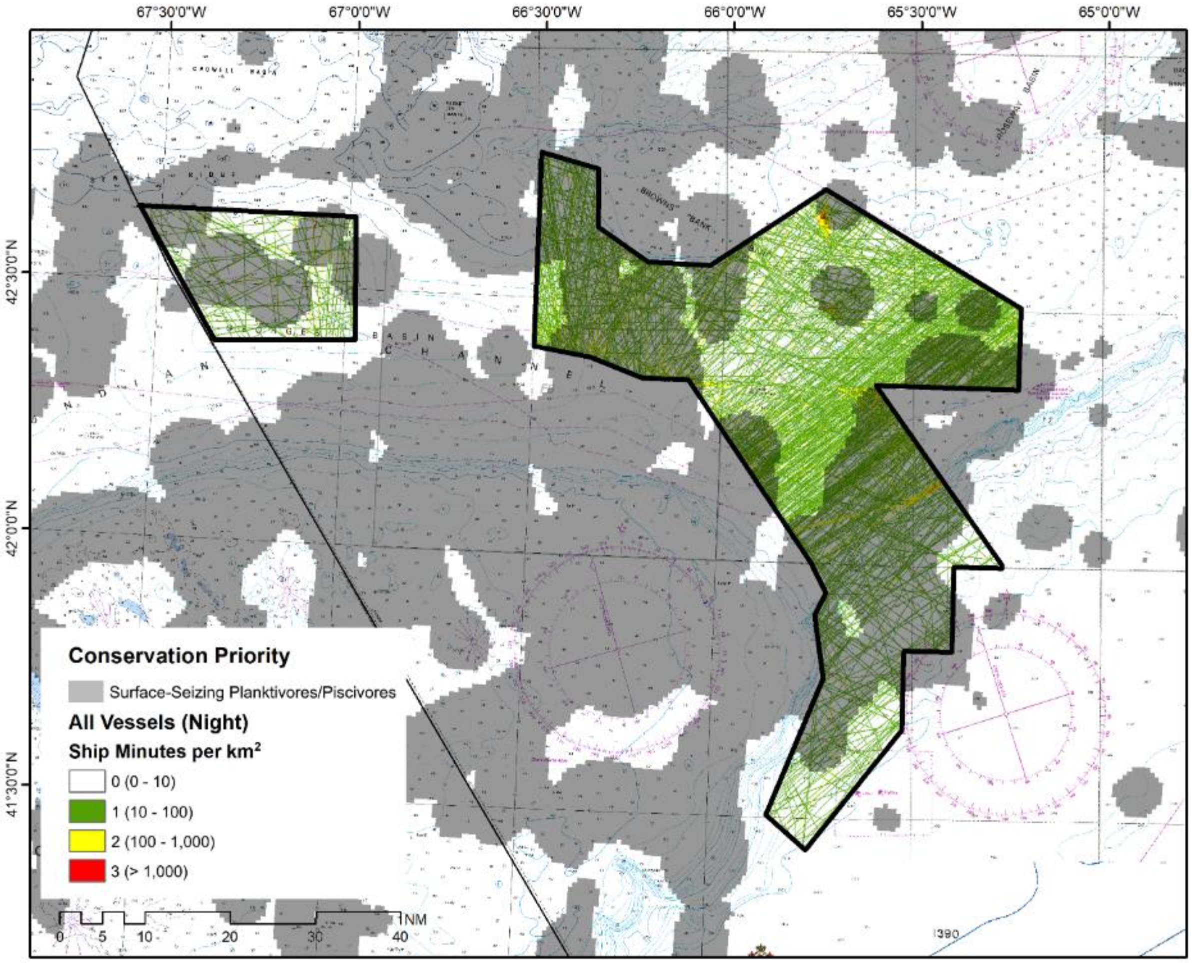


Figure 3.4.1-2. Overlap of important foraging areas for surface-seizing planktivores/piscivores (storm-petrels) and night-time vessel traffic for all vessel types in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) using available Automatic Identification System (AIS) data from March 1, 2017 to February 28, 2018. For intensity calculations vessel traffic was classified into negligible (0), low (1), medium (2), or high (3) intensity categories.

**Risk statement**: There is a risk that light-induced vessel collisions/disorientation will lead to negative impacts on storm-petrels in their foraging habitat within the AOI.

Table 3.4.1-2. Scoring for the risk posed by light-induced vessel collisions/disorientation to storm-petrels within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 2<br>= 6 (raw score) |
| Intensity | 1 | Most of the overlap is characterized by low density vessel traffic, and this stressor does not persist once the vessel has left the area. Navigational lights, which are mandatory for all vessels, are not |

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| | | expected to produce enough light to be a significant factor in collisions and were not considered. The assessment focused on deck lighting used for operational reasons (e.g., illuminating fishing gear), which would be brighter yet occur on less vessels at any one time. This results in an intensity exposure score of 1. |
| Temporal | 3 | Migratory and residency patterns of Leach's Storm-petrel are increasingly well known, with studies suggesting that most individuals spend the winter in tropical waters and the summer at breeding colonies (Godfrey 1986; Pollet et al. 2014; Pollet et al. 2019; Kauffman n.d.). This species has been recorded in Nova Scotia from May to October, where numerous colonies are present (Hedd et al. 2018; Pollet et al. 2019). Vessel traffic occurs throughout the year, with a slight decrease in density at night. This results in a temporal score of 3. |
| Spatial | 2 | Night-time vessel traffic overlaps with 36% of surface seizing planktivore/piscivore foraging habitat within the AOI, resulting in a spatial exposure score of 2. |
| $Q_{Sensitivity}$ | 3 | Many marine birds demonstrate attraction to light, which can cause them to fly towards and interact with the source, resulting in behavioural changes, decreased survivability, and/or mortality (Ryan 1991; Black 2005; Merkel 2010; Ronconi et al. 2015). While attraction is unlikely during the day and when visibility is adequate, the risk increases substantially at night (due to the increased use of lights) and when visibility is poor (i.e., in rain or fog; Black 2005; Merkel 2010). It is suggested that younger birds, especially fledglings, are more susceptible to light attraction than older individuals (Rodriguez et al. 2015; Krug et al. 2021).<br><br>Leach's Storm-petrel, which are part of the surface-seizing planktivore/piscivore foraging guild, are known to be susceptible to collisions with lighted structures at sea (Wiese et al. 2001) and members of this guild were more commonly involved in vessel collisions in the south Atlantic Ocean than other species (Black 2005). Leach's Storm-petrel involved in breeding activities at colonies in Nova Scotia and New Brunswick have been shown to forage within the AOI during the day (Hedd et al. 2018), undertaking trips to and from and colonies at night when they are more susceptible to light attraction (Ryan 1991). Light-induced interactions that generally decrease fitness but may not be immediately lethal, such as strandings on the vessel, increased energy expenditure, distraction from foraging opportunities, and non-mortal injuries, may be a common occurrence (Ryan 1991; Black 2005; Bocetti 2011). Large mortality events involving hundreds of birds are rare, but are known to have occurred closer to colonies (Black 2005; Merkel 2010; Rodriguez et al. 2015; Krug et al. 2021), though mass strandings of Leach's Storm-petrels at |

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| | | offshore locations are not known. Given the offshore location, major mortality events would not be expected in the AOI.<br><br>Little research has focused on the threat posed by vessel collisions and light-induced disorientation to seabirds in the Northwest Atlantic (Wiese et al. 2001; Burke et al. 2012; Ronconi et al. 2015). Lieske et al. (2019) ranked risks posed to seabirds by both vessel collisions and light disorientation lower than risks posed by other anthropogenic activities/pressures, including fishing, oil pollution, marine debris, and offshore wind turbines.<br><br>Taken together, seabirds such as the Leach's Storm-petrel and other surface-seizing planktivores/piscivores exhibit behavioural characteristics, including attraction to light, that increases susceptibility to collisions/disorientation. Leach's Storm-petrel is a long-lived species (25+ years) that has been recently assessed as threatened by COSEWIC (2020). As such, it is possible that the cumulative mortality of such events within the AOI may cause a detectable change in the local Nova Scotia and New Brunswick breeding populations, so a score of 3 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 2 \times 3$<br>$= 6$ (raw score) |
| Likelihood | Moderate | The attraction of seabirds to artificial light is well documented. Collisions/disorientation have predominantly been recorded at night or in compromised visibility (Black 2005; Kingsley 2006; Merkel 2010; COSEWIC 2020) and more commonly involve young individuals (Rodriguez et al. 2015; Krug et al. 2021). It is estimated that non-mortal interactions occur frequently, while larger mortality events are more infrequent (Black 2005). Taken together, a moderate likelihood was assigned. |
| Overall risk | Moderately High | Additional management actions should be considered (where feasible), for vessels that use bright deck lighting during operation (e.g., fishing gear retrieval), such as directing down, shading, or dimming non-essential (i.e., non-navigational) deck lighting when transiting or operating in the future MPA at night. |
| Uncertainty | High | Spatial and temporal occurrence patterns of vessel collisions/ disorientation in the northwest Atlantic are not well described (Montevecchi 2006). Little is known about the extent to which vessel strike mortality or sub-lethal effects contribute to population-level impacts in seabird species (Wiese et al. 2001; Burke et al. 2012; Ronconi et al. 2015), including surface-seizing planktivores/piscivores. Finally, important marine bird foraging areas were identified using available data from offshore seabird surveys. Survey coverage has been limited, and while identified foraging areas are based on occurrences, they contain a predictive component. |

3.4.2 Noise

Sound "loudness" is measured in decibels (dB), which characterize a sound's intensity ratio to a reference level. Decibels in water have a different relative value than decibels in air, measured against a reference pressure of 1 micropascal (dB re 1 µPa) on a logarithmic scale (Hildebrand 2005). Because the decibel scale is logarithmic, a sound of 1 second in duration at 196 dB is more than 10 million times more intense than 1 second sound of 120 dB (Weilgart 2007).

Frequencies refer to the pitch of a sound and are measured in hertz (Hz) and kilohertz (kHz), where 1 kHz = 1000 Hz. The ocean is a naturally sound-rich environment. Ambient sound in the marine environment from natural sources (e.g., earthquakes, wind, rain, marine animals) occupies a wide bandwidth (i.e., range of frequencies), from 10 Hz to 30 kHz (Wenz 1962). Depending on the sea state, the maximum spectrum level of these natural sounds is generally 80 dB ref 1 µPa with many sounds falling below this level (Figure 1 in Walmsley and Theriault 2011; Figure 1 in Hildebrand 2009; Plate 2 in National Research Council 2003*a*).

Hildebrand (2009) outlined three general frequency bands to classify different noise sources: low frequency (10-500 Hz), medium frequency (500 Hz-25 kHz), and high frequency (>25 kHz). Ships are the most ubiquitous and prevalent source of anthropogenic noise in the oceans, and increasing ship traffic has largely contributed to rising ambient noise levels in the low-frequency range (10-100 Hz) in some ocean regions (Andrew et al. 2002; Miksis-Olds and Nichols 2016). Low-frequency vessel traffic noise occurs mainly between 10-1000 Hz (Hildebrand 2009; Chapman and Price 2011; Miksis-Olds and Nichols 2016), although noise levels can be above this range (Hermannsen et al. 2014; Dyndo et al. 2015). Increasing numbers of commercial vessels have been identified as the driving factor behind rising ambient noise levels by an average of 3 dB per decade (McDonald et al. 2006). Noise from vessels can be produced from various sources including the vibrating propeller, engine, and onboard machinery (Erbe et al. 2019), but the strongest source is a process called cavitation which refers to the formation of bubbles due to propeller spin that then burst creating a broadband noise spectrum ranging from a few Hz to over 100 kHz (Ross 1976). The intensity and frequency of noise emitted by a transiting vessel are influenced by numerous factors including vessel size and speed, as well as oceanographic conditions (McKenna et al. 2013; Gassmann et al. 2017). Cavitation noise increases with vessel speed and size (Ross 1976). On the Scotian Shelf, shipping has contributed to rising low-frequency ambient noise levels (Walmsley and Theriault 2011). The majority of sound energy contributing to these ambient noise levels is low-frequency (generally <1 kHz) falling below 100 dB, but levels depend on a number of factors including water depth, location, and the sound source itself.

Compared to shallow water where noise is often scattered and absorbed, vessels can ensonify a large area of the deep ocean. Emitted at the surface, vessel noise reflects off the water surface and, in deep water is directed strongly downward where it propagates with reduced energy loss because of the little interaction it has with the seafloor and other physical features (Erbe et al. 2019). Animals in deeper offshore waters may experience noticeably different noise fields than those in shallow coastal waters, even at the same range from the same vessel. Considering the Fundian Channel-Brown's Bank AOI straddles both channel and continental slope areas, this phenomenon could act to increase the relative noise field for animals that occur in the AOI.

Underwater anthropogenic noise has been identified as a significant stressor in the marine environment, with widespread effects on marine fauna (Hildebrand 2005; Clark et al. 2009; Popper and Hawkins 2019). Because of their heavy reliance on sound production and perception to carry out basic biological functions, marine mammals are particularly at risk of experiencing impacts from anthropogenic noise (Williams et al. 2014), although there is strong evidence that fish also experience negative effects (McCauley et al. 2003; Simpson et al. 2016; Stanley et al. 2017) and that invertebrates are also impacted (André et al. 2011; Filiciotto et al. 2016).

Because of how easily sound travels through an aquatic medium, water is an efficient manner by which to transmit acoustic information over distances, and marine animals have evolved particular communication systems that exploit this phenomenon (McKenna 2011). Low-frequency sounds in particular travel over great distances in water (Payne and Webb 1971); Blue Whale calls have been detected at distances of 250 km from the call location (Moore et al. 1999). However, in environments where there is increased low-frequency noise from ships, the space available for an acoustic signal to travel in between conspecifics can be reduced by the effects of masking (Clark et al. 2009). Masking is the reduction of a receiver's ability to perceive a sound of interest as a result of the interfering presence of other sounds, either natural or anthropogenic. In addition to the effects of masking and reduced communication space, other impacts from vessel noise include displacement or avoidance (Anderwald et al. 2013), behavioral changes (Miller et al. 2015), physiological effects (such as increased stress levels) (Rolland et al. 2012), and auditory injury (Fernández et al. 2005). However, if a sound is completely outside an animal's generalized hearing range, then the likelihood of auditory injury is considered low (NMFS 2018).

For the purposes of this assessment, "vessel noise" refers to noise produced by various vessel types including fishing, cargo, tankers, and passenger vessels, acknowledging that different vessel types produce noise at different levels and frequencies.

In addition to vessel noise generated by propeller and engine operation, active sonar (sound navigation and ranging) is a source of vessel-based noise in the marine environment that can disturb marine animals (Lurton and DeRuiter 2011; Tyack et al. 2011; Sivle et al. 2012). Both active (i.e., signal-emitting) and passive (i.e., listening only) sonar types exist, but only active sonar will be discussed here. Active sonar technology applications include depth sounders, which emit acoustic signals downward that bounce off the ocean bottom providing information on depth and objects on the seafloor, and "fish finders", which send out acoustic signals that reflect off fish or schools of fish to discern fish presence from other undersea objects (Harland 2003). The term "echosounder" refers to sonar technology used for a variety of purposes including identifying fish aggregations, navigation, and marine research (Andersen 2001).

Depending on the application, echosounders may use a variety of frequencies to find out different information about the water column or seafloor. Commercial sonar systems are commonly categorized into three different classes: single-beam echosounders (SBES), side-scanning sonars (SSS), or multibeam echosounders (MBES) (Lurton and DeRuiter 2011). MBES are usually used for hydrographic, geophysical, or imaging work, and are not common on other vessel types or for vessel navigation (Phillips and Kendrick 2020). Typical frequency ranges for these different systems are generally between 12 to 400 kHz, overlapping with the communication ranges of many different marine mammals (Lurton and DeRuiter 2011; Cholewiak et al. 2017). Navigation echosounders normally operate at 50 or 200 kHz (Lurton and DeRuiter 2011), while echosounders for fish finding use various frequencies between 15 and 200 kHz (Hansen 2009; Furuno Electric Co. 2013). Echosounder source levels are generally high and range from 200-240 dB re 1µPa at 1 m (Lurton and DeRuiter 2011; Cholewiak et al. 2017).

The extent of echosounder use in the Fundian Channel-Brown's Bank AOI is not well known, but it is reasonable to presume that most, if not all vessels make use of echosounders for fish-finding, depth-finding, or use devices that combine both technologies. Echosounders are required for vessels to be able to operate reliably in depths of 2 to 400 m, and vessels are likely to use echosounders when approaching depths of 100 to 200 m (G. Anderson, Transport Canada Marine Safety and Security, personal communication, 2021). Consequently, for this analysis, echosounder use was assumed to be one per vessel in the AOI. Echosounders used for fish-finding are not subject to specific regulatory performance requirements but do need to meet safety and compatibility standards as with any marine electronics (Phillips and Kendrick 2020).

Existing management measures

In 2014, the IMO approved a series of non-mandatory guidelines to reduce underwater noise from commercial shipping (IMO 2014). The guidelines are aimed at designers, shipbuilders, and ship operators, and may be applied to any commercial ship. They include considerations on how to design quieter propellers and hulls, operational and maintenance considerations like cleaning propellers, and suggestions on reducing speed. As a signatory to the IMO, Canada then took measures to better understand the scope of the problem of underwater noise from ships. Transport Canada contracted the Green Marine Management Corporation to more fully assess the issue of underwater noise in domestic waters and created a formal working group composed of members of the scientific community, industry, and government agencies. In 2019, Transport Canada hosted an international workshop entitled “Quieting Ships to Protect the Marine Environment” and commissioned an accompanying report on current noise mitigation technologies (Kendrick and Terweij 2019). Results from the workshop included a series of recommended actions and future work, within both the shorter-term (1-2 years) and longer-term (>5 years), that may help to address the impacts from underwater noise generated by ships through improving ship design and implementing certain programs and strategies (Bahtiarian 2019). More local, targeted approaches have largely been initiated by individual localities. An example is the Enhancing Cetacean Habitat and Observation (ECHO) program started by the Vancouver Fraser Port Authority, launched in 2014, with the aim of better understanding and reducing cumulative impacts of commercial vessel activity on Southern Resident Killer Whales (SRKW) off the south coast of British Columbia. Mitigation actions include a voluntary vessel slowdown to 11.5 knots or less in the Haro Strait and Boundary Pass to reduce underwater noise intensity in a known SRKW foraging area (Port of Vancouver 2020). With regards to smaller vessels such as fishing boats, little guidance currently exists. On the East Coast, the annual NOTMAR recommends that vessels avoid the Gully Marine Protected Area to reduce vessel noise-based disturbance to whales (Canadian Coast Guard 2021).

The use of echosounders for safety reasons as means to determine water depth are prescribed in section 3.36(a) of the *Fishing Vessel Safety Regulations* under the *Canada Shipping Act,* which stipulates that fishing vessels must be equipped with means for determining the depth of water under the vessel. Echosounding equipment to measure and display the available depth of water is also a requirement for all vessels of 300 GT or more, per section 110(a) of the *Navigation Safety Regulations* under the *Canada Shipping Act*. The same requirement exists under Chapter V, section 16 of the IMO’s *International Convention for the Safety of Life at Sea* (SOLAS) (IMO 1974), where all vessels 300 GT and greater and all passenger ships regardless of size are required to be fitted with an echosounding device or other electronic means to measure and display water depth.

While no laws pertaining to the management of noise from echosounders and fish-finding devices currently exist, some efforts have been carried out on the west coast of Canada to reduce sonar-related impacts on the endangered population of SRKW. Management measures include a request to mariners to turn off their echosounders in critical habitat where it is safe to do so (Government of Canada 2021), and vessel routing away from known critical habitat (Phillips and Kendrick 2020). The Government of Canada is also investigating the development of alternative depth-finding technologies that do not use sound (Government of Canada 2020) and exploring the possibility of using higher operating frequencies (200 kHz and above) in order to avoid the most sensitive hearing range of toothed whales (Phillips and Kendrick 2020).

Finally, under the *Fisheries Act*, disturbance of marine mammals is prohibited, while the *Species at Risk Act* prohibits harassment of endangered species. As stated in section 3.4.1, the *Marine Mammal Regulations* provide various minimum approach distances to different marine mammals to reduce disturbances. Accordingly, the provisions under these Acts and regulations may indirectly reduce certain noise disturbances for the species assessed here.

**<u>Risk assessment – Vessel noise and beaked whale habitat</u>**

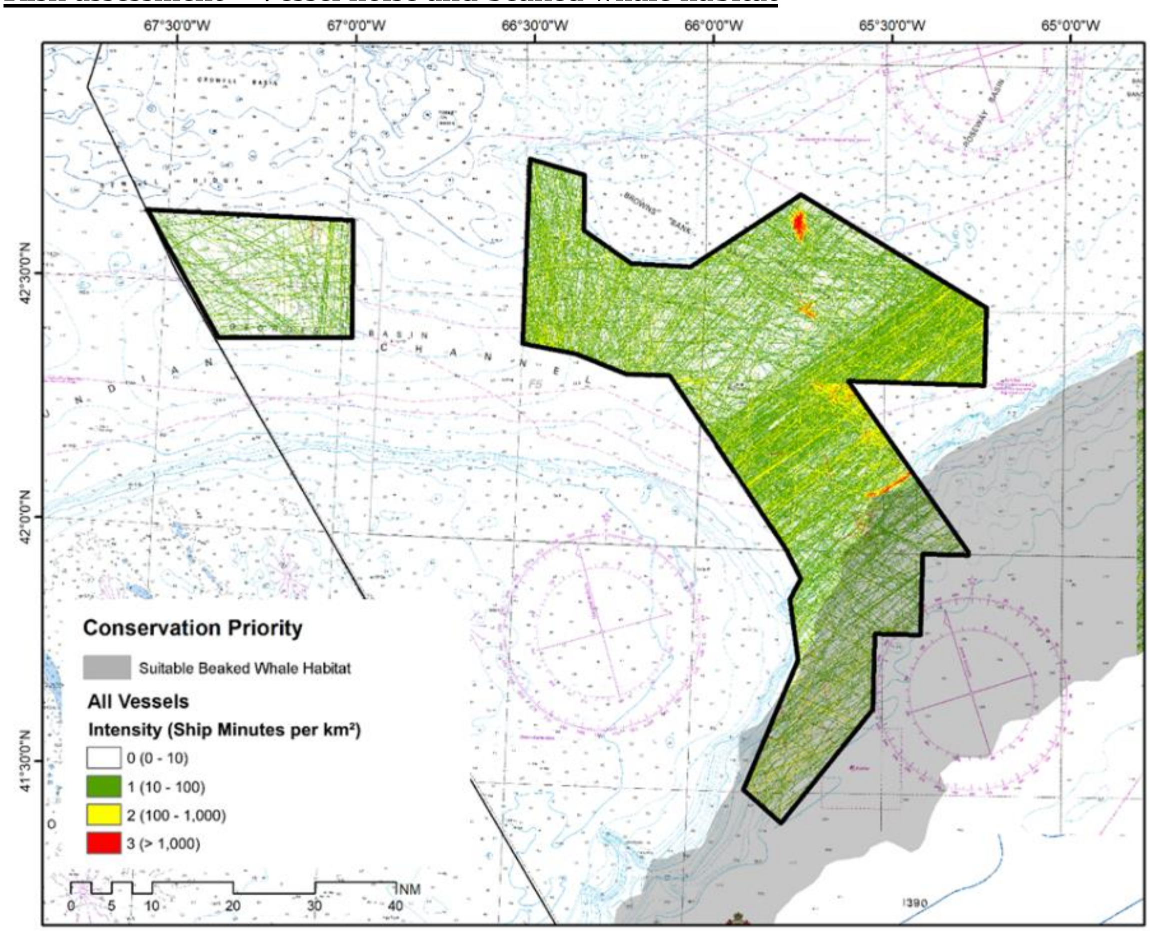


Figure 3.4.2-1. Overlap of extent of suitable beaked whale habitat and all vessel traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available Automatic Identification System (AIS) data. For intensity

calculations vessel traffic was classified into negligible (0), low (1), medium (2), or high (3) intensity categories.

**Risk statement**: There is a risk that noise generated by vessel traffic will lead to negative impacts on beaked whales in their suitable habitat within the AOI.

Table 3.4.2-1. Scoring for the risk posed by vessel noise to beaked whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 3<br>= 12 (raw score) |
| Intensity | 1 | While vessel noise is present before a vessel enters the AOI and persists once the vessel has left the area, overlap is predominantly characterized by low density vessel traffic, resulting in an overall intensity exposure score of 1. |
| Temporal | 4 | Beaked whales occur in the AOI year-round (see Chapter 1, Section 1.4.3). As vessel traffic is present and consistent in the AOI throughout the year, beaked whales may be exposed to vessel noise at all times of the year. |
| Spatial | 3 | There is >50% spatial overlap between beaked whale habitat and vessel traffic in the AOI, resulting in a score of 3. |
| $Q_{Sensitivity}$ | 2 | Beaked whales are believed to have a generalized hearing range of 150 Hz to 160 kHz (NMFS 2018), though with higher sensitivity between 20-90 kHz (Cook et al. 2006; Finneran et al. 2009). Beaked whales are generally known to be sensitive to underwater noise (Fernández et al. 2005; Tyack et al. 2011; Miller et al. 2015). Ship noise peaks at low frequencies (10-100 Hz) (Andrew et al. 2002) while smaller vessels, emit noise at higher frequencies (e.g., 48 kHz as measured by Erbe et al. 2016).<br><br>Noise from large vessels has been linked to disturbances in beaked whale behaviour. Broadband noise from a fast-moving cargo ship at a distance of 700 m coincided with a reduction in vocalizations and prey-capture attempts by a Cuvier’s Beaked Whale, reducing foraging efficiency by >50% during the disturbed dive (Aguilar Soto et al. 2006). Pirotta et al. (2012) found that intense (~206 dB re 1 µPa at 1 m) vessel noise in close proximity to Blainville’s Beaked Whales interfered with foraging behaviour. Because of the energetically expensive nature of deep dives, repeated, chronic disruptions to foraging could result in reduced food intake and reduced energy gain, possibly impacting survival. Intense ship noise may also disrupt foraging by masking prey echoes or by masking acoustic signals used to coordinate group diving behaviour (Aguilar Soto et al. 2006). Evidence that Sowerby’s Beaked Whales may be sensitive to vessel noise is suggested in Whitehead (2013) where a perceived increase in Sowerby’s Beaked Whale presence in the Gully submarine canyon over many |

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| | | years was thought to be due to a reduction in underwater noise, including vessel noise, after the area was designated as a marine protected area.<br><br>There is limited evidence so far that noise from small vessels affects odontocetes. Dyndo et al. (2015) studied responses of captive Harbour Porpoises to noise from sailing boats on engine, recreational boats with outboard motors and fishing boats, and found that higher levels of medium- to high-frequency (0.25-63 kHz) components of vessel noise significantly increased the likelihood of a Harbour Porpoise exhibiting a porpoising reaction.<br><br>In addition, noise has been shown to cause stress in North Atlantic Right Whales (Rolland et al. 2012). While this has not yet been demonstrated for beaked whales, it is possible that chronic exposure to ship noise could elicit stress responses in toothed cetaceans.<br><br>A recent assessment found that vessel noise is considered to be a low threat to Northern Bottlenose Whales in eastern Canadian waters, unlikely to jeopardize survival or recovery at the population level but linked to harassment, disturbance, increased stress or similar impacts to individuals (DFO 2022). Similarly, according to Southall et al. (2018), interference from ship noise is likely to be relatively limited for toothed whales. Large vessels generally tend to be the noisiest in the low-frequency range (Arveson and Vendittis 2000), and in the AOI, cargo ships and tankers are the most common vessel traffic type. Nevertheless, considering the demonstrated effects of noise on beaked whales and the species' known sensitivity to noise, a sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 2$<br>$= 8$ (raw score) |
| Likelihood | Unlikely | An interaction has the potential to occur in instances where a beaked whale and a passing vessel are present at the same time within the AOI within sufficient proximity that the vessel noise causes a disturbance to the animal. Beaked whales are known to be sensitive to acoustic disturbance, and their variable position in the water column may make them more likely to encounter vessel noise than benthic organisms. Vessels travel through the AOI on a consistent but low-intensity basis. Because of the ability of low-frequency sound to propagate long distances, vessel noise presence probability can increase by many folds; a 100 Hz signal can easily propagate 10 km or more on shelves (J. Xu, DFO Science, personal communication, 2022). However, vessel frequencies detectable by beaked whales (> 10 kHz) are likely to occur less frequently and propagate less far. Based on vessel |

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| | | traffic intensity in the AOI, water column propagation distance of vessel traffic noise, and beaked whale hearing sensitivity, an interaction was estimated to occur in roughly less than 19% of cases (J. Xu, personal communication, 2022). While a disturbance resulting in detectable negative impacts is even less likely, it is still reasonable to expect that a detectable negative impact remains greater than 5%. Consequently, likelihood was assessed as unlikely. |
| Overall risk | Moderately High | Additional management actions should be considered (where feasible) in collaboration with Regulators, including voluntary avoidance or speed reduction in high risk areas within the future MPA. |
| Uncertainty | Moderate | The negative impacts of anthropogenic noise on cetaceans have been well established. However, the impacts of vessel noise on beaked whales are still not fully understood, nor is the likelihood or severity of any long-term consequences that may result. Understanding the long-term and population-level impacts of noise exposure on marine mammals is a gap in the field of marine bioacoustics broadly (Erbe et al. 2019), and so any inferences about long-term consequences should be made with caution, while still adhering to the precautionary principle. A recently published analysis concluded that vessel noise is a low threat to Northern Bottlenose Whales in Canadian waters, although the threat to other beaked whale species has not yet been assessed. Furthermore, because no quantitative analyses based on data from the AOI are available, only a qualitative assessment of vessel noise levels in the AOI is possible at this time. In addition, beaked whale habitat was defined using available data from visual detections, acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited. There is also uncertainty associated with the use of this area for Northern Bottlenose Whales in particular, given that it is toward the southern extent of their range. |

**Risk assessment – Vessel noise and Blue Whale foraging area**

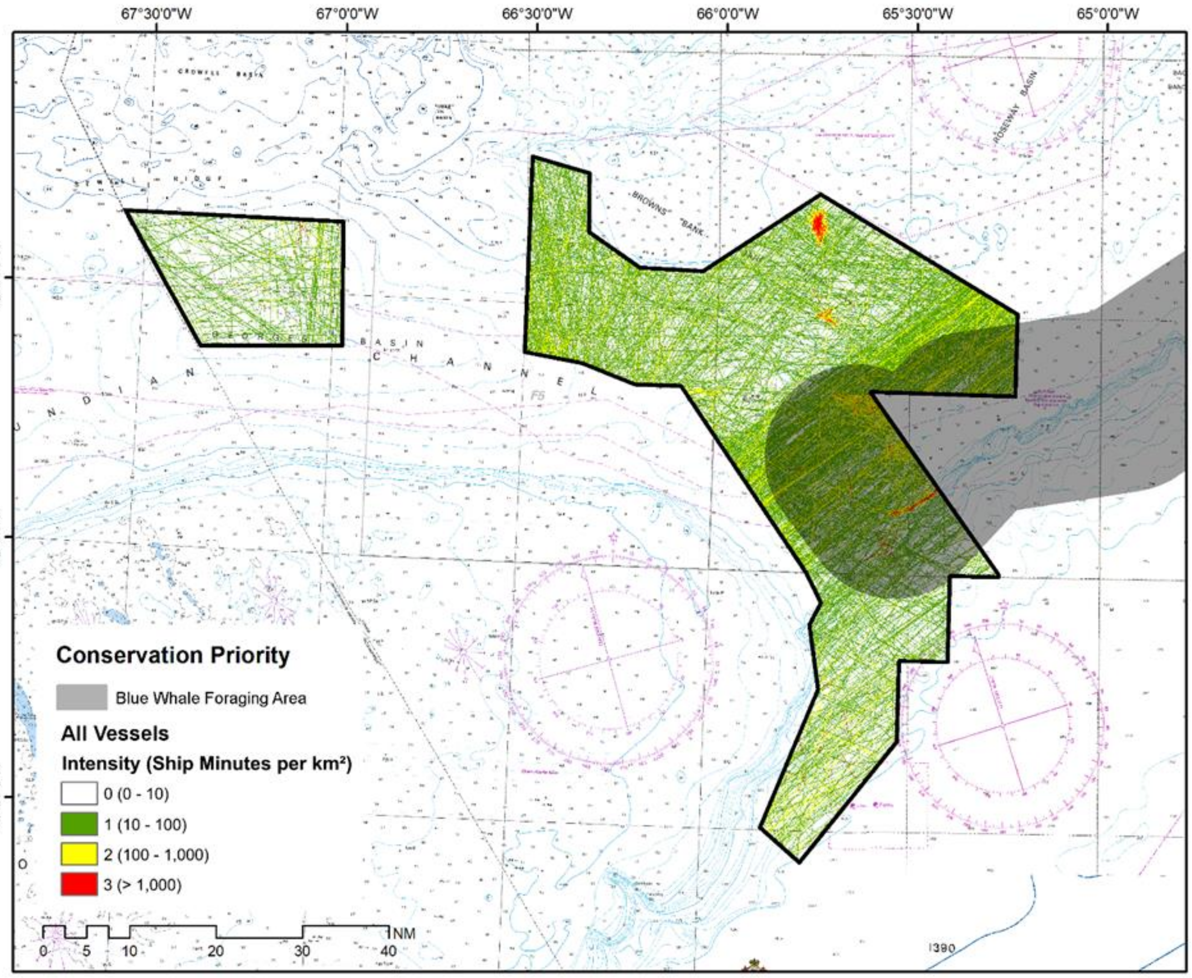


Figure 3.4.2-2. Overlap of Blue Whale foraging habitat and all vessel traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available Automatic Identification System (AIS) data. For intensity calculations vessel traffic was classified into negligible (0), low (1), medium (2), or high (3) intensity categories.

**Risk statement**: There is a risk that noise generated by vessel traffic will lead to negative impacts on Blue Whales in an important foraging area within the AOI.

Table 3.4.2-2. Scoring for the risk posed by vessel noise to Blue Whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 3<br>= 12 (raw score) |
| Intensity | 1 | While vessel noise is present before a vessel enters the AOI and persists once the vessel has left the area, overlap is predominantly characterized by low-density vessel traffic, resulting in an overall intensity exposure score of 1. |

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| Temporal | 4 | Although temporal distribution patterns are not well described, Blue Whales are present in Canadian waters year-round (Lesage et al. 2018). As vessel traffic is present and consistent in the AOI throughout the year, Blue Whales may be exposed to vessel noise at all times of the year. |
| Spatial | 3 | There is >50% spatial overlap between Blue Whale foraging habitat and vessel traffic in the AOI, resulting in a spatial overlap score of 3. |
| $Q_{Sensitivity}$ | 2 | Baleen whales like Blue Whales are believed to be most sensitive to low-frequency sounds between tens of Hz and ~10 kHz (Southall et al. 2007). Ship noise peaks at low frequencies (10-100 Hz) (Andrew et al. 2002), while smaller vessels emit noise at higher frequencies (e.g., 48 kHz as measured by Erbe et al. 2016). Noise produced by large ships is therefore thought to be of particular concern for baleen whales (Hatch et al. 2012; Southall et al. 2018).<br><br>Previous studies have found routine transient passages of container, tanker and cargo ships can reduce communication space (i.e., mask important sound signals) for a low-frequency baleen whale species by as much as 87.4% (Putland et al. 2018). A study by Aulanier et al. (2016) found that shipping noise masked the two main Blue Whale call types in the Gulf of St. Lawrence (GSL) and St. Lawrence Estuary (SLE) and reduced overall communication space, with effects increasing with greater proximity to shipping lanes and with increasing ship traffic. Masking calls of conspecifics can have negative effects for Blue Whales; as largely solitary animals, they are particularly reliant on their ability to communicate over large distances (Payne and Webb 1971) and some call types are thought to serve a reproductive function (Oleson et al. 2007). Consequently, masking and reduced communication space can potentially hamper reproductive recruitment and recovery (Croll et al. 2002) which is important considering the species' endangered status.<br><br>In addition to masking, behavioral responses to vessel noise have also been documented. In the presence of ships, Blue Whales in the Santa Barbara Channel (SBC) off California produced a significantly greater proportion of certain call types and produced more rapid, intense calls (McKenna 2011) and ceased calling and reduced their foraging efficiency when ships were within 4 km (McKenna et al. 2009). Such responses were deemed to have potentially high survival implications, as Blue Whales may continue to forage even in disturbed areas, leading them to experience energy losses and be at a greater risk of ship strike. In the GSL and SLE, it was estimated that the overall risk of exceeding the lowest noise level threshold for behaviour change in |

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| | | Blue Whales exists 30% of the time at ranges up to 20 km from shipping lanes (Aulanier et al. 2016). It is important to note, however, that the GSL, SLE and SBC are subject to more intense ship traffic than the AOI.<br><br>Finally, stress due to exposure to ship noise has been documented in North Atlantic Right Whales (Rolland et al. 2012) and it is possible that Blue Whales could experience a similar stress response.<br><br>With respect to smaller vessel types like fishing vessels, though their smaller size results in higher-frequency and less intense noise than large ships (Au and Green 2000; Hildebrand 2005), these vessels can still emit noise at frequencies and intensities sufficient to cause measurable effects in baleen whales (e.g., Stamation et al. 2010).<br><br>The SARA Blue Whale Recovery Strategy identified anthropogenic noise causing acoustic environmental degradation and changes in behaviour as a threat of high concern to Blue Whales that is likely to jeopardize recovery, with maritime shipping singled out as particularly significant (Beauchamp et al. 2009). Large vessels generally tend to be the noisiest in the low-frequency range (Arveson and Vendittis 2000), and in the AOI, cargo ships and tankers are the most common vessel traffic type. As stated, ship noise occupies the same low-frequency band used by Blue Whales. While it is unlikely that acoustic disturbance due to vessel noise in the AOI would lead to a detectable change in Blue Whale population size or reproductive capacity, a disturbance due to vessel noise is possible, and the time to return to original behaviour post-disturbance could conceivably be on a scale of days, but is unlikely to be longer. An overall sensitivity score of 2 was therefore applied. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 2$<br>$= 8$ (raw score) |
| Likelihood | Moderate | An interaction has the potential to occur in the instances where a Blue Whale and a passing vessel are present at the same time within the AOI within sufficient proximity that the vessel noise causes a disturbance to the animal. Blue Whale occurrence within the AOI is not well known, but they may be present at any time. Vessels travel through on a consistent but low-intensity basis. Because of the ability of low-frequency sound to propagate long distances, vessel noise presence probability can increase by many folds; a 100 Hz signal can easily propagate 10 km or more on shelves (J. Xu, personal communication, 2022). Blue Whales vocalize at a similar frequency as vessel noise, and their variable position in the water column may make them more likely to |

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| | | encounter vessel noise than less mobile organisms. Based on vessel traffic intensity in the AOI, water column propagation distance of low-frequency vessel traffic noise and Blue Whale hearing capability, an interaction is estimated to occur in roughly less than 50% of cases (J. Xu, personal communication, 2022). A disturbance resulting in detectable negative impacts is even less likely, but considering the direct overlap between Blue Whale auditory sensitivity range and large vessel noise, the potential for a detectable negative impact is still expected to be within a moderate range of probability. |
| Overall risk | Moderately High | Additional management actions should be considered (where feasible) in collaboration with Regulators, including voluntary avoidance or speed reduction in high risk areas within the future MPA. |
| Uncertainty | Moderate | Vessel noise is known to cause adverse effects on baleen whales, and behavioural changes due to noise are a known threat to the Northwest Atlantic population of Blue Whales. Nevertheless, the full spectrum of possible effects of noise on Blue Whales is not fully understood, and reactions are generally highly species- and context-dependent. Furthermore, because no quantitative analyses based on data from the AOI are available, only a qualitative assessment of vessel noise levels the AOI is possible at this time. Finally, the likelihood or severity of any long-term consequences of noise exposure are poorly understood. Understanding the long-term and population-level impacts of noise exposure on marine mammals is a gap in the field of marine bioacoustics broadly (Erbe et al. 2019), and so any inferences about long-term consequences should be made with caution, while still adhering to the precautionary principle. |

## Risk assessment – Vessel noise and Atlantic Cod

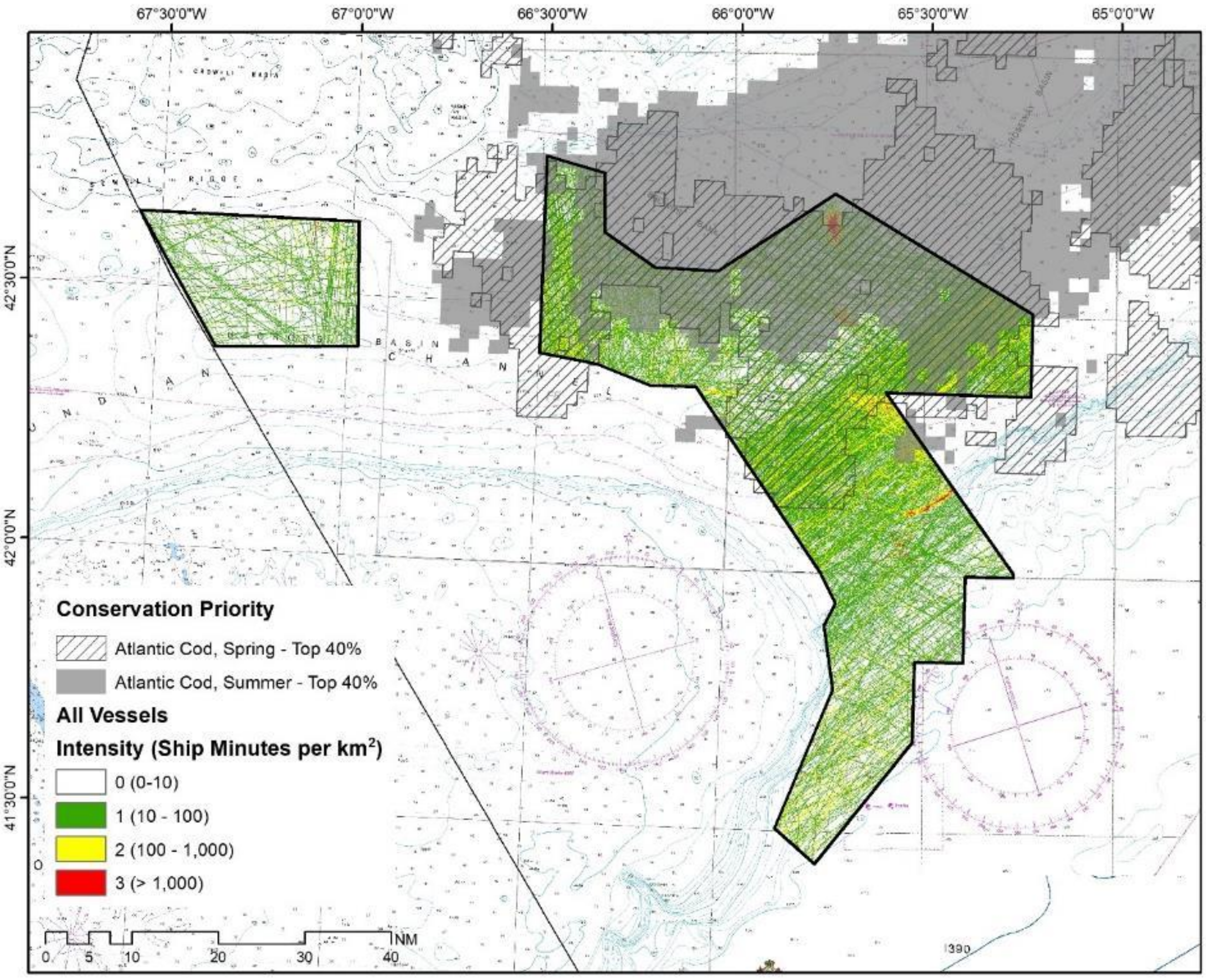


Figure 3.4.2-3. Overlap of representative habitat for Atlantic Cod (from both spring and summer survey data) and all vessel traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from March 1, 2017 to February 28, 2018 using available automatic Identification System (AIS) data. For intensity calculations vessel traffic was classified into negligible (0), low (1), medium (2), or high (3) intensity categories.

**Risk statement**: There is a risk that noise generated by vessel traffic will lead to negative impacts on the local population of Atlantic Cod in its representative habitat within the AOI.

Table 3.4.2-3. Scoring for the risk posed by vessel noise to Atlantic Cod within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 3<br>= 12 (raw score) |
| Intensity | 1 | While vessel noise is present before a vessel enters the AOI and persists once the vessel has left the area, overlap is predominantly characterized by low density vessel traffic, resulting in an overall intensity exposure score of 1. |

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| Temporal | 4 | Vessels are transiting the AOI year-round on a fairly consistent basis. As Atlantic Cod are thought to occur within the AOI throughout the year, temporal overlap was scored as continuous. |
| Spatial | 3 | Vessel traffic overlaps with 66.3% of Atlantic Cod representative habitat during the spring (which includes the reproductive period) and 62.3% in the summer. A spatial score of 3 was therefore applied. |
| $Q_{Sensitivity}$ | 2 | Cod possess swim bladders positioned close to their ears making them sensitive to a wider frequency range of sounds and able to detect lower-intensity sounds compared to other fish species (Popper and Hawkins 2019; Popper et al. 2021). Cod also appear to be sensitive to both sound pressure and particle motion, allowing them to locate sound sources and discriminate sounds against a noise background (Popper and Hawkins 2019). Atlantic Cod perceive low-frequency sounds; it is believed their optimal hearing bandwidth is between 18-400 Hz with high sensitivity around 280 Hz (Buerkle 1967). The species also communicates at low frequencies, mainly during courtship and reproduction (Brawn 1961; Rowe and Hutchings 2004; Rowe and Hutchings 2006). Ship noise peaks at low frequencies (10-100 Hz) (Andrew et al. 2002) while smaller vessels, emit noise at higher frequencies (e.g., 48 kHz as measured by Erbe et al. 2016).<br><br>Ship noise has been shown to mask signals in the Lusitanian toadfish by considerably increasing auditory thresholds and decreasing individuals' abilities to detect signals of conspecifics (Vasconcelos et al. 2007). Masking can also affect foraging success by distracting fish or masking the acoustic stimuli of prey (Purser and Radford 2011; Voellmy et al. 2014). Similar to masking, routine passages of container, tanker and cargo ships were found to reduce acoustic communication space up to 61.5% at 250 Hz for bigeye (Putland et al. 2018), a vocal fish species with hearing sensitivity similar to that of Atlantic Cod.<br><br>In addition to masking and reduced communication space, noise can induce stress responses. Artificial noise in the 100-1000 Hz range has been shown to elicit a stress response in Atlantic Cod by elevating cortisol levels, and repeated and chronic exposure was found to have negative effects on Atlantic Cod brood stock through reduced fertilization rates, leading to compromised spawning performance (Sierra-Flores et al. 2015). Behavior changes can also result from exposure to noise. Playbacks of ship noise have been associated with altered behavior and reduced growth and lower body-length ratios in larval cod (Nedelec et al. 2015), and significant avoidance behaviours have been documented by Atlantic Cod in response to a passing trawl vessel (Handegard et al. 2003).<br><br>Importantly for cod, sound production appears to play a crucial role in spawning behavior (Rowe and Hutchings 2006) and may be |

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| | | associated with reproductive success (Rowe and Hutchings 2008). If sounds associated with critical life functions (such as reproduction or predator avoidance) are compromised due to masking, fitness consequences can result (Slabbekoorn et al. 2010). Soudjin et al. (2020) modeled the impact of noise exposure on Atlantic Cod and concluded that population-level effects can result from noise exposure by increasing energy expenditure, reducing food intake, increasing mortality and reducing reproductive output.<br><br>Large vessels generally tend to be the noisiest in the low-frequency range (Arveson and Vendittis 2000), and in the AOI, cargo ships and tankers are the most common vessel type. Considering that the frequencies of the sounds that are important to the critical life functions of Atlantic Cod overlap directly with low-frequency vessel noise, vessel noise in Atlantic Cod representative habitat could interfere with the production and detection of important acoustic signals, possibly leading to further impacts such as interruptions to spawning behavior. However, population-level impacts would not be expected. A sensitivity score of 2 was therefore was applied. It should be noted that while Atlantic Cod are present year-round, disturbance due to noise may be greatest during courtship and spawning which is constrained to a smaller temporal window of about 3 months (February-April). |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 2$<br>$= 8$ (raw score) |
| Likelihood | Rare | An interaction has the potential to occur in instances where an Atlantic Cod and a vessel are present at the same time within the AOI within sufficient proximity that the vessel noise causes a disturbance to the animal. Vessels travel through on a consistent but very low-intensity basis. Because of the ability of low-frequency sound to propagate long distances, vessel noise presence probability can increase by many folds; a 100 Hz signal can easily propagate 10 km or more on shelves (J. Xu, personal communication, 2022). Based on vessel traffic intensity in the AOI, water column propagation distance of low-frequency vessel traffic noise, and Atlantic Cod hearing sensitivity and demersal nature, an interaction is estimated to occur in roughly less than 19% of cases (J. Xu, personal communication, 2022). However, a disturbance that then leads to detectable negative impacts (i.e., social disturbance that disrupts mating) is expected to be much less likely. Therefore a likelihood score of rare was assigned. |
| Overall risk | Moderate | Additional management actions may be considered in collaboration with Regulators, including voluntary avoidance or speed reduction in high risk areas within the future MPA, especially during the spring mating period. |

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| Uncertainty | High | The impacts of anthropogenic noise on fishes are not well understood, and no quantitative empirical information on sound exposure levels of cod in the wild are currently available. As a result, extent that impacts may affect individuals and populations over different spatial and temporal scales is not well known. Furthermore, cod are sensitive to both particle motion and sound pressure, yet most studies on fish bioacoustics have been based solely on sound pressure (Popper and Hawkins 2019). Cod may therefore be sensitive to sounds in ways that are not yet understood. It is also important to consider that the bulk of studies on fish hearing and sound production have been based on results from laboratory experiments, and results may differ if similar studies were carried out in a natural setting. Furthermore, no quantitative analyses based on data from the AOI are available, only a qualitative assessment of vessel noise levels in the AOI is possible at this time. |

**<u>Risk assessment – Echosounders and beaked whale habitat</u>**

For a map of the overlap of suitable beaked whale habitat and vessel traffic in the Fundian Channel-Browns Bank AOI, please refer to Figure 3.4.2-1.

**Risk Statement:** There is a risk that noise generated by echosounders used by vessels will lead to negative impacts on beaked whales in their suitable habitat within the AOI.

Table 3.4.2-4. Scoring for the risk posed by echosounder noise to beaked whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 3<br>= 12 (raw score) |
| Intensity | 1 | Echosounder use is assumed to be one per vessel. Overlap is predominantly characterized by low-density vessel traffic, resulting in an overall intensity exposure score of 1. |
| Temporal | 4 | Beaked whales occur in the AOI year-round (see Chapter 1, Section 1.4.3). As vessel traffic is present and consistent in the AOI throughout the year, beaked whales may be exposed to echosounder noise at all times of the year. |
| Spatial | 3 | There is >50% spatial overlap between beaked whale habitat and vessel traffic in the AOI, resulting in a score of 3. |
| $Q_{Sensitivity}$ | 2 | Beaked whales are believed to have a generalized hearing range of 150 Hz to 160 kHz (NMFS 2018), though with higher sensitivity between 20-90 kHz (Cook et al. 2006; Finneran et al. 2009). Beaked whales are generally known to be sensitive to underwater noise (Fernández et al. 2005; Tyack et al. 2011; Miller et al. 2015).<br><br>Previous studies have suggested that shipboard echosounders are unlikely to result in significant rates of injury for cetaceans due |

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| | | to their narrow beam width and higher absorption of higher frequencies (Lurton and DeRuiter 2011; Lurton 2016). While few animals are likely to be directly within the echosounder beam, echosounder signals are detectable far beyond the cone of impact beneath the ship. Data show that EK60 echosounder signals can be detected up to 800 m depth and out to 1.3 km (Cholewiak et al. 2017). Modeled sound fields of three different multibeam echosounders suggest that peak amplitudes of 160 dB may radiate out up to nearly 4 km (Lurton 2016). These levels are considered detectable above background noise and could elicit changes in behaviour by sensitive species (Cholewiak et al. 2017).<br><br>Behavioral changes by toothed whales exposed to shipboard echosounders have been demonstrated in previous studies. Quick et al. (2017) found that short-finned Pilot Whales exposed to a scientific echosounder consistently changed their movement behavior. Cholewiak et al. (2017) found that when exposed to shipboard echosounders, beaked whales were significantly less likely to be detected acoustically when the echosounders were actively transmitting. When the whales were detected, they were detected for less time. Such a change could be indicative of an alteration or cessation of foraging or avoidance of the survey vessel (Cholewiak et al. 2017). It is hypothesized that cessation or altering of foraging behaviour is a survival response to a perceived threat. When exposed to Killer Whale playbacks, foraging Northern Bottlenose Whales ceased foraging completely, likely to evade detection (Miller et al. 2022). A similar sustained avoidance response was observed in a Blainville’s Beaked Whale exposed to Killer Whale sounds (Allen et al. 2014). The whale’s reduction in foraging buzzes were hypothesized to indicate reduced foraging effort in favour of fleeing the area. With echosounders being similarly characterized by high-frequency, acute sounds, similar to the calls of Killer Whales, and with echosounders already shown to result in lower beaked whale detections, beaked whales in the presence of operational echosounders could be reacting with similar evasive responses. However, there are many other factors that could influence the likelihood of these responses and the severity of their impacts (e.g., body condition, food availability) (Miller et al. 2022).<br><br>In addition to behaviour change leading to energy trade-offs, noise has been shown to cause stress in cetaceans (Rolland et al. 2012). While this has not yet been demonstrated for beaked whales, exposure to high-intensity sounds that mimic predator calls could cause a stress response. |

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| | | A recent assessment found that the threat of echosounders to Northern Bottlenose Whales in eastern Canadian waters is unknown at this time (DFO 2022). However, this does not indicate that this threat is not important, but rather that the effect on individuals or populations is not known. Based on the above, beaked whales demonstrate clear and measurable behavioural reactions to echosounder noise and these reactions can have implications for survival. The time to return to original behaviour post-disturbance could conceivably be on a scale of days, but is unlikely to be longer. An overall sensitivity score of 2 was therefore assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 2$<br>$= 8$ (raw score) |
| Likelihood | Unlikely | An interaction has the potential to occur in the instances where a beaked whale and a vessel are present at the same time in the AOI within sufficient proximity that the echosounder noise causes a disturbance to the animal. According to Phillips and Kendrick (2020), odontocetes are likely to perceive typical echosounders at lateral ranges within about 5.5 km at 50 kHz and 1 km at 200 kHz, and typical fish finders from about 6.2 km at 50 kHz to 1.2 km at 200 kHz. However, these numbers may vary. Beaked whales are known to be sensitive to acoustic disturbance, and their variable position in the water column may make them more likely to encounter echosounder noise than benthic organisms. Based on water column propagation distance of echosounder noise, and beaked whale hearing capability, a negative interaction is estimated to occur in roughly less than 25% of cases (J. Xu, personal communication, 2022). While a disturbance resulting in detectable negative impacts is even less likely, it is still reasonable to expect that a detectable negative impact remains greater than 5%. Consequently, likelihood was assessed as unlikely. |
| Overall risk | Moderately High | Additional management actions should be considered (where feasible) in collaboration with Regulators, including voluntary echosounder shutoffs in high risk areas within the future MPA where and when safe to do so. |
| Uncertainty | Moderate | The negative impacts of anthropogenic noise on cetaceans have been well established, and there is clear evidence that the noise emitted by echosounding devices are perceived by and cause impacts to beaked whales. However, the full impacts of echosounder noise beaked whales are still not fully understood, nor is the likelihood or severity of any long-term consequences that may result. There also remains uncertainty around the degree of echosounder use in the AOI. Additionally, because no quantitative analyses based on data from the AOI are available, |

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| | | only a qualitative assessment of vessel noise levels the AOI is possible at this time. Understanding the long-term and population-level impacts of noise exposure on marine mammals is a gap in the field of marine bioacoustics more broadly (Erbe et al. 2019), and so any inferences about long-term consequences should be made with caution, while still adhering to the precautionary principle. Finally, beaked whale habitat was defined using available data from visual detections, acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited. There is also uncertainty associated with the use of this area for Northern Bottlenose Whales in particular, given that it is toward the southern extent of their range. |

**Risk assessment – Echosounders and Blue Whale foraging area**

For a map of the overlap of Blue Whale foraging habitat and all vessel traffic in the Fundian Channel-Browns Bank AOI, please refer to Figure 3.4.2-2.

**Risk Statement:** There is a risk that noise generated by echosounders used by vessels will lead to negative impacts on Blue Whales in an important foraging area within the AOI.

Table 3.4.2-4. Scoring for the risk posed by echosounder noise to Blue Whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 3<br>= 12 (raw score) |
| Intensity | 1 | Echosounder use is assumed to be one per vessel. Overlap is predominantly characterized by low-density vessel traffic, resulting in an overall intensity exposure score of 1. |
| Temporal | 4 | Although temporal distribution patterns are not well described, Blue Whales are present in Canadian waters year-round (Lesage et al. 2018). As vessel traffic is present and consistent in the AOI throughout the year, Blue Whales may be exposed to echosounder noise at all times of the year. |
| Spatial | 3 | There is >50% spatial overlap between Blue Whale foraging habitat and vessel traffic in the AOI, resulting in a spatial overlap score of 3. |
| $Q_{Sensitivity}$ | 2 | Baleen whales, like Blue Whales, are believed to be most sensitive to low-frequency sounds between tens of Hz and ~10 kHz (Southall et al. 2007). As largely solitary animals, Blue Whales are particularly reliant on their ability to communicate over large distances (Payne and Webb 1971), and the low-frequency tonal calls used in long-distance communication are thought to serve a reproductive function (Oleson et al. 2007). |

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| | | There is little information on the effects of shipboard echosounders on baleen whales. One study observed Humpback Whales moving away from 3.3 kHz sonar pulses and frequency sweeps, and increasing their speed with higher sound intensity (Maybaum 1989). Another study found that a low-frequency (50 Hz) fish imaging sonar used in the Gulf of Maine was the likely cause of reduced singing in male Humpback Whales 200 km away (Risch et al. 2012). Humpback Whale songs cover a large bandwidth of 20 Hz to 24kHz (CSA Ocean Sciences Inc. 2022), which overlaps the lower range of echosounder frequencies (Lurton and DeRuiter 2011). Nevertheless, there remains uncertainty associated with the hearing range of baleen whales (Southall et al. 2019*a*) and the upper limit of Blue Whale generalized hearing range does appear to overlap with the lower limit of frequencies (15-20 kHz) used by some types of fish-finding echosounders.<br><br>The SARA Blue Whale Recovery Strategy identified anthropogenic noise causing acoustic environmental degradation and changes in behaviour as a threat of high concern to Blue Whales that is likely to jeopardize recovery, with maritime shipping singled out as particularly significant (Beauchamp et al. 2009). Based on the above, it is possible that Blue Whales may be able to detect at least some portions of the noise signals emitted by certain types of echosounders, possibly leading to behavioural changes, although impacts remain largely unknown. Furthermore, the time to return to original behaviour post-disturbance could conceivably be on a scale of days, but is unlikely to be longer. In the absence of more information on the effects of echosounders on Blue Whales, a sensitivity score of 2 was applied. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 2$<br>$= 8$ (raw score) |
| Likelihood | Rare | An interaction has the potential to occur in the instances where a Blue Whale and a vessel with an active echosounder are present at the same time within the AOI where the echosounder is operating at a frequency detectable by a Blue Whale and within close enough proximity to cause a disturbance to the animal. Blue Whale occurrence within the AOI is not well known, but they may be present anytime. The frequency range of echosounders are generally beyond what is believed to be the most sensitive range of Blue Whale hearing capability. Based on the water column propagation distance of echosounder noise, and Blue Whale hearing capability, a negative interaction is estimated to occur in roughly less than 5% of cases (J. Xu, personal communication, 2022). The likelihood of interaction was therefore deemed to be rare. |

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| Overall risk | Moderate | Additional management actions may be considered in collaboration with Regulators, including voluntary echosounder shutoffs in high risk areas within the future MPA where and when safe to do so. |
| Uncertainty | High | The full spectrum of possible effects of noise on Blue Whales is not fully understood. Very few studies, if any, have directly examined the effects of echosounder noise on Blue Whales. While previous studies suggests that echosounders are unlikely to directly result in auditory or injury, especially for baleen whales (Lurton and DeRuiter 2011), the potential for behavioural effects remains, but is currently poorly understood. Furthermore, because no quantitative analyses based on data from the AOI are available, only a qualitative assessment of vessel noise levels the AOI is possible at this time. As well, the likelihood or severity of any long-term consequences of noise exposure are poorly understood. Understanding the long-term and population-level impacts of noise exposure on marine mammals is a gap in the field of marine bioacoustics broadly (Erbe et al. 2019), and so any inferences about long-term consequences should be made with caution, while still adhering to the precautionary principle. |

### 3.4.3 Oil spills (small operational and large accidental spills)

Vessel-sourced operational spills include small releases of oily bilge water, fuel oil sludge, and oil held as cargo or fuel (GESAMP 2007). Large accidental spills can occur as a result of collisions, groundings, structural failure, or other unintentional instances of vessels in distress at sea. The severity and impact of an oil spill depends on numerous factors (GESAMP 2007; Lee et al. 2015), including size and type of oil spilled, location, risk to public safety, ecosystem sensitivity, and complexity of the response (e.g., involvement of multiple jurisdictions, human resource and equipment requirements). Spill location and timing are crucial (Spaulding et al. 1983; GESAMP 2007; DFO 2011; GENIVAR 2013); for example, a spill that overlaps with spawning habitat or foraging area when the spawning or foraging species is present could have a greater impact than a spill that occurred elsewhere or during a different time. Wind, water, and tidal currents differ throughout the year and play a role in the fate and behaviour of a spill (DFO 2011).

The physical properties and chemical composition of a petroleum product also affect its behaviour and persistence in the environment (Lee et al. 2015). For example, light distillates of refined crude oils, such as diesel fuel, generally contain more volatile compounds ($C_{10}$ to $C_{15}$), which evaporate in air and/or naturally disperse in the water column, resulting in dilution and degradation of the product to below detectable concentrations within hours or days following a spill (Lee et al. 2015; GENIVAR 2013; NOAA n.d.). The lighter distillates are often more associated with acute toxic effects (NOAA n.d.); however, they are also more buoyant and tend not to sink and thus avoid accumulating to any significant degree in sediment or contacting benthic organisms. Crude oils, classified as light, medium, and heavy depending on their chemical composition and physical properties, tend to persist longer in the environment and are generally less acutely toxic (Lee et al. 2015). A spill of crude oil will typically form a surface slick that will spread to form thin films that may remain on the water surface longer than spills of lighter distillates. Depending on the location of the spill, these surface slicks could eventually reach shorelines where they would interact with sediments and potentially become bioavailable to benthic organisms through sinking (DFO 2011; Lee et al. 2015). Heavy fuel oil, a blend of viscous residual fuel oil and less viscous distillates, is commonly used for propulsion aboard vessels due to its low cost (Fritt-Rasmussen et al. 2018). Though the chemical composition is highly variable due to a lack of blending standards, heavy fuel oil is generally quite viscous with low dispersibility, meaning it tends to remain in a coherent surface slick longer than conventional crude oils (Lee et al. 2015; Fritt-Rasmussen et al. 2018). Due to a density that approaches or exceeds that of sea water, heavy fuel oils can sink to the seafloor under certain environmental conditions (Franco et al. 2006; Lee et al. 2015).

Along with the physical properties and chemical composition of the spilled product, environmental factors such as water temperature, sea state, and the presence of suspended sediments influence weathering time, and therefore also play a role in determining the fate, behaviour and overall severity of an oil spill (GENIVAR 2013; Lee et al. 2015). Biodegradation, the largely microbial process by which petroleum products are broken down into simpler compounds, is one of the most important contributors to weathering (National Research Council 2003*b*; Lee et al. 2015). Naturally occurring marine oil seeps have made oil-degrading bacteria ubiquitous throughout the oceans and these communities can proliferate rapidly under spill conditions (Leahy and Colwell 1990). Biodegradation is generally positively correlated with temperature, nutrient availability, and the amount of oil dispersed (i.e., bioavailable) in the water column.

The Marine Pollution Incident Reporting System (MPIRS; described below under existing management measures) includes records of two oil spills within the AOI boundary from 2001 to 2018 (Figure 3.4.3-1). Both were associated with mechanical failure. One incident involved a sailing vessel and one involved a fishing vessel; quantities were unknown in both cases. Available data (2007-2017) from the National Aerial Surveillance Program (NASP, described below) include no spill sightings within the AOI boundaries. It is suspected that most operational spills go undetected (GESAMP 2007).

Vessel-sourced small-volume operational oil spills and large accidental spills present a threat to many aspects of the marine environment. Seabirds are particularly susceptible to even very low concentrations of oil such as may be expelled in small operational spills, and alcids are especially sensitive due to the amount of time they spend on and in the water (Irons et al. 2000; Wiese and Robertson 2004; Lieske et al. 2019). Large spills (e.g., *Exxon Valdez, Deepwater Horizon*) have caused widespread yet nuanced impacts to entire ecosystems including fishes, marine mammals, benthic invertebrates, seabirds, and plankton (Peterson et al. 2003; Carassou et al. 2014; DHNRDAT 2016).

<u>Existing management measures</u>

The Ship-source Oil Spill Preparedness and Response Regime was implemented in 1995 and provides the framework to prevent and mitigate oil spills in Canada (Tanker Safety Panel Secretariat 2013). It is supported by legislation including the *Canada Shipping Act*, the *Environmental Response Arrangements Regulations,* and the *Response Organization and Oil Handling Facilities Regulations*. This regime includes three pillars: prevention; preparedness and response; and liability and compensation. Numerous measures are incorporated into each aspect, though prevention plays a key role in regulating oil spills. For example, all single-hulled tankers operating in Canada were to be phased out by 2015 and replaced with safer, double-hulled tankers (*Vessel Pollution and Dangerous Chemicals Regulations*). Preventative measures also include aids to navigation, pilotage, and vessel traffic management. Regarding preparedness, tankers are required to form an agreement with a certified oil spill Response Organization before entering Canadian waters to coordinate a response plan in case of a spill. Finally, all vessels are required to carry insurance for cargo and fuel oil spills and have access to international (International Oil Pollution Compensation Fund) and domestic (Canadian Ship-source Oil Pollution Fund) industry-funded sources of financial aid to support clean-up efforts (Transport Canada 2020*b*).

Due to the proximity of the AOI to the international maritime boundary with the USA, it is likely that planning, preparedness, and response of oil spills would be managed jointly between the Canadian and American coast guards as outlined in the Canada-United States Joint Marine Pollution Contingency Plan. The regional annex that covers Atlantic waters is called CANUSLANT.

Operational discharges are regulated through Transport Canada's *Vessel Pollution and Dangerous Chemicals Regulations*. For example, vessels are prohibited from discharging oily bilge water that has an oil concentration greater than 15 ppm in Canadian waters under these regulations.

Oil spill detections and reporting are managed by Transport Canada and the Canadian Coast Guard, respectively. Transport Canada is the lead agency for the NASP, which is the main surveillance mechanism for detecting oil pollution at sea. It uses a variety of remote sensing technologies to help detect oil spills, including side-looking airborne radar (enables sight-lines up to 45 nm on either side of the plane), infrared/ultraviolet line scanners, geo-coded digital cameras and electro-optical infrared cameras, and satellite-based vessel tracking, communications, and oil-like anomaly detections. NASP surveillance flights are scheduled in accordance with operational requirements and are conducted on an 'as-required' basis (weather and equipment availability permitting). The Canadian Coast Guard manages MPIRS, which tracks oil spill incident reports, including reports from harbour authorities, surveillance personnel, self-reporting from the polluter, and reports from the general public received via the marine pollution incident emergency phone line/VHF radio channel 16.

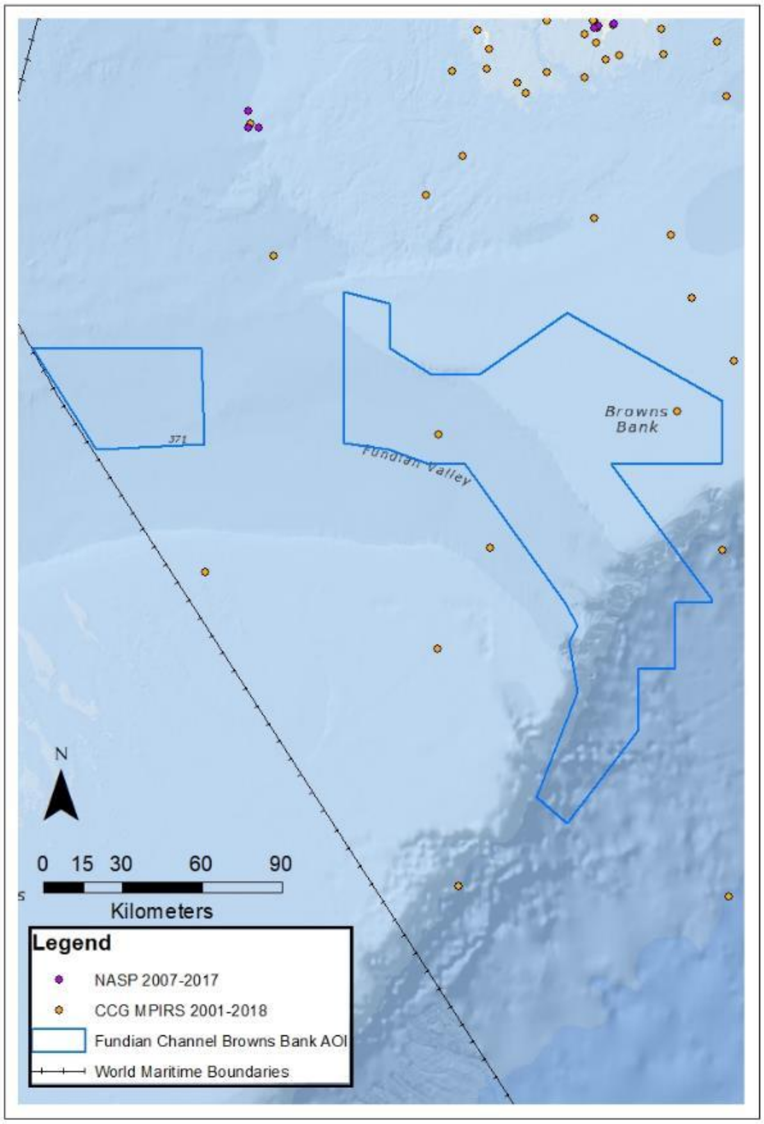


Figure 3.4.3-1. Known oil spills within and adjacent to the Fundian Channel-Browns Bank AOI. National Aerial Surveillance Program (NASP) spill sightings data spans from 2007-2017. Marine Pollution Incident Reporting System (MPIRS) data spans from 2001-2018.

**Risk assessment – Small-volume operational oil spills and pursuit-diving piscivores (alcids)**

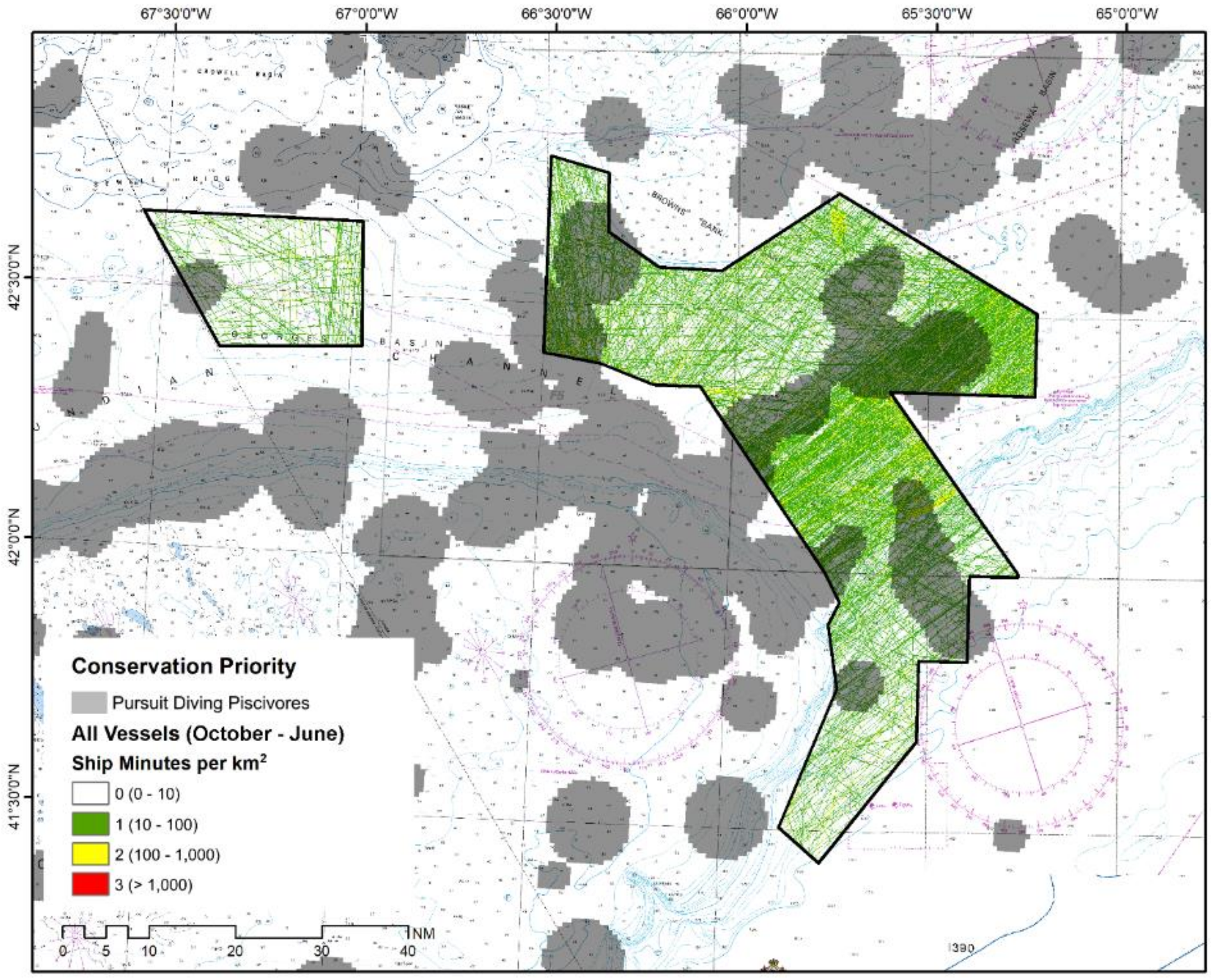


Figure 3.4.3-2. Overlap of important foraging areas for pursuit-diving piscivores (alcids) and all vessel traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from October to June, when alcids are present within the AOI. Vessel traffic patterns were generated using the available Automatic Identification System (AIS) dataset (March 1, 2017 to February 28, 2018).

**Risk statement**: There is a risk that small-volume operational oil spills will lead to negative impacts on alcids in their foraging habitat within the AOI.

Table 3.4.3-1. Scoring for the risk posed by small-volume operational oil spills to alcids within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 1 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 1<br>= 3 (raw score) |
| Intensity | 1 | Although small operational oil spills may occur relatively frequently during normal vessel operation (National Research Council 2003*b*; Wiese and Robertson 2004; GESAMP 2007), |

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| | | volumes released are expected to be small. Furthermore, while the type of oil may be variable, more refined products, such as diesel, will have lower persistence in the environment (GENIVAR 2013; NOAA n.d.), and weathering in the dynamic offshore environment is likely to be rapid. Taken together, the overall intensity of operational spills within the AOI is predicted to be low. |
| Temporal | 3 | Alcids spend the winter foraging in offshore waters such as the AOI (Godfrey 1986; Environment and Climate Change Canada 2017). Vessel traffic persists throughout the year and operational spills can occur at any time. This results in a temporal exposure score of 3. |
| Spatial | 1 | Operational oil spills can occur anywhere vessels are present throughout the AOI. The spatial footprint of any one spill is expected to be small and weathering in the offshore environment will occur rapidly. Thus, spatial overlap of a spill would be low. |
| $Q_{Sensitivity}$ | 3 | Oil can negatively impact birds by decreasing insulative capacity and waterproofing ability, which can lead to death from hypothermia, exhaustion, starvation, and increased vulnerability to predators (Wiese et al. 2001; Morandin and O'Hara 2016). Oiled birds will preen to try and remove oil, resulting in ingestion, which could lead to dehydration, a reduction in nutrient absorption and developmental delays, reproductive impairment, and mortality (Clark 1984; Wiese et al. 2001; GENIVAR 2013). Even thin oil sheens, which may be typical of small volume spills, can negatively impact bird feather microstructure and cause other negative impacts such as ingestion of oil (O'Hara and Morandin 2010; Morandin and O'Hara 2016). External oiling increases the energetic cost of flight by 20-45%, and can alter flight paths and thus increase flight distance and duration during long-distance migratory or foraging trips (Bursian et al. 2017).<br><br>Even small amounts of oil can lead to large cumulative mortality – it was estimated that >300,000 Dovekie, Thick-billed Murre, and Common Murre die each winter from chronic oil discharge in the offshore environment of southern Newfoundland (Wiese and Robertson 2004).<br><br>The amount of time that alcids spend on the surface of the water and swimming through the water column, increases their susceptibility to acute oil exposure (Mead and Baillie 1981; Irons et al. 2000). This susceptibility has been demonstrated in mortality estimates from past oil spills; for example, alcids made up the majority of the estimated 250,000 birds killed acutely by the *Exxon Valdez* event (Piatt and Ford 1996). Similarly, alcids such as Guillemot (also called Common Murre) and Razorbill accounted for 84% of seabird mortality in an assessment including large spills and operational discharges in British waters (Mead and Baillie 1981). |

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| | | Overall, the susceptibility of seabirds, and specifically alcids, to oil spills is well described. Acute negative impacts can be extensive and the understanding of chronic effects is increasing. It is estimated that impacts from small operational oil spills could cause a detectable change in population size. Therefore, a sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | Low | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 1 \times 3$<br>$= 3$ (raw score) |
| Likelihood | Likely | Small-volume spills during standard operation of vessels is estimated to occur frequently (National Research Council 2003*b*; GESAMP 2007). |
| Overall risk | Moderate | Additional management measures aimed at reducing the occurrence of this stressor may be considered, such as engaging with vessel operators to identify and address any gaps with existing rules. |
| Uncertainty | Moderate | The total amount of oil introduced into the marine environment from operational oil spills and its cumulative impact on seabird population mortality are poorly described. However, the negative effects of oil on marine birds, even in small amounts, are well known. Numerous studies have specifically documented the susceptibility of alcids to oil.<br><br>Important marine bird foraging areas were identified using available data from offshore seabird surveys. Survey coverage has been limited, and while identified foraging areas are based on occurrences, they contain a predictive component. |

**<u>Risk assessment – Large heavy fuel oil spill and large mature female lobster</u>**

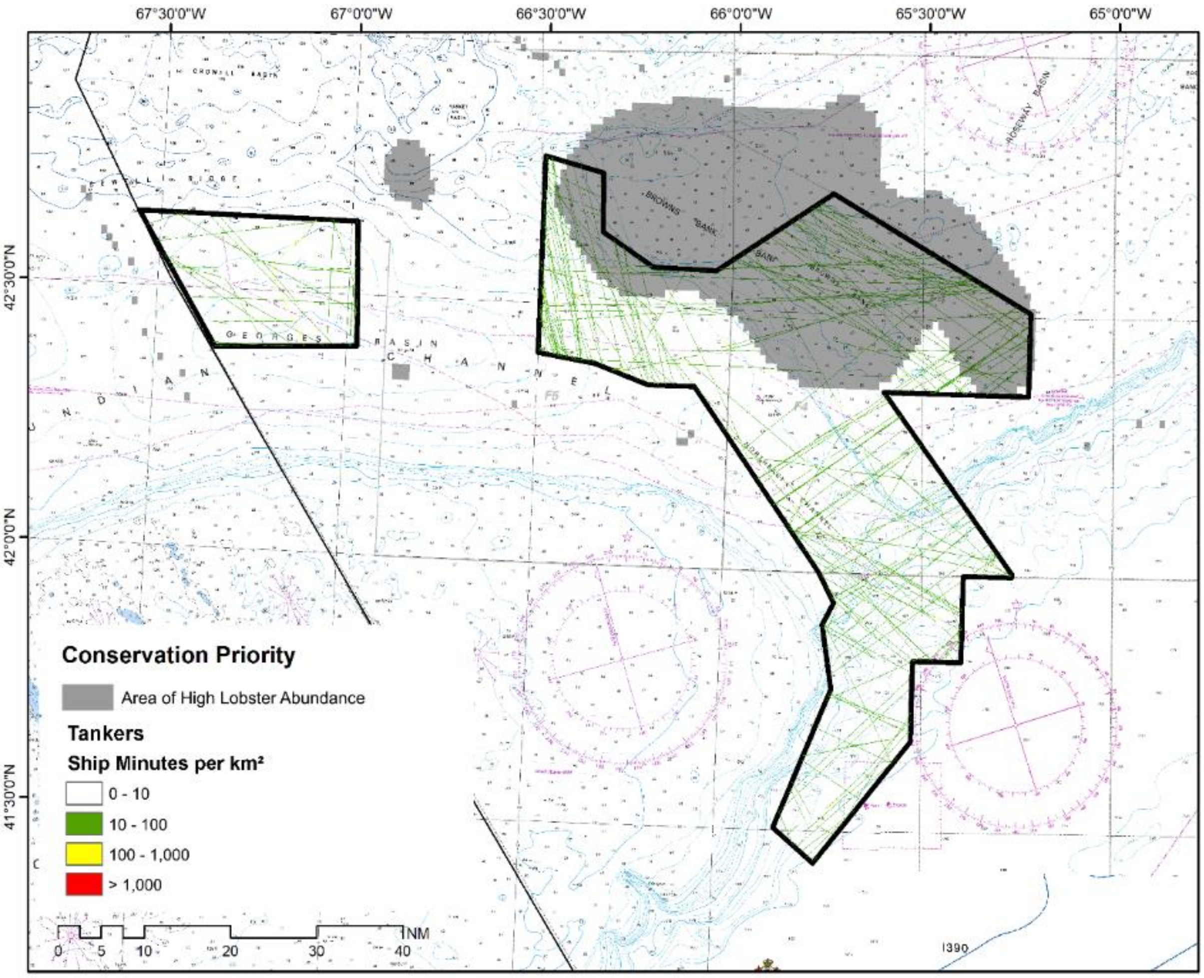


Figure 3.4.3-3. Overlap of area of high lobster abundance and tanker traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) using available Automatic Identification System (AIS) data from March 1, 2017 to February 28, 2018.

**Risk statement**: There is a risk that a large ship-sourced heavy fuel oil spill will lead to negative impacts on the local lobster population within the AOI.

Table 3.4.3-2. Scoring for the risk posed by a large heavy fuel oil spill to large mature female lobster within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 1<br>= 4 (raw score) |
| Intensity | 1 | The total quantity of oil expected to sink and reach the sediments in an open ocean spill scenario is likely low due to the oceanographic, weather, and bathymetric conditions in the AOI (see spatial exposure rationale below). Though oil compounds can persist in sediments for years (Elmgren et al. 1983; Yang et al. 2018), those |

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| | | that may accumulate on the benthos are likely to be less acutely toxic due to the evaporation of many compounds in a matter of hours or days after the spill (Serrano et al. 2006; Lee et al. 2015). Additionally, sunken heavy fuel oil can form tar balls, which have low bioavailability and may be covered by shifting sediment within months, further limiting exposure in non-burrowing organisms (Serrano et al. 2006). This results in an intensity score of 1. |
| Temporal | 4 | Lobster abundance varies seasonally and peaks in summer months during spawning (DFO 2020), though it is assumed that lobster are present within the AOI year-round. Tanker traffic is light yet persists throughout the year, so a large spill could occur at any time. This results in a temporal exposure score of 4. |
| Spatial | 1 | Tankers occur throughout the AOI and a ship in distress could discharge a large volume of oil at any location within the boundaries. The physical properties of unweathered heavy fuel oil (i.e., a density approaching or exceeding that of sea water) can lead to a portion of the slick sinking, and subsequent weathering may increase the density of the oil and further increase the proportion of the slick that sinks (Franco et al. 2006; Serrano et al. 2006; Lee et al. 2015). However, the dynamic oceanographic conditions, including wind, water currents, and wave action will limit the amount of time the slick will spend in the vicinity of the AOI (Lee et al. 2015). For cases where heavy fuel oil reaches the benthos, it will likely have a patchy distribution (Franco et al. 2006; Serrano et al. 2006). Additionally, the deep water present in the AOI further reduces the exposure potential to benthic organisms (Serrano et al. 2006; Lee et al. 2015). Sedimentation (the attachment of oil particles to suspended sediment which causes the aggregate to sink) is another process by which oil can reach the benthos but the low levels of suspended sediment within the AOI's offshore location (Brewer et al. 1976) will limit benthic exposure via this route (Lee et al. 2015).<br><br>Considering the above, a heavy fuel oil spill of this volume would not be expected to impact >10% of lobster habitat, resulting in a spatial exposure score of 1. |
| $Q_{Sensitivity}$ | 1 | Documented effects on post-larval lobsters in real-world oil spills are inconsistent in part due to the variety of circumstances in which spills have occurred. For example, models estimated that a fuel oil spill in Rhode Island, USA, killed up to 9 million juvenile lobsters (NOAA 2002), with abundances significantly lower four months later (Michel et al. 1997). This spill occurred in the shallow nearshore environment, involving a product with high toxicity, and conditions produced high levels of mixing and thus exposure to lobsters on the benthos, likely contributing to the high levels of mortality. Another fuel oil spill in the coastal zone in the USA resulted in lobster mortality, though the level was not quantified in |

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| | | available literature (Blumer et al. 1970). A 4 tonne crude oil spill in Newfoundland did not cause tissue assimilation of polycyclic aromatic hydrocarbons (PAHs; common indicators of chronic impacts due to their toxicity and carcinogenicity [Lee et al. 2015]) nor gill browning in resident lobsters, with the researchers suggesting a lack of potential long-term effects (Williams et al. 1988). An 85,000 tonne crude oil spill in the Shetland Islands caused high tissue PAH concentrations in lobster *Homarus vulgaris* immediately after the spill that were not present one month later, indicating an ability to depurate toxicants (Kingston 1999). In contrast, the same study found that the burrowing Norway lobster *Nephrops norvegicus* displayed elevated PAH levels at least five years after the spill, though it was unclear that this resulted in negative effects at the population level. A significant decline was also seen in Norway lobster abundance after the 50,000 tonne heavy fuel oil *Prestige* spill which resulted in patchy and uneven oil distribution to the benthic environment (Sanchez et al. 2006; Serrano et al. 2006). The researchers noted that similar fluctuations in population abundance for Norway lobster were seen in the years pre-spill and that population abundance overall was low before the spill. Significant declines in abundance were only displayed in the areas of highest exposure and the trend was not seen if the entire affected area was considered. Signs of recovery were noted a year after the spill, though not to pre-spill levels (Sanchez et al. 2006). As with Kingston (1999), the researchers suggested the burrowing nature of this organism increased its exposure levels, contrasting with the behaviour of American Lobster.<br><br>Laboratory studies involving crude oils have demonstrated that exposure produced no significant effects on body weight or consumption rate, no histological damage, and no mortality (Wilder 1970; Aiken and Zitko 1977; Payne et al. 1983). Sprague and Carson (1970) determined that Bunker C could be considered “practically non-toxic”, even at concentrations higher than would be expected in a real-world spill (levels above 10 000 mg/L). A study investigating the effects of diluted bitumen on egg-carrying (‘berried’) female lobsters was unable to detect mortality or effects to molting at any concentrations (Huntsman Marine Science Centre, unpublished report, 2016). In the absence of acute effects, it was suggested that chronic or sub-lethal effects may occur, and that oil exposure may increase susceptibility to other environmental stressors (Wilder 1970; Aiken and Zitko 1977). It has been suggested that foraging behavior could be impacted by oil exposure, via interference of chemosensory capabilities. The time between lobsters sensing food and beginning to search for it more than doubled when exposed to whole crude oil, though no difference was demonstrated in the same experiment using a water- |

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| | | oil emulsion at environmentally-relevant concentrations (Blumer et al. 1973). No morphological impacts on olfactory sensory hairs were seen.<br><br>Overall, available literature indicates that effects to post-larval lobsters are generally limited to scenarios involving acutely lethal products and/or where exposure is substantial (e.g., through burrowing in contaminated sediment or in shallow water). Neither scenario is probable given the oceanographic conditions and water depth in the AOI and the non-burrowing behaviour of American Lobster. This results in a sensitivity score of 1. |
| $Q_{Consequence}$ | Negligible | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 2 \times 1$<br>$= 2$ (raw score) |
| Likelihood | Rare | Although benthic exposure in a deep-water environment like the AOI from a surface spill would be a rare event, it is possible under certain conditions. The *Prestige* heavy fuel oil spill, which occurred under similar circumstances to the hypothetical scenario discussed in this analysis, offers real-world evidence that a limited amount of oil may reach the benthos (Franco et al. 2006; Serrano et al. 2006). The number of large oil spills has been decreasing worldwide in the last couple of decades. This trend can be attributed to a variety of improvements, including increased regulations, more training for crews, improved navigational aids, and the phase-out of single-hulled tankers. The annual probability for a catastrophic oil spill of >10,000 $m^3$ in Canada has been calculated to be 0.004, or once every 242 years; more specifically for offshore waters in the region of the AOI, it is estimated to occur once every 27,995-35,416 years (WSP 2014). |
| Overall risk | Low | No additional management actions need to be considered. |
| Uncertainty | Moderate | Although dated, numerous laboratory investigations on the effects of oil on adult lobster exist; however, rigorous in-situ studies are limited. Oil spill fate and behaviour modelling for the assessed scenario was unavailable and there was no relevant pre-existing spill modelling to infer benthic exposure; therefore, the extent of benthic exposure is uncertain. |

## Risk assessment – Large heavy fuel oil spill and beaked whale habitat

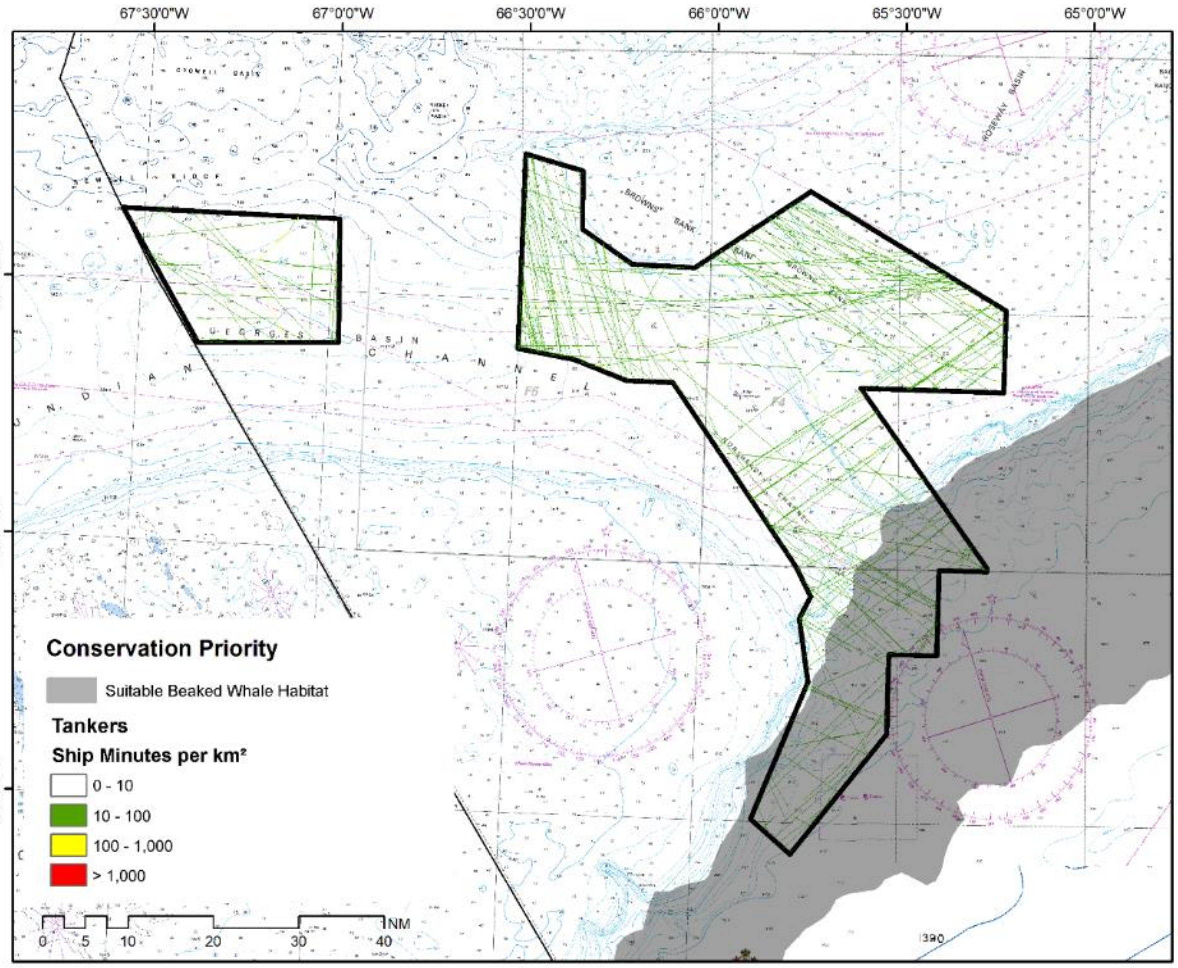


Figure 3.4.3-4. Overlap of extent of suitable beaked whale habitat and tanker traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) using available Automatic Identification System (AIS) data from March 1, 2017 to February 28, 2018.

**Risk statement**: There is a risk that a large ship-sourced heavy fuel oil spill will lead to negative impacts on beaked whales in their suitable habitat within the AOI.

Table 3.4.3-5. Scoring for the risk posed by a large heavy fuel oil spill to beaked whales within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 4 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 3<br>= 12 (raw score) |
| Intensity | 1 | Although a small proportion of the lighter components of Bunker C fuel oil are expected to evaporate in hours to days (see modelling results), the less volatile components would likely form a slick covering a large surface area. However, given the dynamic oceanographic and weather conditions oil is not expected to persist for long periods within the pelagic environment of the AOI. Oil |

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| | | compounds may persist longer in beaked whale prey. Taken together, an intensity score of 1 was assigned. |
| Temporal | 4 | Beaked whales occur in the AOI year-round (see Chapter 1, Section 1.4.3). Tanker traffic is light yet persists throughout the year, so a large oil spill could occur at any time. This results in a temporal exposure score of 4. |
| Spatial | 3 | Tankers occur throughout the AOI and a ship in distress could discharge a large volume of oil at any location within the boundaries. Though modelling indicates that up to 5% of the oil would evaporate after approximately 4 days, this number does not increase significantly thereafter and the majority of the oil would remain in the upper water column until at least five days post-spill. Dependent upon circulation and weather patterns at the time, a surface slick could encompass >50% of beaked whale habitat, resulting in a spatial exposure score of 3. |
| $Q_{Sensitivity}$ | 4 | Predicted short-term impacts of oil spill exposure to cetaceans can include changes in distribution due to avoidance, mortality due to ingestion, inhalation, or increased oil compounds in tissues leading to compromised health; long-term impacts can include increased rate of disease, compromised reproductive output, distributional changes, and changes in population age structure due to age-skewed impacts (Harvey and Dahlheim 1994; Schwake et al. 2014; Helm et al. 2015; DHNRDAT 2016). Fouling or inflammatory effects are not thought to negatively impact cetaceans due to their lack of fur, thick skin, and tight intercellular spaces (Geraci 1990), though any cuts or lesions would allow oil to be absorbed (DHNRDAT 2016). It has been suggested that toothed whales can detect oil (Geraci 1990), though avoidance behavior has been inconsistently demonstrated. Cetaceans with high site fidelity are known to continue to occupy their preferred habitat (Beland et al. 1993; Matkin et al. 2008; Lane et al. 2015), and a variety of cetacean species were documented swimming in oiled water during the *Deepwater Horizon* spill (Dias et al. 2017).<br><br>After major oil spills, both resident and transient cetaceans have demonstrated significantly increased mortality, reduced reproductive success, lower annual survival rate, and other negative health effects (Matkin et al. 2008; Schwake et al. 2014; Lane et al. 2015; Colegrove et al. 2016). Impacts are not limited to cetaceans occupying coastal (i.e., more contained) habitat – populations occupying offshore environments, including beaked whale populations, have also experienced mortality, negative impacts to reproductive success, and other adverse health effects (Hooker et al. 2008; DHMMIQT 2015). Conversely, Humpback Whales that occasionally visited the site of the *Exxon Valdez* spill did not demonstrate any discernable impacts to mortality or |

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| | | reproductive success, which was attributed to their large range and ability to exploit other locations (Von Ziegesar et al. 1994).<br><br>As apex predators with long life expectancy, marine mammals are thought to be especially sensitive to the health of their environment (Moore 2008), which underscores the potential impact of oil via sub-lethal but chronic effects. At-risk species with limited population resilience such as Northern Bottlenose Whales and Sowerby's Beaked Whales are likely even more susceptible (COSEWIC 2006; COSEWIC 2011). Northern Bottlenose Whales are expected to demonstrate a high degree of habitat fidelity and limited or no migration (COSEWIC 2011), which would further impair their ability to escape oiled habitat to avoid exposure.<br><br>Both Northern Bottlenose Whales and Sowerby's Beaked Whales are long-lived species that reproduce at a low rate, similar to other beaked whale species (DFO 2016; DFO 2017*b*). This low reproductive rate may limit a population's ability to adapt to or recover from disturbance (COSEWIC 2019). The Scotian Shelf population of Northern Bottlenose Whales is estimated at roughly 175 individuals (Feyrer 2021). This population has a potential biological removal (PBR: the maximum number of non-natural mortalities that the population could sustain while allowing that stock to reach or maintain its optimum sustainable population) of 0.3 individuals per year (DFO 2007; DFO 2010). This means that the level of allowable harm for this population is low (DFO 2016).<br><br>Overall, although limited information exists regarding Northern Bottlenose Whales and Sowerby's Beaked Whales specifically, there have been documented cases of acute mortality in cetacean populations after a spill and growing evidence of chronic effects. Considering the population size, status and low reproduction rate of the more at-risk beaked whale populations that can occur within the AOI, impacts from large heavy fuel oil spills could cause major mortality and result in detectable changes in population size. Therefore, a sensitivity score of 4 was assigned. |
| $Q_{Consequence}$ | Very High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 4 \times 4$<br>$= 16$ (raw score) |
| Likelihood | Rare | The number of large oil spills has been decreasing worldwide in the last couple of decades. This trend can be attributed to a variety of improvements, including increased regulations, more training for crews, improved navigational aids, and the phase-out of single-hulled tankers. The annual probability for a catastrophic oil spill of >10,000 $m^3$ in Canada has been calculated to be 0.004, or once every 242 years; more specifically for offshore waters in the |

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| | | region of the AOI it is estimated to occur once every 27,995-35,416 years (WSP 2014). |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible), such as the development of an emergency oil spill response plan for the future Fundian Channel-Browns Bank MPA to mitigate impacts from accidental spill events. |
| Uncertainty | High | Beaked whale distribution patterns, social and reproductive behaviours, population structure, and the impacts from anthropogenic stressors require more study (Hooker et al. 2019). It is difficult to estimate potential direct (e.g., mortality) or indirect (e.g., changes to predator-prey dynamics) impacts from an oil spill when baseline population conditions are not well known. Limited empirical study has focused on the impacts of oil specifically on Northern Bottlenose Whales and Sowerby's Beaked Whales. Opportunistic studies during oil spills (e.g., *Exxon Valdez* and *Deepwater Horizon*) have provided a greater understanding of acute and chronic impacts on cetaceans, though less so for offshore species and populations.<br><br>Beaked whale habitat was defined using available data from visual detections, acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited.<br><br>Additionally, oil spill fate and behaviour modelling for the assessed scenario was unavailable and there was no relevant pre-existing spill modelling from which to infer trajectory. |

## Risk assessment – Large heavy fuel oil spill and deep-water corals

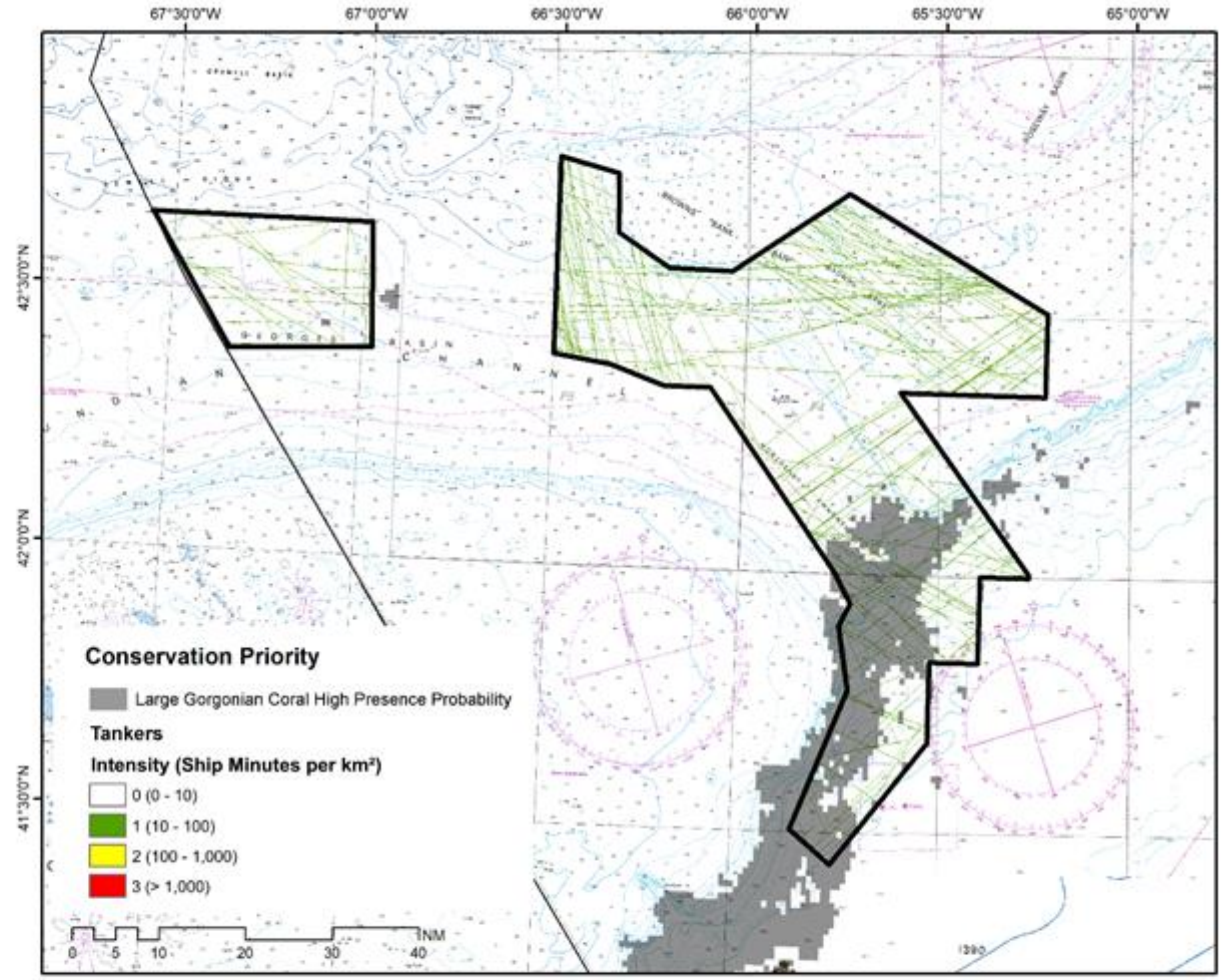


Figure 3.4.3-4. Overlap of large Gorgonian coral area and tanker traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) using available Automatic Identification System (AIS) data from March 1, 2017 to February 28, 2018.

**Risk statement**: There is a risk that a large ship-sourced heavy fuel oil spill will lead to negative impacts to deep-water coral communities within the AOI.

Table 3.4.3-3. Scoring for the risk posed by a large heavy fuel oil spill to deep-water corals within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 1<br>= 4 (raw score) |
| Intensity | 1 | The total quantity of oil expected to sink and reach the sediments in an open ocean spill scenario is likely low due to the oceanographic, weather, and bathymetric conditions in the AOI (see spatial exposure rationale below). Though oil compounds can persist in sediments for years (Elmgren et al. 1983; Yang et al. 2018), those that may accumulate on the benthos are likely to be less acutely |

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| | | toxic due to the evaporation of many compounds in a matter of hours or days after the spill (Serrano et al. 2006; Lee et al. 2015). This results in an intensity score of 1. |
| Temporal | 4 | Corals are long-lived, sessile animals. Tanker traffic is light yet persists throughout the year, so a large spill could occur at any time. This results in a temporal exposure score of 4. |
| Spatial | 1 | Tankers occur throughout the AOI and a ship in distress could discharge a large volume of oil at any location within the boundaries. The physical properties of unweathered heavy fuel oil (i.e., a density approaching or exceeding that of sea water) can lead to a portion of the slick sinking, and subsequent weathering may increase the density of the oil and further increase the proportion of the slick that sinks (Franco et al. 2006; Serrano et al. 2006; Lee et al. 2015). However, the dynamic oceanographic conditions, including wind, water currents, and wave action will limit the amount of time the slick will spend in the vicinity of the AOI (Lee et al. 2015). For cases where heavy fuel oil reaches the benthos, it will likely have a patchy distribution (Franco et al. 2006; Serrano et al. 2006). Additionally, the deep water present in the AOI further reduces the exposure potential to benthic organisms (Serrano et al. 2006; Lee et al. 2015). Sedimentation (the attachment of oil particles to suspended sediment which causes the aggregate to sink) is another process by which oil can reach the benthos but the low levels of suspended sediment within the AOI's offshore location (Brewer et al. 1976) will limit benthic exposure via this route (Lee et al. 2015).<br><br>Considering the above, a heavy fuel oil spill of this volume would not be expected to impact >10% of the predicted extent of large gorgonian corals, resulting in a spatial exposure score of 1. |
| $Q_{Sensitivity}$ | 4 | Deep-water corals are sessile, fragile, slow-growing organisms that are susceptible to anthropogenic disturbance (Girard et al. 2018; Montagna and Girard 2020). It is known that some species of coral can sense and react to oil. For example, exposure to sub-lethal concentrations caused polyps to contract partially after two days and completely after four to five days, remaining shut for the remainder of the experiment (Ducklow and Mitchell 1979). The researchers suggested possible inhibition of feeding behaviour, although normal polyp activity resumed upon removal from oiled water.<br><br>Much of the current research on coral susceptibility to oil spills has been opportunistic sampling following the *Deepwater Horizon* event in 2010. The unprecedented volume of oil, amounting to a major oil spill daily for 87 days, the use of chemical dispersants, and the subsea location of the spill all contributed to increasing the exposure of oil to corals. White et al. (2012) investigated coral 11 km from the well-head (i.e., site MC294) 3-4 months after the well |

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| | | was capped and found that coral colonies presented with widespread signs of stress, including varying degrees of tissue loss, sclerite enlargement, excess mucous production, bleached commensal ophiuroids, and covering by brown flocculent material, with 46% of corals imaged at this site displaying impact on more than half the colony. Another study visited MC294 over the 17 months following the spill and determined that signs of visible impact to the coral tissue decreased over time, suggesting limited recovery, though hydroid colonization of coral structure (a sign of coral deterioration from which recovery is unlikely) increased; additional non-apparent impacts were suggested (Hsing et al. 2013). A follow-up study from 2011-2017 demonstrated that unhealthy coral tissue was significantly higher at impacted sites even after seven years, and branch loss was significantly higher in unhealthy colonies (Girard and Fisher 2018). Branch loss was still significantly higher at some impacted sites between the final two years of the study, indicating sustained long-term impacts and possibly delayed mortality. Additionally, the immobility of corals increases their susceptibility to smothering from oil compounds, which may persist for years (Elmgren et al. 1983; DHNRDAT 2016).<br><br>Coral regeneration is a complex combination of intrinsic (e.g., coral size and age) and extrinsic (e.g., food availability) factors and it is suggested that negative impacts to growth and sexual reproduction can affect long-term community viability (Henry and Hart 2005). There is evidence that lightly impacted coral colonies can recover completely in approximately 1.5 years (Hsing et al. 2013). Additionally, Girard et al. (2019) found that more heavily impacted corals demonstrated higher growth rates; it was suggested that growth was compensatory for damage sustained and may have diverted energy from other activities, such as reproduction. Importantly, although growth rates were not affected negatively at most sites, acute branch loss resulted in an overall decrease of coral tissue. Models of long-term recovery concluded that most colonies would appear completely healthy after a decade, though with a cumulative biomass loss of 3-14% (Girard et al. 2018). Recovery of heavily impacted colonies to the point that all tissue appeared healthy was estimated to take 37 years, though by that time only 17% of initial coral biomass would remain.<br><br>It is important to note when interpreting the literature on coral sensitivity to oil exposure documented above that a vessel-source surface spill in the Fundian Channel-Browns Bank AOI would result in lower volumes of oil reaching the benthos, even in a worst case scenario with heavy fuel oil. Taken together, a sensitivity score of 4 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$ |

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| | | = 2 x 4<br>= 8 (raw score) |
| Likelihood | Rare | Although benthic exposure in a deep water environment like the AOI from a surface spill would be a rare event, it is possible under certain conditions. The *Prestige* heavy fuel oil spill, which occurred under similar circumstances to the hypothetical scenario discussed in this analysis, offers real-world evidence that a limited amount of oil may reach the benthos (Franco et al. 2006; Serrano et al. 2006).<br><br>The number of large oil spills has been decreasing worldwide in the last couple of decades. This trend can be attributed to a variety of improvements, including increased regulations, more training for crews, improved navigational aids, and the phase-out of single-hulled tankers. The annual probability for a catastrophic oil spill of >10,000 $m^3$ in Canada has been calculated to be 0.004, or once every 242 years; more specifically for offshore waters in the region of the AOI it is estimated to occur once every 27,995-35,416 years (WSP 2014). |
| Overall risk | Moderate | Additional management measures may be considered, such as the development of an emergency oil spill response plan for the future Fundian Channel-Browns Bank MPA to mitigate impacts from accidental spill events. |
| Uncertainty | High | The presence probability map for deep-water corals within the AOI was developed using available data from research surveys. The identified coral area is predictive in nature due to limited survey coverage in the deeper waters.<br><br>The logistical difficulty and high cost have limited in-situ study of deep-water corals. Basic life history characteristics such as reproductive output, time to maturity, recovery from disturbance, and growth rates for many deep-water coral species are unknown. There has been limited investigation of the effects of oil spills on deep-water corals and most studies focused only on one spill event (i.e., *Deepwater Horizon*). However, it is known that corals mature, grow, and recover slowly and that they are susceptible to disturbance.<br><br>Additionally, oil spill fate and behaviour modelling for the assessed scenario was unavailable and there was no relevant pre-existing spill modelling from which to infer benthic exposure. |

**Risk assessment – Large heavy fuel oil spill and Atlantic Cod**

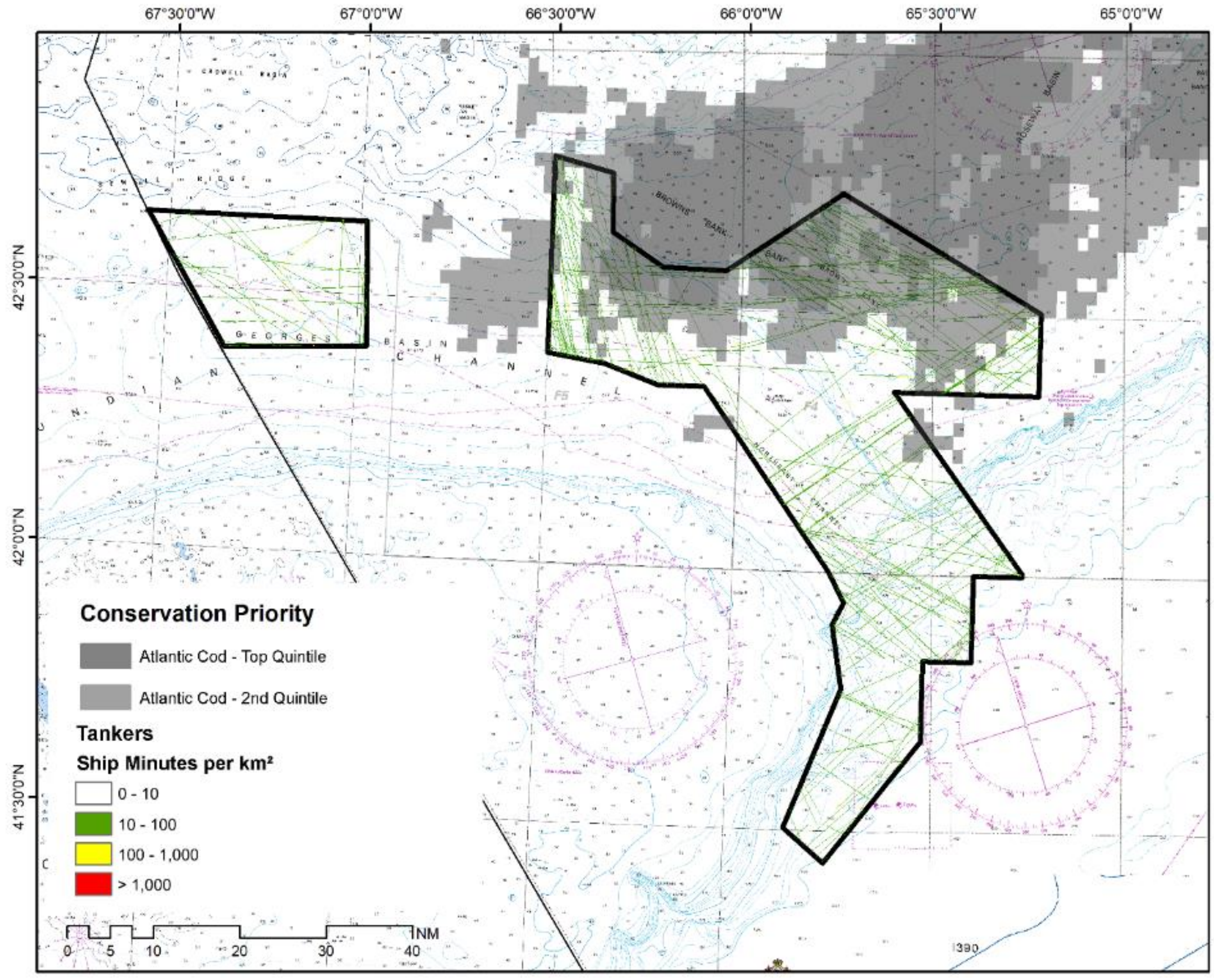


Figure 3.4.3-6. Overlap of Atlantic Cod important habitat and tanker traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) using available Automatic Identification System (AIS) data from March 1, 2017 to February 28, 2018.

**Risk statement**: There is a risk that a large ship-sourced heavy fuel oil spill will lead to negative impacts on the local population of Atlantic Cod in its representative habitat within the AOI.

Table 3.4.4-4. Scoring for the risk posed by a large heavy fuel oil spill to Atlantic Cod within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 2 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 4 x 1<br>= 4 (raw score) |
| Intensity | 1 | The total quantity of oil expected to sink and reach the sediments in an open ocean spill scenario is likely low due to the oceanographic, weather, and bathymetric conditions in the AOI (see spatial exposure rationale below). Though oil compounds can persist in sediments for years (Elmgren et al. 1983; Yang et al. 2018), those |

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| | | that may accumulate on the benthos are likely less acutely toxic due to the evaporation of many compounds in a matter of hours or days after the spill (Serrano et al. 2006; Lee et al. 2015). Additionally, sunken heavy fuel oil often forms tar balls, which have low bioavailability and may be covered by shifting sediment in a matter of months, further limiting exposure in non-burrowing organisms (Serrano et al. 2006). This results in an intensity score of 1. |
| Temporal | 4 | Atlantic Cod are thought to occur within the AOI year-round. Tanker traffic is light yet persists throughout the year, so a large spill could occur at any time. This results in a temporal exposure score of 4. |
| Spatial | 1 | Tankers occur throughout the AOI and a ship in distress could discharge a large volume of oil at any location within the boundaries. The physical properties of unweathered heavy fuel oil (i.e., a density approaching or exceeding that of sea water) can lead to a portion of the slick sinking, and subsequent weathering may increase the density of the oil and further increase the proportion of the slick that sinks (Franco et al. 2006; Serrano et al. 2006; Lee et al. 2015). However, the dynamic oceanographic conditions, including wind, water currents, and wave action will limit the amount of time the slick will spend in the vicinity of the AOI (Lee et al. 2015). For cases where heavy fuel oil reaches the benthos, it will likely have a patchy distribution (Franco et al. 2006; Serrano et al. 2006). Additionally, the deep water present in the AOI further reduces the exposure potential to benthic organisms (Serrano et al. 2006; Lee et al. 2015). Sedimentation (the attachment of oil particles to suspended sediment which causes the aggregate to sink) is another process by which oil can reach the benthos but the low levels of suspended sediment within the AOI's offshore location (Brewer et al. 1976) will limit benthic exposure via this route (Lee et al. 2015).<br><br>Considering the above, a heavy fuel oil spill of this volume would not be expected to impact >10% of Atlantic Cod habitat, resulting in a spatial exposure score of 1. |
| $Q_{Sensitivity}$ | 2 | Exposure to oil contaminants may cause tissue damage, increased susceptibility to disease, and in some cases mortality in demersal fish species, though adult fish are less susceptible than early life stages (Hutchinson et al. 1998; DFO 2011). Crude oil exposure in a laboratory setting induced gill lesions, reduced weight gain, disrupted gonadal development, and delayed spawning in mature Atlantic Cod (Khan 2012), suggesting that reproductive capacity could be impacted. A separate laboratory study subjecting juvenile cod to crude oil for up to three weeks caused elevated levels of multiple negative biomarkers and DNA damage at environmentally relevant concentrations (Jensen 2014), leading the author to suggest that effects could reduce fitness in wild cod. Similar results were displayed in a separate study of juvenile cod and crude oil at |

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| | | environmentally-relevant exposure levels (Holth et al. 2014). Enerstvedt et al. (2018) demonstrated some mortality and reduced immune response capability in adult Atlantic Cod exposed to crude oil at environmentally-relevant concentrations in a laboratory setting; it was suggested that these effects could heighten susceptibility to cancer, infection, and disease. Lab studies using the Atlantic Croaker (*Micropogonius undulatus*) and simulating oil concentrations measured during *Deepwater Horizon* suggested that oil exposure may negatively alter behaviour in fishes, decreasing both their foraging efficiency and the effectiveness of group cohesion to provide anti-predator benefits (Armstrong et al. 2019). Additionally, there is initial evidence that some fish species [i.e., Tidepool (*Oligocottus masculosus)* and Mosshead (*Clinocottus gobiceps*) Sculpin and Pink (*Oncorhynchus gorbuscha*) and Sockeye (*Oncorhynchus nerka*) Salmon] will actively avoid oil-contaminated sediment, dependent on life stage and exposure concentration (C. Kennedy, unpublished data, 2021).<br><br>In-situ sampling after the *Deepwater Horizon* event demonstrated increased prevalence of skin lesions, especially in bottom-dwelling fishes (Murawski et al. 2014). However, prevalence of skin lesions and liver PAH metabolite concentration decreased significantly over time, indicating the ability of fish to detoxify harmful compounds. The *Deepwater Horizon* spill significantly reduced growth rate (Herdter 2014) and size (Paterson III 2015) in Red Snapper *Lutjanus campechanus*, though significant decreases in abundance were not demonstrated (DHNRDAT 2016). It is important to recognize the unprecedented scale and subsea location of the *Deepwater Horizon* spill when interpreting these results for the current spill scenario.<br><br>While individual-level effects have been documented, there is inconsistent evidence to suggest that a large oil spill has negative population-level effects on healthy, mobile adult fish populations (Law and Hellou 1999; DFO 2011; Snyder et al. 2015; DHNRDAT 2016) especially in the offshore environment (Thurberg and Gould 2005).<br><br>Taken together, while laboratory tests and limited in-situ study suggest crude oil exposure could have negative effects, it is expected that the mobility and detoxification capabilities of adult Atlantic Cod could mitigate potential impacts. Thus, a large heavy fuel oil spill within the AOI could have detectable impacts on the local cod population through changes in behaviour, susceptibility to disease, or reproductive output. A sensitivity score of 2 was assigned. |
| $Q_{Consequence}$ | Low | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 2 \times 2$<br>$= 4$ (raw score) |

| | | |
|---|---|---|
| Likelihood | Rare | Although benthic exposure in a deep water environment like the AOI from a surface spill would be a rare event, it is possible under certain conditions. The *Prestige* heavy fuel oil spill, which occurred under similar circumstances to the hypothetical scenario discussed in this analysis, offers real-world evidence that a limited amount of oil may reach the benthos (Franco et al. 2006; Serrano et al. 2006).<br><br>The number of large oil spills has been decreasing worldwide in the last couple of decades. This trend can be attributed to a variety of improvements, including increased regulations, more training for crews, improved navigational aids, and the phase-out of single-hulled tankers. The annual probability for a catastrophic oil spill of >10,000 $m^3$ in Canada has been calculated to be 0.004, or once every 242 years; more specifically for offshore waters in the region of the AOI it is estimated to occur once every 27,995-35,416 years (WSP 2014). |
| Overall risk | Low | No additional management actions need to be considered. |
| Uncertainty | Moderate | Some laboratory studies have documented negative impacts of oil on cod at environmentally-relevant concentrations. In-situ studies on benthic fish populations are limited, though no mass mortality events have ever been recorded in mobile adult fish populations. Oil spill fate and behaviour modelling for the assessed scenario was unavailable and there was no relevant pre-existing spill modelling from which to infer benthic exposure; therefore, the extent of benthic exposure is uncertain. |

**Risk assessment – Large heavy fuel oil spill and pursuit-diving piscivores (alcids)**

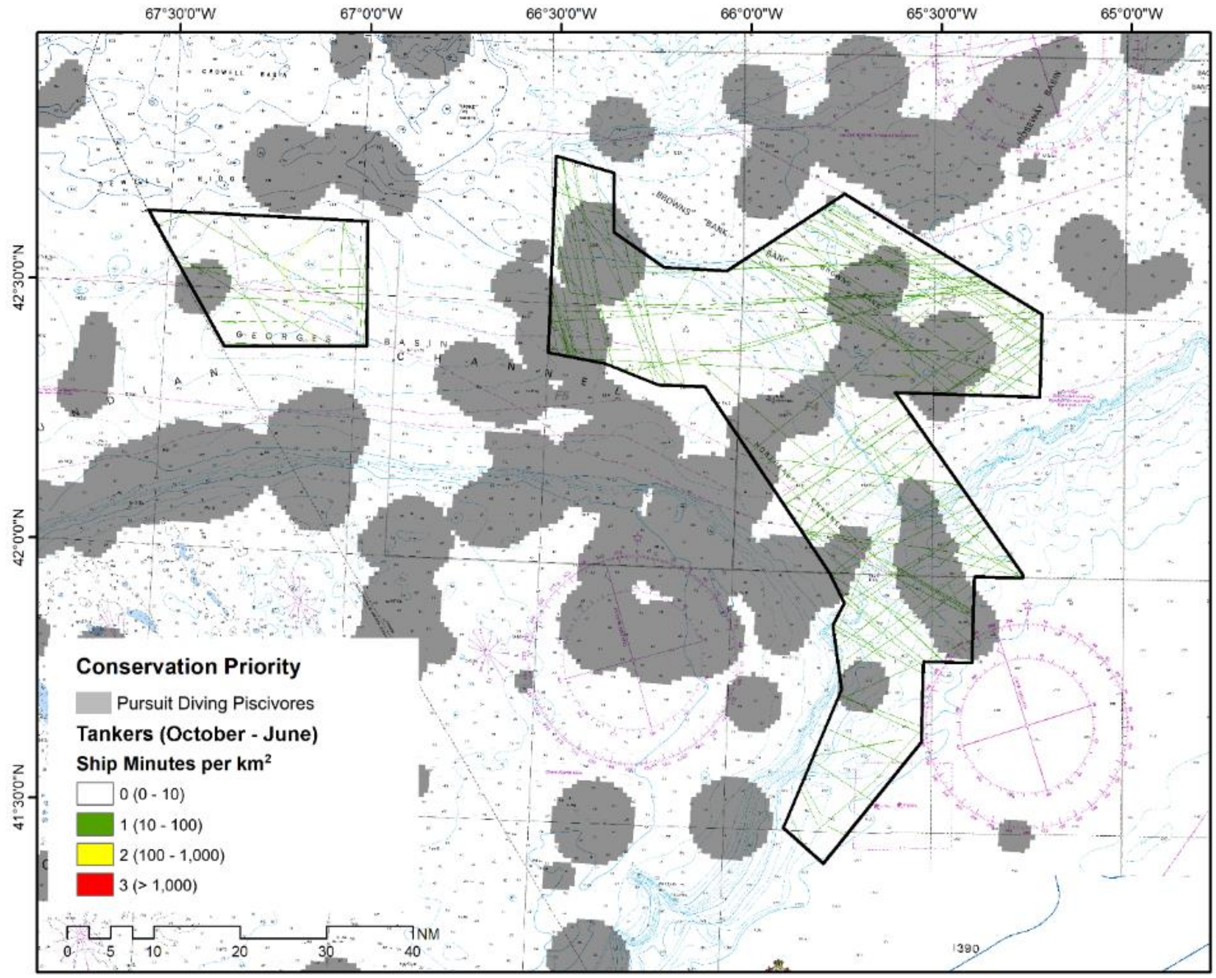


Figure 3.4.3-7. Overlap of important foraging areas for pursuit-diving piscivores (alcids) and tanker traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) from October to June, when alcids are present within the AOI. Vessel traffic patterns were generated using the available Automatic Identification System (AIS) dataset (March 1, 2017 to February 28, 2018).

**Risk statement**: There is a risk that a large ship-sourced heavy fuel oil spill will lead to negative impacts to alcids in their foraging habitat within the AOI.

Table 3.4.3-6. Scoring for the risk posed by a large heavy fuel oil spill to alcids within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 3 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 3 x 3<br>= 9 (raw score) |
| Intensity | 1 | Although a small proportion of the lighter components of Bunker C fuel oil are expected to evaporate in hours to days (see modelling results), the less volatile components would likely form a slick covering a large surface area. However, given the dynamic |

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| | | oceanographic and weather conditions oil is not expected to persist for long within the pelagic environment of the AOI boundaries. Taken together, an intensity score of 1 was assigned. |
| Temporal | 3 | Alcids spend the winter foraging in offshore waters such as the AOI (Godfrey 1986). Tanker traffic is light yet persists throughout the year, so a large oil spill could occur at any time. This results in temporal exposure score of 3. |
| Spatial | 3 | Tankers occur throughout the AOI and a ship in distress could discharge a large volume of oil at any location within the boundaries. Though modelling indicates that up to 5% of the oil would evaporate after approximately 4 days, this number does not increase significantly thereafter and the majority of the oil would remain in the upper water column until at least five days post-spill. Dependent upon circulation and weather patterns at the time, a surface slick could encompass >50% of alcid foraging habitat, resulting in a spatial exposure score of 3. |
| $Q_{Sensitivity}$ | 4 | Oil can harm birds by decreasing insulative capacity and waterproofing ability, which can lead to death due to hypothermia, exhaustion, starvation, and increased vulnerability to predators (Wiese et al. 2001; Morandin and O'Hara 2016). Oiled birds often preen to try and remove oil, resulting in ingestion, which could lead to dehydration, a reduction in nutrient absorption, developmental delays, reproductive impairment, and mortality (Clark 1984; Wiese et al. 2001; GENIVAR 2013). External oiling increases the energetic cost of flight by 20-45%, and can alter flight paths and increase flight distance and duration during long-distance migratory or foraging voyages (Bursian et al. 2017 and citations within).<br><br>Crude oil can persist in the environment for long time periods and may continue to affect bird populations well after the initial spill. Marine birds can ingest toxic components via foraging on contaminated prey, a factor which Peterson et al. (2003) suggested can contribute to cascading and long-term population level effects. It was calculated that time to recovery for the Harlequin Duck population after the *Exxon Valdez* incident was 24 years and that chronic deaths outweighed acute deaths (Iverson and Esler 2010). Decreased populations of a variety of bird taxa – including murres – were demonstrated after the *Exxon Valdez* spill, and most of the negatively affected populations were birds that foraged by diving into the water column (Irons et al. 2000). Reproductive success and number of fledged chicks per pair were significantly reduced in another diving seabird (i.e., European Shag *Phalacrocorax aristotelis*) after the *Prestige* heavy fuel oil spill; signs of recovery were not apparent until five years post spill, with reproductive impairment still evident a decade later (Barros et al. 2014). |

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| | | The amount of time that pursuit-diving piscivores spend on the surface of the water and swimming through the water column, and the possibility of surfacing in a slick after a dive, increases their susceptibility to acute oil exposure (Mead and Baillie 1981; Irons et al. 2000). For example, alcids made up the majority of the 250,000 birds killed by the *Exxon Valdez* spill (Piatt and Ford 1996). Similarly, Common Murre (also called Common Guillemot ) and Razorbill accounted for 84% of seabird mortality in an assessment in British waters (Mead and Baillie 1981). Even small amounts of oil can lead to large cumulative mortality – it was estimated that >300,000 Dovekies, Thick-billed Murres, and Common Murres die each winter from chronic oil discharge in the offshore environment of southern Newfoundland (Wiese and Robertson 2004). If a spill were to occur during a time of year when large numbers of birds congregate while migrating or foraging, population-level impacts could be seen (Stantec Consulting Ltd. 2013).<br><br>Overall, the susceptibility of seabirds, and specifically alcids, to oil spills is well described. Negative acute and chronic effects are also expected. Taken together, a large heavy fuel oil spill within the AOI could be a major source of mortality and cause detectable changes in population size. A sensitivity score of 4 was assigned. |
| $Q_{Consequence}$ | High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 3 \times 4$<br>$= 12$ (raw score) |
| Likelihood | Rare | The number of large oil spills has been decreasing worldwide in the last couple of decades. This trend can be attributed to a variety of improvements, including increased regulations, more training for crews, improved navigational aids, and the phase-out of single-hulled tankers. The annual probability for a large oil spill of >10,000 $m^3$ in Canada has been calculated to be 0.004, or once every 242 years; more specifically for offshore waters in the region of the AOI it is estimated to occur once every 27,995-35,416 years (WSP 2014). |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible), such as the development of an emergency oil spill response plan for the future Fundian Channel-Browns Bank MPA to mitigate impacts from accidental spill events, including measures for treatment of oiled birds. |
| Uncertainty | Low | The negative effects of oil on marine birds are well-known and numerous studies have specifically documented the susceptibility of alcids to oil spills. Long-term and population-level effects of oil spills on seabirds in the offshore environment are not well studied.<br><br>Important marine bird foraging areas were identified using available data from offshore seabird surveys. Survey coverage has |

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| | | been limited, and while identified foraging areas are based on occurrences, they contain a predictive component. Additionally, oil spill fate and behaviour modeling for the assessed scenario was unavailable and there was no relevant pre-existing spill modeling from which to infer trajectory. |

**Risk assessment – Large heavy fuel oil spill and area of high productivity**

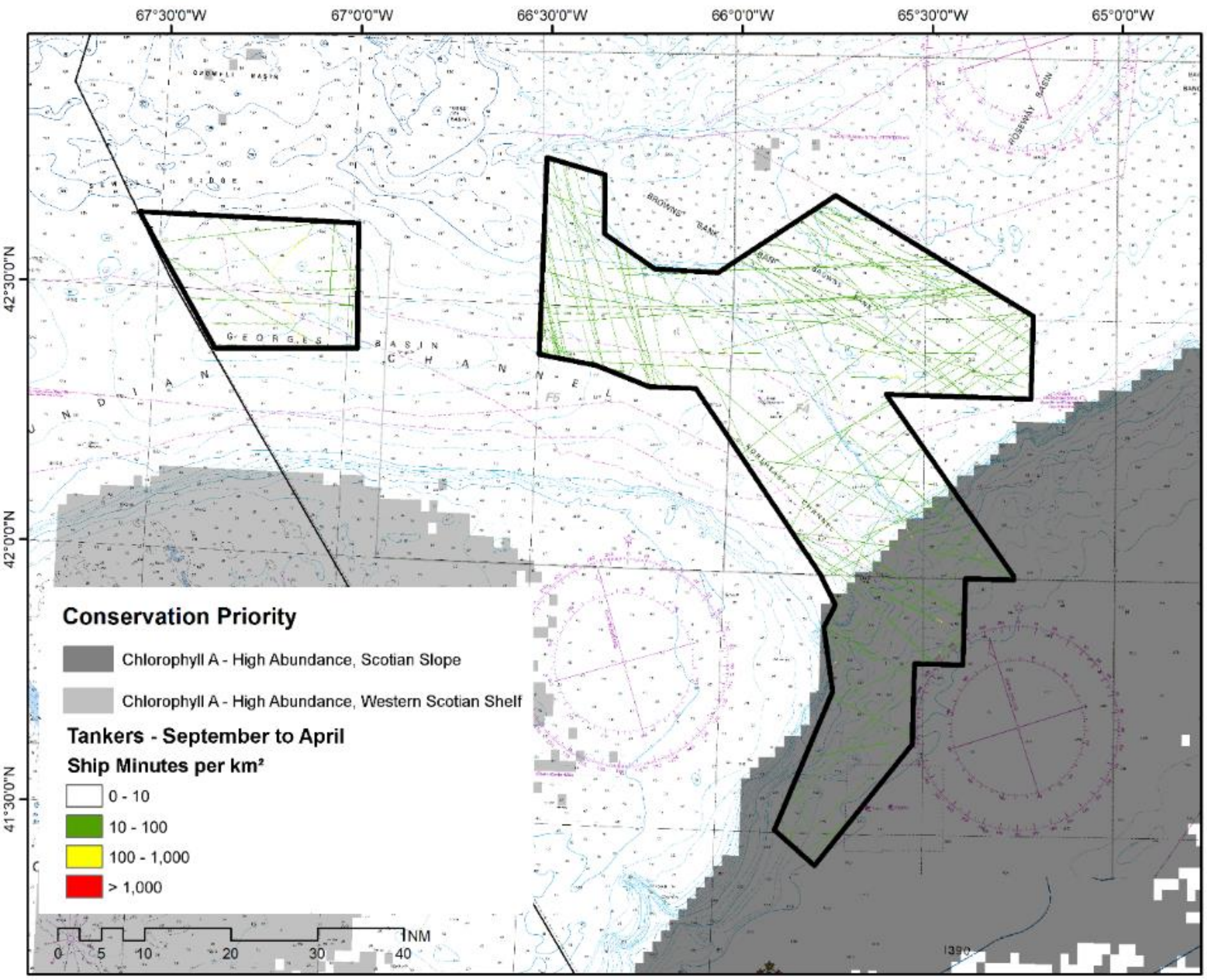


Figure 3.4.3-8. Overlap of area of high productivity (indicated by high chlorophyll A abundance) and tanker traffic in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon) using available Automatic Identification System (AIS) dataset (March 1, 2017 to February 28, 2018) from September through April.

**Risk statement**: There is a risk that a large ship-sourced heavy fuel oil spill will lead to negative impacts on the local plankton community in the area of high productivity within the AOI.

Table 3.4.3-7. Scoring for the risk posed by a large heavy fuel oil spill to the area of high productivity within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 5 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 2 x 3 x 3<br>= 18 (raw score) |
| Intensity | 2 | Although a certain proportion of the lighter components of Bunker C fuel oil are expected to evaporate in hours to days (see modelling results), some of the less volatile components would likely remain and form a slick covering a large surface area. Given the dynamic oceanographic and weather conditions oil is not expected to persist for long on the water surface within the AOI boundaries. However, planktonic organisms have limited mobility and could remain in close contact with the slick as they both followed the dominant circulation patterns at the time of the spill. Therefore, although an offshore surface oil spill would not be considered persistent for most organisms, the short lifespan and limited mobility of plankton result in an intensity score of 2. |
| Temporal | 3 | Chlorophyll a abundance is highest during the period of September to April with a large peak in March/April and a smaller peak in late fall (Johnson et al. 2017). Tanker traffic is light yet persists throughout the year, so a large oil spill could occur at any time. This results in a temporal exposure score of 3. |
| Spatial | 3 | Tankers occur throughout the AOI and a ship in distress could discharge a large volume of oil at any location within the boundaries. Though modelling indicates that up to 5% of the oil would evaporate after approximately 4 days, this number does not increase significantly thereafter and the majority of the oil would remain in the upper water column until at least five days post-spill. Additionally, planktonic organisms have limited mobility and would be concentrated in the same areas as oil, following the dominant circulation patterns. Dependent upon weather and circulation patterns at the time, a spill could encompass >50% of the highly productive area, resulting in a spatial exposure score of 3. |
| $Q_{Sensitivity}$ | 3 | Dissolved hydrocarbons can be toxic to zoo- and phytoplankton with interspecific variation in sensitivity and effects. Oil can interfere with phytoplankton photosynthesis via direct toxicity or production of damaging reactive oxygen species, causing cellular damage (Sargian et al. 2005). Laboratory studies using environmentally-relevant concentrations have determined that hydrocarbon products can be lethal to phytoplankton (Sargian et al. 2005; Adekunle et al. 2010; Ozhan et al. 2014*a*; Ozhan et al. 2014*b*), though recovery can occur in 72 hours (Gonzalez et al. 2009). Similarly, mortality (Almeda et al. 2013) and reduced |

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| | | feeding efficiency (Lemcke et al. 2019) have also been described in laboratory studies of hydrocarbon exposure to zooplankton.<br><br>There is inconclusive evidence that planktonic communities suffer long-term damage from major oil spills. The *Tsesis* oil spill in a coastal archipelago in Sweden caused no change in phyto- or zooplankton community composition (Johansson et al. 1980). An increase in phytoplankton biomass was observed during a 2-3 week period following the event, which the researchers suggested may have resulted from the removal of predatory pressure due to impacts on zooplankton populations. In the same study, zooplankton biomass decreased immediately following the spill but recovered within five days. Varela et al. (2006) demonstrated that there were no significant changes in primary productivity, zoo- or phytoplankton biomass, or community composition after the *Prestige* oil spill off the northwest coast of Spain, though it was suggested that a spill occurring during a time of high annual phytoplankton abundance (i.e., the spring bloom) could have larger impacts. A decrease in primary productivity was documented after the *Deepwater Horizon* event (Parsons et al. 2015; Li et al. 2019) and recovery to pre-spill levels took five years, though it was noted that a causal link to the oil spill could not be determined (Li et al. 2019). All phytoplankton that could be identified to the species or genus level demonstrated a decrease in abundance (Parsons et al. 2015). Significant changes to zooplankton community composition compared with pre-spill data was also observed during *Deepwater Horizon*, with increases or decreases in abundance dependent on species (Carassou et al. 2014). However, community composition recovery occurred even before the spill had ceased, on the order of weeks to one month. The scope, location (i.e., deep-sea well blowout), and confounding factors potentially affecting recovery (e.g., high levels of eutrophication; Li et al. 2019) related to this event must be considered when interpreting these results in the context of potential for impacts to productivity from a spill in the AOI.<br><br>Large natural variability in abundance and community composition as well as sensitivity to environmental factors (e.g., water temperature, irradiance) can confound attempts to determine acute and long-term effects of oil spills on plankton (Varela et al. 2006; Carassou et al. 2014; Li et al. 2019). It is suggested that an influx of new plankton into the affected area and short generation time could help mitigate the effects of acute large-scale oil-related mortality and increase recovery potential (Varela et al. 2006).<br><br>Overall, though detectable community-level changes have been documented and recovery may take months, short generation time |

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| | | and influx of new populations, facilitated by the dynamic oceanographic conditions in the AOI, may limit the long-term impacts of a heavy fuel oil spill. A sensitivity score of 3 was assigned. |
| $Q_{Consequence}$ | High | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 5 \times 3$<br>$= 15$ (raw score) |
| Likelihood | Rare | The number of large oil spills has been decreasing worldwide in the last couple of decades. This trend can be attributed to a variety of improvements, including increased regulations, more training for crews, improved navigational aids, and the phase-out of single-hulled tankers. The annual probability for a large oil spill of >10,000 $m^3$ in Canada has been calculated to be 0.004, or once every 242 years; more specifically for offshore waters in the region of the AOI it is estimated to occur once every 27,995-35,416 years (WSP 2014). |
| Overall risk | Moderately-high | Additional management measures should be considered (where feasible), such as the development of an emergency oil spill response plan for the future Fundian Channel-Browns Bank MPA to mitigate impacts from accidental spill events. |
| Uncertainty | Moderate | The toxicity of hydrocarbons to numerous plankton species and taxa has been documented in laboratory and mesocosm studies, with mortality and community compositional changes displayed at environmentally-relevant concentrations. It is less well understood how these effects manifest in real-world cases and what the acute or chronic impacts are on the remainder of the food web. Oil spill fate and behaviour modelling for the assessed scenario was unavailable and there was no relevant pre-existing spill modelling from which to infer trajectory. |

## 3.5 SUMMARY OF MARINE TRANSPORTATION RESULTS

The risks presented by pressures associated with marine transportation for the Fundian Channel-Browns Bank AOI were determined from available vessel traffic data, modeling outputs, literature review, and expert opinion. Table 3.5-1 contains the risk scores for all marine transportation activities and conservation priorities assessed in the AOI.

Table 3.5-1. Summary of the risk levels for each interaction assessed for marine transportation, grouped by conservation priority.

| Conservation Priority | Pressure | Exposure | Sensitivity | Likelihood | Risk Level |
|---|---|---|---|---|---|
| **Large mature female lobster** | Large heavy fuel oil spill | 2 | 1 | Rare | Low |
| **Beaked whale habitat** | Vessel noise | 4 | 2 | Unlikely | Moderately High |
| | Echosounder noise | 4 | 2 | Unlikely | Moderately High |
| | Large heavy fuel oil spill | 4 | 4 | Rare | Moderately High |
| **Blue Whale foraging area** | Vessel strikes | 4 | 3 | Rare | Moderately High |
| | Vessel noise | 4 | 2 | Moderate | Moderately High |
| | Echosounder noise | 4 | 2 | Rare | Moderate |
| **Deep-water corals** | Large heavy fuel oil spill | 2 | 4 | Rare | Moderate |
| **Atlantic Cod habitat** | Vessel noise | 4 | 2 | Rare | Moderate |
| | Large heavy fuel oil spill | 2 | 2 | Rare | Low |
| **Surface-seizing planktivores/piscivores** | Light-induced disorientation/collisions | 2 | 3 | Moderate | Moderately High |
| **Pursuit-diving piscivores** | Small operational oil spills | 1 | 3 | Likely | Moderate |
| | Large heavy fuel oil spill | 3 | 4 | Rare | Moderately High |
| **Area of high productivity** | Large heavy fuel oil spill | 5 | 3 | Rare | Moderately High |

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# 4.0 SUBMARINE CABLES

## 4.1 SECTOR OVERVIEW

Submarine cables are installed on the seafloor to enable telecommunications or transfer of electricity across ocean spaces. In general, each cable has an expected lifespan of 20-25 years (Carter et al. 2014). With the increased reliance on digital media in the 21st century, a desire for faster and more reliable service has resulted in a greater number of submarine cable projects, and demand is still growing (Oslo/Paris Convention for the Protection of the Marine Environment of the North-east Atlantic (OSPAR) Commission 2008).

Telecommunications cable technology has improved since its inception with a concurrent reduction in cable size; fiber-optic technology is now used and cables are approximately 2-5 cm in diameter (OSPAR Commission 2008). In comparison, power cables, used to transfer electricity from offshore installations to the terrestrial electricity grid or across relatively shorter oceanic stretches, are generally thicker, up to 15 cm in diameter. Before installation, proponents undertake a series of surveys (e.g., side-scan sonar, Remotely Operated Vehicle (ROV) transects, geological) to explore possible routes and the physical or ecological impediments that may be encountered (Kraus and Carter 2018). Routes attempt to avoid hard substrate, steep slopes, boulder fields, and ecologically sensitive areas where possible (NOAA 2018). Submarine cables can be installed using different methods. For deeper-water installations located beyond the reach of human activities that might interact with the cables (i.e., vessel anchoring and interaction with fishing gear), cables may be laid directly on the seabed without burying. Alternatively, and in shallower waters where cables may be exposed to fishing gear or anchors, they are routinely buried. This can occur using a variety of methods, including a tread-mounted plough pulled behind a vessel or by spraying streams of water (i.e., water jetting) from a tread-mounted vehicle or ROV (Kraus and Carter 2018). Before the cable itself is buried, a pre-lay grapnel run is often conducted. This consists of a grapnel towed along the route to clear any obstructions; the grapnel can penetrate the sediment to a depth of 0.5-1 m (Carter et al. 2014), disturbing bottom sediments and bottom-dwelling organisms (CSRIC 2014; NOAA 2018).

Though rare, repairs may need to be conducted throughout the lifespan of a cable. This process may cause similar impacts to the marine environment as the initial installation. For example, this activity may require the use of a grapnel for cutting and/or collecting the cable during repair. Once the damaged portion of the cable is located, a cut is made and each end is brought to the water surface, resulting in a length of cable twice the water depth being removed and disturbing sediment and organisms that may have recolonized the area after initial installation (Carter et al. 2014; NOAA 2018). After repairs, extra cable (generally twice the water depth) is used to splice the cut ends together and the damaged cable is re-buried or re-laid back in place (CSRIC 2014). This extra cable is installed in a loop extending from the original path and thus requires more trenching for buried sections (NOAA 2018).

At the end of the lifespan, cables are decommissioned, either through cable removal or abandonment. Depending on the type of cable and impact of leaving the cable (e.g., release of contaminants, interference with fisheries, etc.), recovery may be recommended (OSPAR Commission 2012). Due to the commercial value of recycled materials, recovery is being explored more frequently (Carter et al. 2014). However, because removal can be costly, abandonment is still a common practice.

Submarine cables on the Scotian Shelf

Numerous submarine telecommunications and transmission cables exist on the Scotian Shelf (OCMD 2005). Existing installations include both active and abandoned cables. There are four known cables that cross through the AOI, including a new telecommunications cable installed in 2022 (Submarine Cable Networks 2021) (Figure 4.1-1).

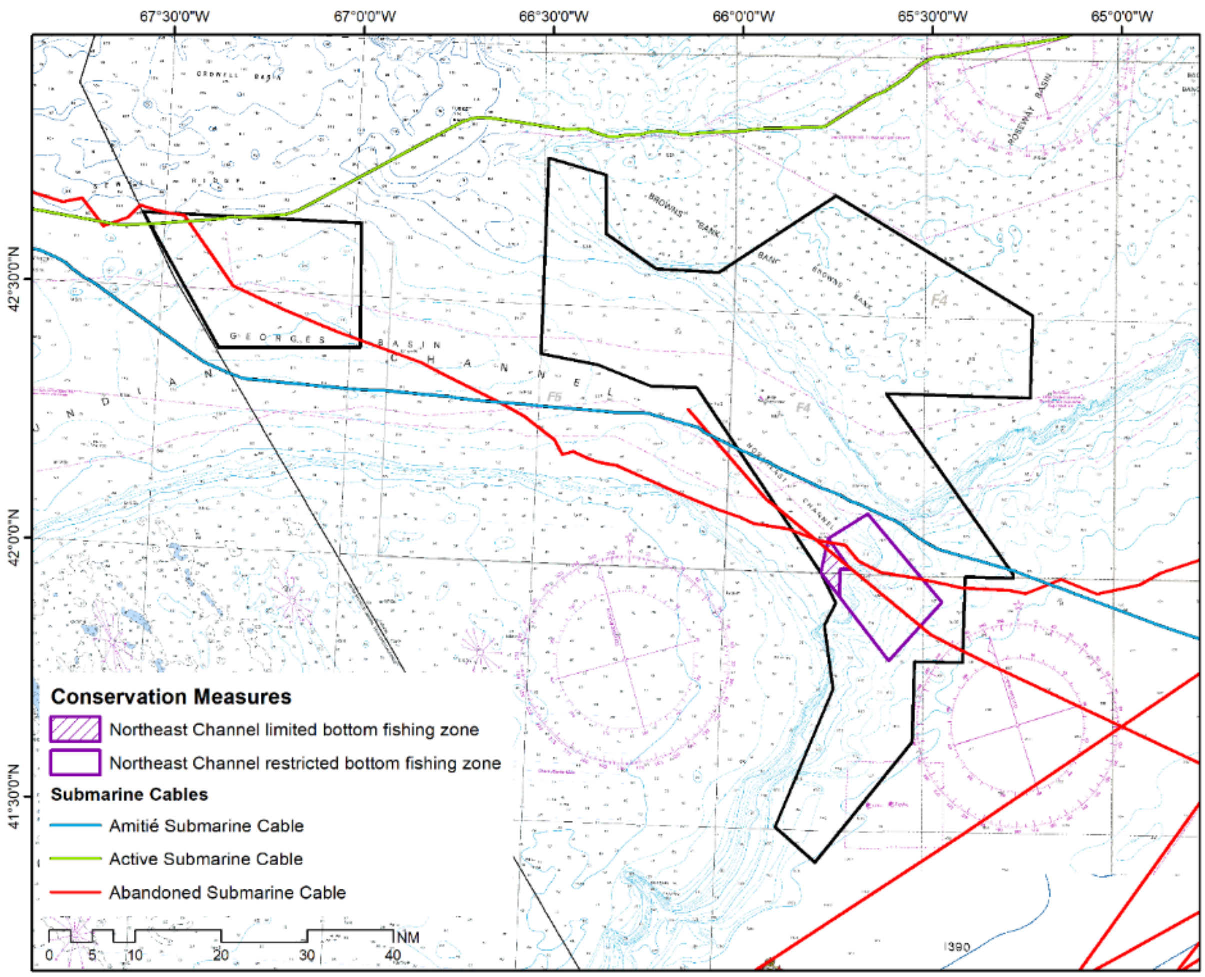


Figure 4.1-1. Known existing submarine cables near the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). The route depicted for the Amitié Submarine Cable is the route described in the project proposal.

Existing Management Measures

The *United Nations Convention on the Law of the Sea* (1982) outlines the right of coastal states for "conserving and managing the natural resources, whether living or non-living…of the seabed" as well as "the protection and preservation of the marine environment" within its Exclusive Economic Zone (EEZ) (Article 56.1). However, foreign states also retain the right to install submarine cables in the EEZ of coastal states (Article 58.1). Therefore, although the coastal state may not prohibit submarine cable installation outright, they may provide input on a proposed project in order to best protect marine resources within its EEZ.

The *International Submarine Cable Licenses Regulations* of the *Telecommunications Act* apply to the territorial sea of Canada but its jurisdiction does not extend to cables that only traverse the EEZ. For projects solely within the EEZ, permits may be granted under the *Fisheries Act* and the *Species at Risk Act*. The review processes that are applied to determine whether permits are granted is described further below.

Subsection 34.4(1) of the *Fisheries Act* prohibits the carrying out of a work, undertaking or activity, other than fishing, that results in the death of fish. Subsection 35(1) prohibits the carrying out of a work, undertaking, or activity that results in the harmful alteration, disruption, or destruction of fish habitat. If a project cannot avoid the death of fish or the harmful alteration, disruption, or destruction of fish habitat, the proponent must submit an application for regulatory review to Fisheries and Oceans Canada. If the review deems the project will likely contravene these conditions, the proponent is required to obtain an authorization from the department which will outline terms and conditions to be followed to avoid, mitigate, offset, and monitor the impacts.

Section 32(1) of the *Species at Risk Act* states that "no person shall kill, harm, harass, capture, or take" an individual of a species listed under the Act and Section 33 states that "no person shall damage or destroy the residence" of a listed species. Similar to the process described above, and often done in conjunction, a regulatory review process is required when a project will kill, harm, harass, capture, or take an aquatic species at risk. Authorization may be provided if the activity incidentally affects the species at risk and three conditions are met: all reasonable alternative solutions were considered and the best solution was adopted; all feasible measures will be taken to minimize impacts; and the activity will not jeopardize the survival or recovery of the species.

These review and authorization processes offer the opportunity to work with the proponent to make changes to the project so that impacts are mitigated, such as modification to the methods or alterations in the route. The authorizations may be denied if the proponent does not comply with suggestions that aim to limit the impact to fish and fish habitat or species at risk.

The *Impact Assessment Act* authorizes federal agencies to evaluate projects for their potential to cause significant adverse effects on the environment or to Indigenous Peoples. More specifically, and pertaining to submarine cables, the act prohibits any change to fish and fish habitat as defined in the *Fisheries Act* or any change to the environment on federal lands. The *Physical Activity Regulations* under the Act outlines activities that must undergo a review by the Impact Assessment Agency of Canada when a new project is proposed. Although submarine cable installation is not included in this list, the act authorizes review of such activities by an appropriate federal agency if requested by that agency. A separate review process (e.g., as discussed above for the *Fisheries Act*) may be substituted for the Impact Assessment process if it considers the same factors and allows for the same level of consultation.

The planning phase of the assessment process involves an initial review of the project details to determine whether an impact assessment is required, which includes a public comment period. If an assessment proceeds, consultation with affected stakeholders and Indigenous groups must be undertaken, followed by a report on the determination of significant adverse environmental effects, and another public review period. The final determination includes any conditions deemed appropriate to authorize the project, including mitigation measures.

In addition to regulatory measures, best management practices in submarine cable installation are also available. For example, the Oslo/Paris Convention for the Protection of the Marine

Environment of the North-east Atlantic (OSPAR Commission 2012) outlines measures that can be taken during the survey, installation, repair, and decommissioning phases to limit the environmental impact. Appropriate routing that avoids sensitive benthic features is cited as one of the most effective techniques.

## 4.2 SCOPE OF THE SUBMARINE CABLES RISK ASSESSMENT

For the purposes of this evaluation, submarine cable-related pressures to be assessed are bottom disturbance for both buried and surface-laid cables, and increased suspended sediment load associated with buried cable installations. Risk results associated with buried cable installation will also be considered as a proxy for cable repair. Surface-laid cables are not expected to introduce a measurable amount of sediment into the water column and will not be assessed for sediment loading. At the end of the lifespan, cables are most commonly abandoned (Carter et al. 2014). While abandoned submarine cables might have some impacts on surrounding benthic communities [e.g. potential of dissolving small quantities of heavy metals into surrounding waters (Taormina et al. 2018)], these impacts are believed to be minor, and fall outside of the scope of this risk assessment. In the event that a cable is recovered, disturbance can be expected to be similar to when the cable was installed, and will therefore not be assessed separately.

Submarine cable installation and maintenance occurs rarely (perhaps a few times per decade), so noticeable increases in the general effects of vessel traffic are not expected and are covered by analyses conducted elsewhere (i.e., see Chapter 3).

The presence of an unburied cable may disturb sediment over the long-term as the structure sways in the water current, though research suggests that this is an issue mostly in shallow water environments where wave action is more dominant (Kogan et al. 2006). The cable may also be snagged by bottom-contacting fishing gear and dragged across the substrate (Kogan et al. 2006; NOAA 2018). Given the deep-water location of the AOI, currents are not expected to move the cable dramatically. As well, mobile bottom-contacting fishing gear would not be permitted in a future MPA and the cable would likely be buried in areas where other bottom-contacting fishing gear would be allowed; therefore, these pressures will not be assessed.

With no known energy installations planned that would impact the AOI, this assessment will focus on fiber-optic telecommunications cable installation.

Potential for interaction

The potential for interactions between submarine cable activities and conservation priorities for the AOI are identified in Table 4.2-1.

Table 4.2-1. Potential for interaction between marine transportation pressures and conservation priorities for the Fundian Channel-Browns Bank AOI. Dark blue shading indicates that an exposure pathway exists and effects are known to occur, light blue indicates that an exposure pathway exists and effects may occur, and white indicates a lack of interaction. An asterisk identifies interactions selected to undergo the risk assessment.

| Conservation priority | Cable installation – surface-laid | Cable installation – burial | |
|---|---|---|---|
| | Bottom disturbance | Bottom disturbance | Increased suspended sediment load |
| Large mature female lobster | | | |
| Cetaceans: Beaked whale habitat | | | |
| Cetaceans: Blue Whale foraging area | | | |
| Sensitive benthic sp: Deep-water corals | * | * | * |
| Sensitive benthic sp: Significant sponge concentrations | | | * |
| Groundfish: juvenile Atlantic Halibut habitat | | | |
| Groundfish: Atlantic Cod habitat | | | |
| Groundfish: Atlantic Wolffish habitat | | | |
| Groundfish: Thorny Skate habitat | | | |
| Groundfish: Winter Skate habitat | | | |
| Groundfish: White Hake habitat | | | |
| Groundfish: Cusk habitat | | | |
| Marine birds: Shallow-diving pursuit generalists | | | |
| Marine birds: Surface-seizing planktivores/piscivores | | | |
| Marine birds: Surface shallow-diving piscivores | | | |
| Marine birds: Pursuit-diving piscivores | | | |
| Marine birds: Pursuit-diving planktivores | | | |
| Area of high productivity (plankton) | | | |

*Submarine cable installation (burial) – bottom disturbance:* The plough blade used for cable burial generally disturbs an area of seabed <1 m wide and up to 3 m deep, while the entire assembly operates on treads that can range from 2-8 m wide (Kraus and Carter 2018). Mobile organisms (e.g., fish and lobsters) could avoid the assembly and any disturbance would be short in duration. Multiple studies (Andrulewicz et al. 2003; Kogan et al. 2006; Auster et al. 2013; NOAA 2018) have failed to document negative impacts of cable installation on mobile organisms, and some report positive impacts, likely due to increased habitat heterogeneity (Kogan et al. 2006). However, sessile organisms such as corals and sponges located along the cable route are susceptible to damage. Due to spatial overlap, impacts to deep-water corals will be assessed, and results will be used as a proxy for sponge impacts.

*Submarine cable installation (burial) – increased suspended sediment load:* It is expected that where cable burial occurs there will be an increased suspended sediment load for a period of minutes to hours (Swanson and Isaji 2006). Deep-water corals and sponges have differing susceptibilities to an increased suspended sediment load, though negative effects may occur for both types of organisms. Though the area of high sponge concentration does not coincide with the likely route of a cable installation, Russian Hat Sponges (*Vazella pourtalesi*) may be found along the route; therefore, the assessment of impacts of sediment load to deep-water corals will also factor in the sensitivity of sponges.

*Submarine cable installation (surface-laid) – bottom disturbance:* Surface-laid cables may disturb mobile invertebrates and fish over a very short time period (i.e., minutes to hours) though lasting impacts have not been demonstrated (Kogan et al. 2006; NOAA 2018). Entanglements with diving marine mammals have not been recorded since 1959, as technology and installation techniques have improved (Wood and Carter 2008). However, there is evidence that this method may cause damage to sensitive benthic organisms (e.g., glass sponges; Dunham et al. 2015). Due to spatial overlap, impacts to deep-water corals will be assessed, and results will be used as a proxy for sponge impacts.

## 4.3 METHODS

Consequence

$Q_{Exposure}$

The Amitié fiber-optic cable installation project (Submarine Cable Networks 2021) was used to determine the length and placement of a potential route through the AOI. The surface-laid method involves the placement of a cable directly on the seafloor; therefore the spatial component of exposure was calculated as the width of the cable (approximately 50 mm in diameter) multiplied by its length where it overlaps the conservation priority within the AOI.

For the assessment of bottom disturbance by cable burial, the installation vehicle operates on treads ranging from 2-8 m wide (Kraus and Carter 2018). To be precautionary, the spatial component of exposure for this technique was calculated using 8 m as the width, which was multiplied by the cable length as described above.

To calculate the potential spatial exposure for increased suspended sediment load due to cable burial, a 100 m corridor on either side of the burial path (i.e., from the midpoint of the installation vehicle; 200 m in total) was used to estimate the width of the impact, as modelling outputs indicate this is the distance from the source where suspended sediment load may be higher than ambient (Swanson and Isaji 2006). Width was multiplied by the cable length as described above.

To calculate the potential temporal exposure, the life history characteristics of the conservation priority and the expected frequency and duration of cable installations were considered. To calculate the intensity score, the density of cable installations and the persistence of the activity were considered.

$Q_{Sensitivity}$

The sensitivities of the conservation priorities to submarine cable-related pressures were determined through review of available literature and expert opinion.

Likelihood levels

For submarine cable-related risk analyses, levels of likelihood were determined by considering the probability of the pressure interacting with the conservation priority, based on literature and expert opinion, with consideration for level of exposure. For example, cable installation equipment is designed to interact with the seafloor and thus high likelihood values were assigned.

## 4.4 RISK ASSESSMENT FOR SUBMARINE CABLES IN THE FUNDIAN CHANNEL-BROWNS BANK AOI

### <u>Risk Assessment - Submarine cable installation (burial) bottom disturbance and deep-water corals</u>

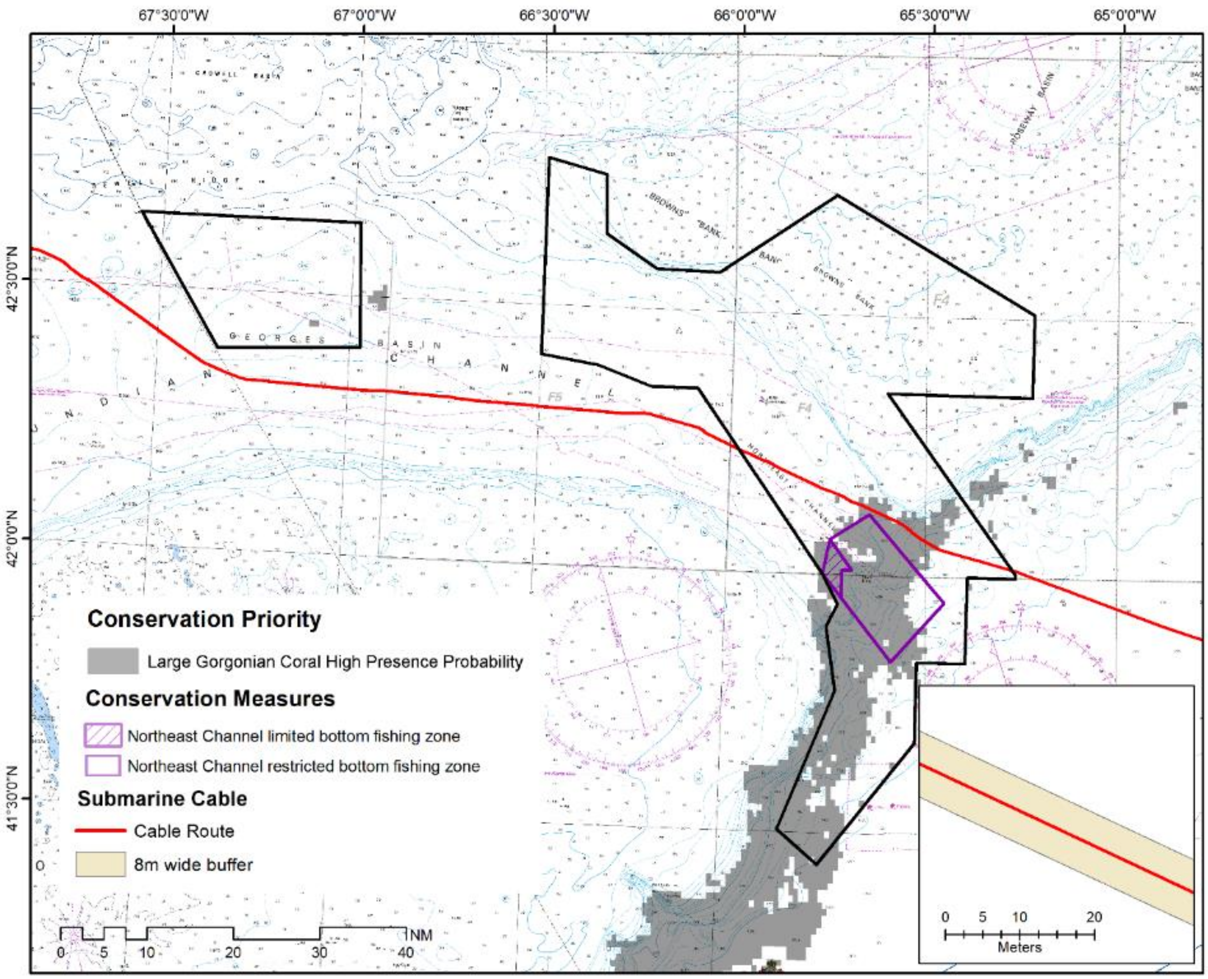


Figure 4.4-1. Overlap of the predicted extent of large gorgonian corals and submarine cable installation (burial method) in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). The width of installation equipment was set at 8 m.

**Risk statement**: There is a risk that bottom disturbance from the burial of a submarine cable will lead to negative impacts on deep-water coral communities within the AOI.

Table 4.4-1. Scoring for the risk posed by submarine cable installation (burial) bottom disturbance to deep-water corals within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 1 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 1 x 1<br>= 1 (raw score) |
| Intensity | 1 | Submarine cable density is low and the effects of bottom disturbance (i.e., grapnel run and cable burial) do not persist beyond when the activity occurs. |
| Temporal | 1 | Corals are long-lived, sessile animals. Submarine cable installations occur rarely, with perhaps years passing between new installations and/or repair activities. This results in a temporal exposure score of 1. |
| Spatial | 1 | The plough or water jetting from cable installation disturbs an area approximately 1 m wide, though the treads on cable installation vehicles are 2-8 m wide. A route 8 m wide through the Fundian Channel AOI would result in overlap of 0.15 $km^2$ with the predicted extent of large gorgonian corals, and a spatial score of 1. |
| $Q_{Sensitivity}$ | 5 | Deep-water corals are sessile, fragile, slow-growing, long-lived organisms that are susceptible to anthropogenic disturbance (Sherwood and Edinger 2009; Girard et al. 2018; Montagna and Girard 2020). Coral regeneration after disturbance is a complex combination of intrinsic (e.g., coral size and age) and extrinsic (e.g., food availability) factors and it is suggested that negative impacts to growth and sexual reproduction can affect long-term community viability (Henry and Hart 2005). Growth rates and life spans of corals vary by species; studies of gorgonian corals have calculated growth rates of 5-26 mm per year and lifespans of 100 to 200 years (Roberts et al. 2006 as cited in Campbell and Simms 2009). Some of the species of deep-water corals found in Nova Scotia may take decades to centuries to recover from impacts associated with fishing activities, if they recover at all (Sherwood and Edinger 2009; DFO 2010).<br><br>Though the effects of cable installation via burial have not been studied empirically on corals, it is known that where corals are exposed to physical disturbance, such as mobile bottom-contacting fishing gear, they can be damaged or destroyed (DFO 2006; Fuller et al. 2008; Althaus et al. 2009). The degree of impact has been related to the depth of sediment penetration and the amount of bottom contact (Gass and Willison 2005; Campbell and Simms 2009). Similarly, submarine cable burial methods drag heavy objects along the seafloor. A pre-lay grapnel run is often conducted, consisting of a grapnel towed along the route to clear any obstructions; these can penetrate the sediment to a depth |

| | | |
|---|---|---|
| | | of 0.5-1 m (Carter et al. 2014), which is deeper than the penetration depth range for fishing gear (Eigaard et al. 2016). Corals located in the path of the grapnel or installation vehicle are therefore expected to be extensively damaged or be completely destroyed. Considering also the slow recovery time from physical damage, a sensitivity score of 5 was assigned. |
| $Q_{Consequence}$ | Moderate | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 1 \times 5$<br>$= 5$ (raw score) |
| Likelihood | Almost certain | Submarine cable installation equipment disturbs the substrate by design, through the pre-lay grapnel run and the burial process using a cable plough or water-jetting. The treads or skids that support the installation vehicle contact the bottom. Bottom disturbance is therefore considered almost certain. |
| Overall risk | Moderately High | Additional management measures should be considered (where feasible) in collaboration with regulators, especially considering the high sensitivity score assigned during this assessment. Because impacts are highly localized they could be largely mitigated through route selection; routing should take care to avoid areas of high coral density with an appropriately sized buffer to ensure variance in route installation does not inadvertently interact with these sensitive organisms. |
| Uncertainty | Low | The presence probability map for deep-water corals within the AOI was developed using available data from research surveys. The identified coral area is predictive in nature due to limited survey coverage in the deeper waters.<br><br>The logistical difficulty and high cost have limited in-situ study of deep-water corals. Basic life history characteristics such as reproductive output, time to maturity, recovery from disturbance, and growth rates for many deep-water coral species are unknown. However, it is known that corals mature, grow, and recover slowly and that they are susceptible to disturbance.<br><br>The impacts of submarine cable burial has not been studied empirically on deep-water corals, though it is known that where corals are contacted by heavy gear towed along the substrate that catastrophic damage can occur. If another route were chosen for analysis differences in exposure calculations might result. |

**Risk Assessment - Submarine cable installation (burial) increased suspended sediment and deep-water corals and sponges**

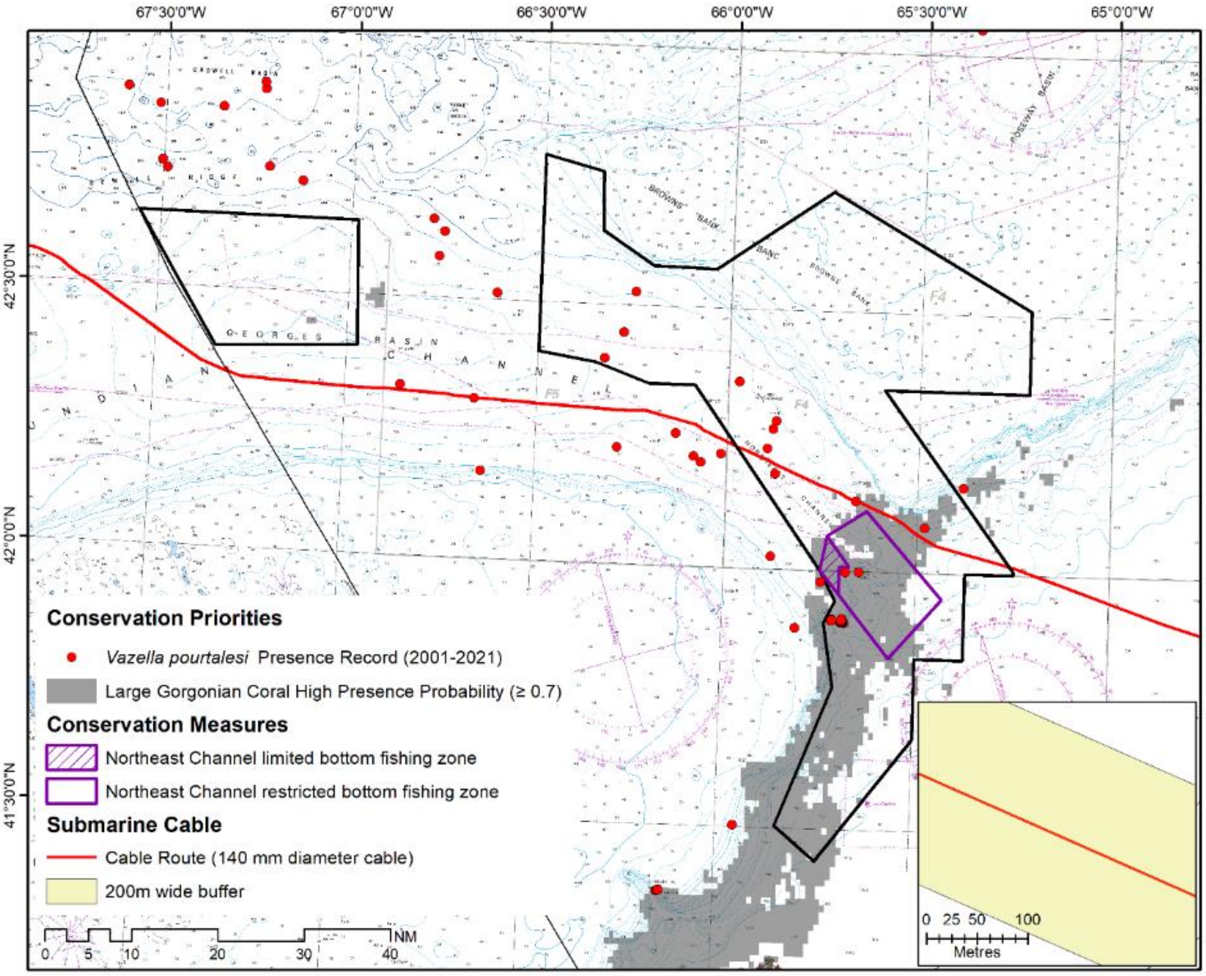


Figure 4.4-2. Overlap of the predicted extent of large gorgonian corals and known *Vazella pourtalesi* locations and the area of effect of increased suspended sediment load due to submarine cable burial installation in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon). The extent of the suspended sediment plume was set at 100 m to either side of the installation route.

**Risk statement**: There is a risk that increased suspended sediment load from the burial of a submarine cable will lead to negative impacts on deep-water coral and sponge communities within the AOI.

Table 4.4-2. Scoring for the risk posed by increased suspended sediment load from submarine cable burial installation to deep-water corals and sponges within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 1 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 1 x 1<br>= 1 (raw score) |

| | | |
|---|---|---|
| Intensity | 1 | Submarine cable density is low and sediment plumes may persist for minutes to hours, resulting in a low intensity score. |
| Temporal | 1 | Corals and sponges are long-lived, sessile animals. Submarine cable installations occur rarely, with perhaps years passing between new installations/repair activities. This results in a temporal exposure score of 1. |
| Spatial | 1 | A measurable sediment plume may extend for up to 100 m beyond the midpoint of the installation vehicle (i.e., the area directly ploughed). A route 200 m wide through the AOI would result in overlap of 3.7 $km^2$ with the predicted extent of large gorgonian corals, and a spatial score of 1. |
| $Q_{Sensitivity}$ | 1 | Deep-water corals are sessile, fragile, slow-growing, long-lived organisms that are susceptible to anthropogenic disturbance (Sherwood and Edinger 2009; Girard et al. 2018; Montagna and Girard 2020). Coral regeneration after disturbance is a complex combination of intrinsic (e.g., coral size and age) and extrinsic (e.g., food availability) factors and it is suggested that negative impacts to growth and sexual reproduction can affect long-term community viability (Henry and Hart 2005). Growth rates and life spans of corals vary by species; studies of gorgonian corals have calculated growth rates of 5-26 mm per year and lifespans of 100 to 200 years (Roberts et al. 2006 as cited in Campbell and Simms 2009). Some of the species of deep-water corals found in Nova Scotia may take decades to centuries to recover from impacts associated with fishing activities, if they recover at all (Sherwood and Edinger 2009; DFO 2010).<br><br>Cable burial can introduce increased suspended sediment into the water column which may interfere with the regular functioning of corals and sponges. Modelling has suggested that cable burial activities can increase suspended sediment levels in the water column typically amounting to 50 mg/L, though with higher concentrations of >100 mg/L lasting <2 hours (Swanson and Isaji 2006). This study emphasized that the background level of suspended sediment is important to consider and that organisms may regularly interact with heightened sediment levels over short time periods due to natural processes.<br><br>Many species of corals exhibit an outer mucus coating which functions in defense and feeding, and can be used to expel or ingest sediments (Stafford-Smith and Ormond 1992; Brown and Bythell 2005; Bessell-Browne et al. 2017). Larsson and Purser (2011) exposed a deep-water coral (*Lophelia pertusa*) to one-time sediment loads equivalent to a large storm event and demonstrated efficient sediment removal where it contacted live tissue. Brooke and authors (2009) introduced the same species to suspended sediment loads over 14 days and saw no difference in |

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| | | survival up to 54 mg/L, with higher levels of mortality as concentrations increased. It was suggested that though sediment removal efficiency can differ among species, *Lophelia* retained efficient removal processes that were not easily exhausted over long periods (Brooke et al. 2009; Larsson and Purser 2011). 100% colony survival was also demonstrated in *Primnoa resedaeformis* over 14 days of exposure though significant individual polyp death occurred (Liefmann et al. 2018). Taken together, though in extreme and/or protracted sediment exposures corals may suffer damage and mortality, the short duration of increased sediment load during cable burial activities is not expected to have a measurable impact on deep-water coral populations within the AOI.<br><br>Sponges, as filter-feeding organisms, may be susceptible to the effects of increased sediment load. Particles can reduce the pumping efficiency and filtering capacity of some species (Bell et al. 2015; Grant et al. 2018; Wurz et al. 2021) and interfere with feeding activities (Strehlow et al. 2017). However, sponges also exhibit certain abilities to limit impacts from suspended sediment including mucus production, cessation of pumping, and expulsion of particles. Glass sponges, such as the Russian Hat Sponges that may be found along the proposed cable route, have shown the ability to arrest pumping in response to suspended sediment. One-time exposures caused pumping to cease for minutes and recovery occurred once sediment load returned to the baseline (Tompkins-Macdonald and Leys 2008; Wurz et al. 2021). Repeated exposures could interfere with long-term viability and it is plausible that higher one-time sediment depositions (i.e., partial or complete burial, likely only in close proximity to the ploughed area) could cause acute detrimental effects (Airoldi 2003). However, a single exposure to increased sediment load at the scale discussed above over a few hours is not expected to cause detrimental long-term effects.<br><br>Beyond the range where burial under sediment is a factor (i.e., directly adjacent to the installation vehicle), where corals and sponges are exposed to an increased suspended sediment load for a few hours impacts are expected to be insignificant, resulting in a sensitivity score of 1. |
| $Q_{Consequence}$ | Negligible | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 1 \times 1$<br>$= 1$ (raw score) |
| Likelihood | Almost certain | Submarine cable installation equipment disturbs the substrate by design through the burial process using a cable plough or water-jetting. The size and concentration of the sediment plume will depend on the characteristics of the substrate and the currents at |

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| | | the time of installation. Therefore, increased suspended sediment load is considered almost certain. |
| Overall risk | Low | No additional management actions suggested. |
| Uncertainty | High | The presence probability map for deep-water corals within the AOI was developed using available data from research surveys. The identified coral area is predictive in nature due to limited survey coverage in the deeper waters. Known *Vazella pourtalesi* locations are limited due to limited survey coverage in the deeper waters where they are found.<br><br>The logistical difficulty and high cost have generally limited in-situ study of deep-water corals and sponges. Basic life history characteristics such as reproductive output, time to maturity, and recovery from disturbance for many deep-water species are unknown. However, it is known that corals and sponges mature, grow, and recover slowly and that they are susceptible to disturbance.<br><br>The impacts of submarine cable burial has not been studied empirically on deep-water corals and sponges, especially the effects of increased suspended sediment load. If another route were chosen for analysis differences in exposure calculations might result. |

**Risk Assessment - Submarine cable installation (surface-laid) bottom disturbance and deep-water corals**

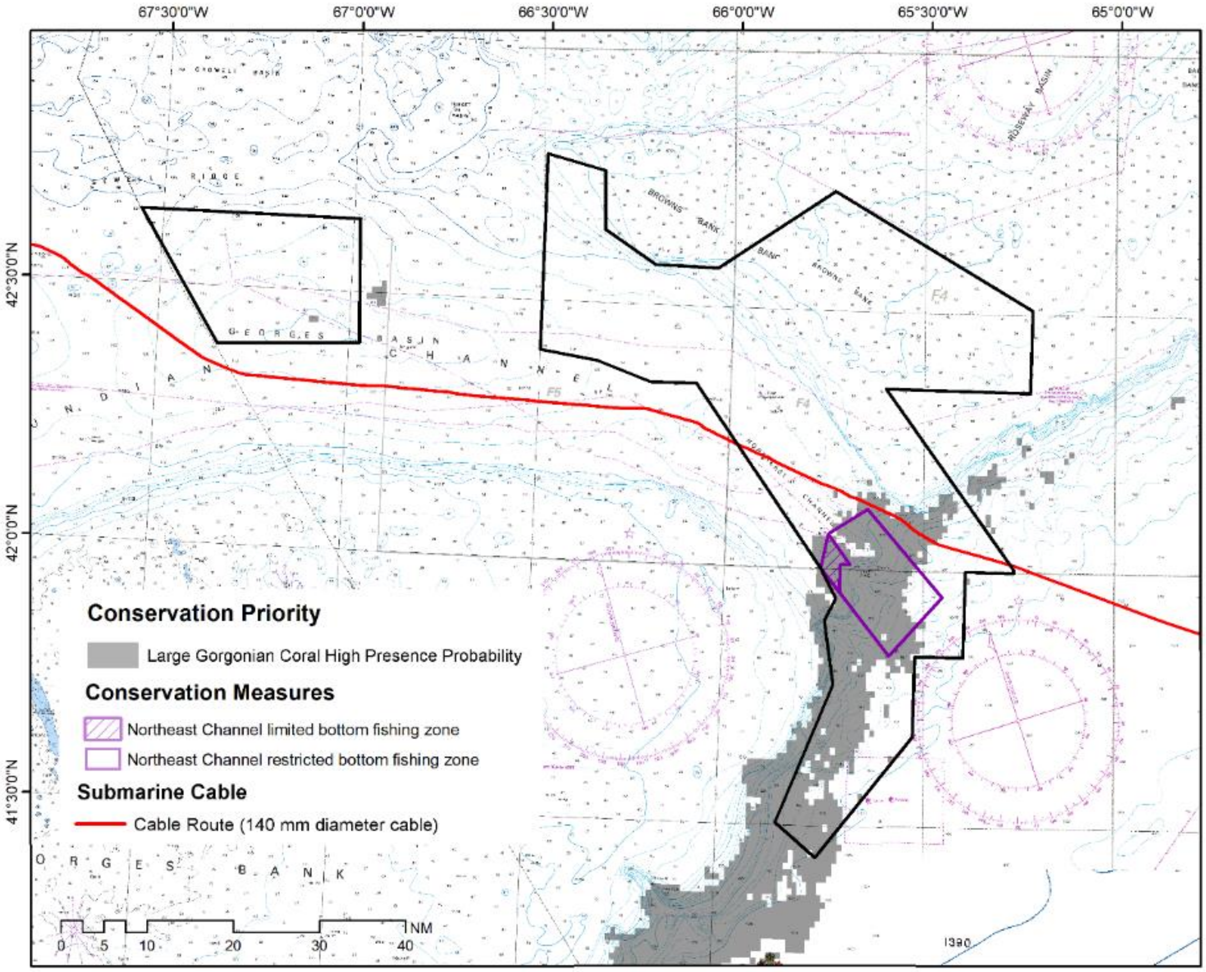


Figure 4.4-3. Overlap of the predicted extent of large Gorgonian corals and surface-laid submarine cable in the Fundian Channel-Browns Bank Area of Interest (AOI; black polygon).

**Risk statement**: There is a risk that bottom disturbance from the laying of a submarine cable on the seabed will lead negative impacts on deep-water coral communities within the AOI.

Table 4.4-3. Scoring for the risk posed by submarine cable installation (surface-laid) bottom disturbance to deep-water corals within the AOI.

| Risk factor | Score | Rationale |
|---|---|---|
| $Q_{Exposure}$ | 1 (binned) | $Q_{Exposure}$ = Intensity x Temporal x Spatial<br>= 1 x 1 x 1<br>= 1 (raw score) |
| Intensity | 1 | Submarine cable density is low and the effects of bottom disturbance (i.e., laying of the cable) do not persist beyond when the activity occurs. |
| Temporal | 1 | Corals are long-lived, sessile animals. Submarine cable installations occur rarely, with perhaps years passing between new |

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| | | installations/repair activities. This results in a temporal exposure score of 1. |
| Spatial | 1 | A fiber-optic submarine cable is only a few centimeters wide and laying activities are not expected to extend beyond the physical footprint of the cable. A route through the AOI would overlap <0.01 $km^2$ with the predicted extent of large gorgonian corals, resulting in a spatial score of 1. |
| $Q_{Sensitivity}$ | 3 | Deep-water corals are sessile, fragile, slow-growing, long-lived organisms that are susceptible to anthropogenic disturbance (Sherwood and Edinger 2009; Girard et al. 2018; Montagna and Girard 2020). Coral regeneration after disturbance is a complex combination of intrinsic (e.g., coral size and age) and extrinsic (e.g., food availability) factors and it is suggested that negative impacts to growth and sexual reproduction can affect long-term community viability (Henry and Hart 2005). Growth rates and life spans of corals vary by species; studies of gorgonian corals have calculated growth rates of 5-26 mm per year and lifespans of 100 to 200 years (Roberts et al. 2006 as cited in Campbell and Simms 2009). Some of the species of deep-water corals found in Nova Scotia may take decades to centuries to recover from impacts associated with fishing activities, if they recover at all (Sherwood and Edinger 2009; DFO 2010).<br><br>Though the effects of a surface-laid cable have not been studied empirically on corals it is known that where corals are exposed to physical disturbance they can be damaged (DFO 2006; Fuller et al. 2008; Althaus et al. 2009). Campbell and Simms (2009) note that the degree of impact is related to the depth of sediment penetration and the amount of bottom contact. Surface-laid cables are not expected to penetrate the sediment and occupy a small spatial footprint, though direct contact with a sensitive organism or habitat may still be detrimental.<br><br>Though limited to a restricted spatial footprint, a surface-laid cable may cause damage to deep-water corals located in the path of the cable; however, habitat function is expected to be minimally impacted. This results in a sensitivity score of 3. |
| $Q_{Consequence}$ | Low | $Q_{Consequence} = Q_{Exposure} \times Q_{Sensitivity}$<br>$= 1 \times 3$<br>$= 3$ (raw score) |
| Likelihood | Almost certain | Surface-laid submarine cables interact with the substrate by design. Bottom disturbance is therefore considered almost certain. |
| Overall risk | Moderate | Additional management measures may be considered, such as routing to avoid sensitive benthic habitats. |
| Uncertainty | High | The presence probability map for deep-water corals within the AOI was developed using available data from research surveys. |

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| | | The identified coral area is predictive in nature due to limited survey coverage in the deeper waters.<br><br>The logistical difficulty and high cost have limited in-situ study of deep-water corals. Basic life history characteristics such as reproductive output, time to maturity, recovery from disturbance, and growth rates for many deep-water coral species are unknown. However, it is known that corals mature, grow, and recover slowly and that they are susceptible to disturbance.<br><br>The impacts of surface-laid submarine cables have not been studied empirically on deep-water corals. The ability of a single colony or population to recover from interaction with a fiber-optic cable is unknown. Additionally, little is known about the impacts of repair operations specifically on non-buried cables. If another route were chosen for analysis differences in exposure calculations might result. |

## 4.5 SUMMARY OF SUBMARINE CABLE RESULTS

The risks presented by pressures associated with submarine cables for the Fundian Channel-Browns Bank AOI were determined from available literature review and expert opinion. Table 4.5-1 summarize for all submarine cables activities and conservation priorities assessed in the AOI.

Table 4.5-1. Summary of the risk levels for each interaction assessed for submarine cables; grouped by conservation priority.

| Conservation Priority | Pressure | Exposure | Sensitivity | Likelihood | Risk Level |
|---|---|---|---|---|---|
| **Deep-water corals** | Cable installation (burial) – bottom disturbance | 1 | 5 | Almost certain | Moderately High |
| | Cable installation (surface-laid) – bottom disturbance | 1 | 3 | Almost certain | Moderate |
| **Deep-water corals and sponges** | Cable installation (burial) – increased suspended sediment load | 1 | 1 | Almost certain | Low |

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## 5.0 SUMMARY AND NEXT STEPS

The ecological risk assessment for the Fundian Channel-Browns Bank AOI was conducted to establish the relative risk presented by interactions between the conservation priorities for a potential future MPA and human activities that occur (or may occur in the near future) in the area. In general, scoring for exposure, sensitivity, and likelihood was limited by available knowledge and data for the area. With better information, some scores could be altered. Because this assessment was conducted with an MPA as its focus, tolerance for risk was lower than it would be for areas not set aside for conservation purposes. Thus, the risk levels reported here may not represent DFO's assessment of risks for the same activities elsewhere in the Scotian Shelf bioregion.

At the time of writing, the ecological risk assessment method used here aligned with national guidance for ecological risk analyses developed for DFO's Marine Planning and Conservation Program. While this approach is an improvement on previous ecological risk assessment approaches for AOIs (e.g., Aker et al. 2014), further refinement of aspects of the method would be useful for future applications. For example, an expansion of the spatial component of exposure to allow for consideration of the three dimensional environment (Table 1.7.1-1) could improve exposure estimates for certain pressures, such as oil contamination from spill events. Further work is also needed to expand upon this method to allow for consideration of cumulative impacts to conservation priorities from multiple activities. Without the ability to assess cumulative impacts, risks posed to single species and the overall ecosystem may be underestimated by the approach used here.

The findings of this work will contribute to decision-making about activities that would be allowed under the regulations within a future Fundian Channel-Browns Bank MPA, and will also help to inform the design of boundaries and zones where certain activities would be permitted. It must be noted that the findings presented here are not prescriptive and do not represent final decisions about how activities would be managed. Rather, the assessment provides a structure for considering information about the ecological effects of activities in a systematic manner to help inform discussions and decisions. Other factors, including the precautionary approach, social and economic considerations, and feedback from consultations will also be taken into account in determining proposed design and management measures for a potential future Fundian Channel-Browns Bank MPA.

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## APPENDIX A

Table A-1. Federal Government Sectors that have contributed to the review of this document[16].

| Chapter | Department | Branch (Division) |
|---|---|---|
| Chapter 1 (Introduction) | DFO | Science (Population Ecology, Coastal Ecosystem Science, Ocean and Ecosystem Science) |
| | | Aquatic Ecosystems (Species at Risk) |
| | Environment and Climate Change Canada | Canadian Wildlife Service |
| Chapter 2 (Fisheries) | DFO | Science (Population Ecology, Coastal Ecosystem Science, Ocean and Ecosystem Science) |
| | | Resource Management (Fisheries Management) |
| | | Aquatic Ecosystems (Species at Risk) |
| | Environment and Climate Change Canada | Canadian Wildlife Service |
| Chapter 3 (Marine Transportation) | DFO | Science (Population Ecology, Coastal Ecosystem Science, Ocean and Ecosystem Science, Environmental Response) |
| | | Aquatic Ecosystems (Ecosystems Management –Marine Development; Species at Risk) |
| | Transport Canada | Marine Safety and Security - Atlantic |
| | Environment and Climate Change Canada | Canadian Wildlife Service |
| Chapter 4 (Submarine Cables) | DFO | Science (Ocean and Ecosystem Science) |
| | | Aquatic Ecosystems (Ecosystems Management –Marine Development) |

[16] While every effort was made to consider and incorporate feedback received during the review process, scores were determined by the authors, with careful consideration for the fair and consistent application of the method across activities/pressures and conservation priorities.

Table A-2. Advisory Committee Organizations that have contributed to the review of this document[17].

| Chapter | Category | Organization |
|---|---|---|
| Chapter 1 (Introduction) | First Nations/Indigenous Peoples | Kwilmu'kw Maw-klusuaqn Negotiation Office |
| | Province of Nova Scotia | NS Dept of Fisheries and Aquaculture |
| | Shipping industry | Shipping Federation of Canada |
| | Environmental non-governmental organizations (ENGOs) | Canadian Parks and Wilderness Society – Nova Scotia Chapter |
| | Environmental non-governmental organizations (ENGOs) | Ecology Action Center |
| | Academia | Dalhousie University |
| Chapter 2 (Fisheries) | First Nations/Indigenous Peoples | Kwilmu'kw Maw-klusuaqn Negotiation Office |
| | Fishing industry | Clearwater Seafoods |
| | | Atlantic Groundfish Council |
| | | NS Swordfishermen's Association |
| | Province of Nova Scotia | NS Dept of Fisheries and Aquaculture |
| | Environmental non-governmental organizations (ENGOs) | Canadian Parks and Wilderness Society – Nova Scotia Chapter |
| | Environmental non-governmental organizations (ENGOs) | Ecology Action Center |
| | Academia | Dalhousie University |
| Chapter 3 (Marine Transportation) | First Nations/Indigenous Peoples | Kwilmu'kw Maw-klusuaqn Negotiation Office |
| | Province of Nova Scotia | NS Dept of Fisheries and Aquaculture |
| | Oil and gas industry | Canadian Association of Petroleum Producers |
| | Shipping industry | Shipping Federation of Canada |
| | Academia | Dalhousie University |
| Chapter 4 (Submarine Cables) | First Nations/Indigenous Peoples | Kwilmu'kw Maw-klusuaqn Negotiation Office |

[17] While every effort was made to consider and incorporate feedback received during the review process, scores were determined by the authors, with careful consideration for the fair and consistent application of the method across activities/pressures and conservation priorities.

| | | |
|---|---|---|
| | Oil and gas industry | Canadian Association of Petroleum Producers |
| | Environmental non-governmental organizations (ENGOs) | Canadian Parks and Wilderness Society – Nova Scotia Chapter |
| | Academia | Dalhousie University |

## APPENDIX B

### INFORMATION GAPS

Information gaps associated with characterization of Conservation Priorities in the Area of Interest:

- Beaked whale habitat was defined using available data from visual and acoustic detections, and modeling based on known habitat preferences; however, the knowledge of spatial and temporal habitat use patterns within the AOI is currently limited. There is uncertainty associated with the use of this area for Northern Bottlenose Whales, as it is toward the southern extent of their range.
- Understanding of beaked whale distribution patterns, social and reproductive behaviours, population structure, and impacts from anthropogenic stressors are limited.
- Many life history characteristics of Blue Whales are not well understood including population size, generation time, distribution, and natural mortality.
- The presence probability map for the deep-water coral area within the AOI was developed using available data from different types of research surveys and uses a Random Forest model to produce a map of predicted large gorgonian presence probability. The identified coral area is predictive in nature due to limited survey coverage in deeper waters.
- Basic life history characteristics such as reproductive output, time to maturity, recovery from disturbance, and growth rates for many deep-water corals and sponges are unknown.
- The area of highly suitable habitat for Cusk was determined using the outputs of a habitat suitability model (predicted presence) for Cusk for the Maritimes Region predicted using a Random Forest method and is therefore predictive in nature.
- Important marine bird foraging areas were identified using available data from offshore seabird surveys. Survey coverage has been limited, and while identified foraging areas are based on occurrences, they contain a predictive component.

Information gaps associated with characterization of activities/pressures in the Area of Interest:

- There is currently no research or data available for buoy gear in DFO Maritimes Region due to the novel nature of this fishing gear in the region. As a result, various proxies were used to conduct the buoy gear risk assessment. Potential species interactions and associated risks were determined through evaluation of United States fisheries data. Additionally, the pelagic longline footprint was used as an estimate for areas where buoy gear activity may occur within the AOI.
- Due to the minimal use of midwater trawls within the region at the time of assessment, a proxy fisheries footprint was developed using predicted species distribution of Silver Hake, which was identified as a potential target species for this fishery. Intensity was also presumed to be moderate due to lack of available data, and potential species interactions and associated risks were determined using data and information from similar fisheries occurring elsewhere.
- No in-situ measurements or sound modeling outputs are currently available to properly characterize noise levels within the AOI. Due to its potentially chronic nature and the

potential for increased vessel traffic in the years to come, vessel noise should be a priority for monitoring in the future MPA.

Information gaps associated with characterization of sensitivities and impacts in the Area of Interest:

*Fisheries Interactions:*

- The survival of discarded animals is not well understood for many species, and can depend on many factors such as environmental conditions, soak time, hook location, and handling.
- Few studies are available assessing the impacts of bottom longlines on lobster.
- There were no studies found that directly assess the impacts of groundfish gillnet fisheries on American Lobster. Studies used to determine sensitivity mainly focused on impacts of trawl gear on crustacean discard survival, and did not include American Lobster in the assessments.
- Reported entanglement events and entanglement scarring for whales often do not have clear links to a specific fishing gear type. Further, observer data are limited in their ability to approximate rates of cetacean bycatch and entanglement.
- Entanglement events for whales are likely underreported due to offshore distribution, and sinking of carcasses. As well, entangled whales may break free prior to detection (potentially with gear attached) and there is a lack of information on long-term health and survival rates post-entanglement
- Low observer coverage and underreporting mortality limit understanding of Shearwater and fishing activity interactions.
- Shearwaters complete extensive migrations and have a large habitat range: there is limited understanding on how one activity in one location is impacting the overall population.

*Marine Transportation Interactions*:

- Vessel collisions with cetaceans are likely underreported due to detection challenges, lack of information on long-term health and survival post-collision, and uncertainty around conditions (e.g., vessel size and speed, morphological differences) that result in lethal strikes.
- Lack of research on vessel strike mortality or sub-lethal effects contribution to population-level impacts in seabird species.
- Little information on the proportion of vessel noise that occupies frequency ranges detectable by mid-frequency cetaceans, and therefore a limited understanding on the relative threat and full spectrum of impacts that vessel noise poses to cetaceans.
- Lack of understanding on long-term and population-level impacts of noise exposure (including echosounders) on marine mammals.
- The impacts of anthropogenic noise (from both particle motion and sound pressure) on Atlantic Cod are not well understood including individual and population impacts over different spatial and temporal scales. Most available studies on fish hearing and sound production are laboratory-based, and may not be representative of impacts experiences in natural settings. Additionally, most studies are based on sound pressure, not particle motion.

- Little research has focused on the threat posed by vessel collisions and light-induced disorientation to seabirds in the Northwest Atlantic.
- Little is known about the extent to which vessel strike mortality or sub-lethal effects contribute to population-level impacts in seabird species, including surface-seizing planktivores/piscivores.
- Oil spill fate and behaviour modeling in offshore areas like the FC-BB AOI are limited.
- Limited in situ studies on oil impact on adult lobsters, deep-water corals, benthic fish populations (e.g., cod), and areas of high productivity. Existing studies are generally laboratory-based, and may not be representative of impacts experienced in natural settings. Acute or chronic impacts on the food web are not well understood.
- Understanding of potential direct or indirect impacts of oil spills on beaked whales is limited.
- Long-term, cumulative, and population-level effects of oil spills on seabirds in the offshore environment are not well studied.

*Submarine Cables:*

- Impacts of submarine cable burial and surface-laid submarine cables have not been studied empirically on deep-water corals and sponges. Little information is available on impacts of repair operations on deep-water corals.

Information gaps associated with risk approach:

- Further work is needed to expand upon the risk assessment methodology to allow for consideration of cumulative impacts to conservation priorities from multiple activities.