

The Cape Breton Trough: a distinctive feature of the Western Cape Breton Ecologically and Biologically Significant Area (EBSA) of the southern Gulf of St. Lawrence, Canada

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by

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TABLE OF CONTENTS

| | |
|--|----|
| ABSTRACT..... | V |
| RÉSUMÉ | VI |
| INTRODUCTION | 1 |
| PHYSICAL SYSTEM..... | 2 |
| BATHYMETRY..... | 2 |
| GEOLOGY | 3 |
| PHYSICAL OCEANOGRAPHY | 4 |
| Water Circulation..... | 4 |
| Tidal Regime | 4 |
| Water Temperature and Salinity | 4 |
| Dissolved Oxygen | 5 |
| Nutrients..... | 5 |
| Sea-Ice Cover | 6 |
| BIOLOGICAL SYSTEM..... | 6 |
| PLANKTON..... | 6 |
| Phytoplankton | 6 |
| Zooplankton | 7 |
| FISH..... | 9 |
| Atlantic Bluefin Tuna (pelagic)..... | 14 |
| Atlantic Cod (demersal) | 15 |
| White Hake (demersal)..... | 19 |
| Winter Skate (demersal)..... | 22 |
| Acadian Redfish (semi-pelagic)..... | 25 |
| American Plaice (demersal) | 27 |
| Smooth Skate (demersal)..... | 29 |
| Thorny Skate (demersal)..... | 32 |
| Atlantic Wolffish (demersal)..... | 35 |
| SHARKS | 37 |
| Porbeagle Shark | 38 |
| Basking Shark | 40 |
| Shortfin mako shark | 42 |
| Spiny Dogfish Shark..... | 44 |
| Great White Shark..... | 45 |
| MARINE MAMMALS | 45 |
| Cetaceans (whales, dolphins and porpoises) | 46 |
| Pinnipeds (seals)..... | 55 |
| LEATHERBACK SEA TURTLE | 58 |
| CONCLUSION | 60 |
| REFERENCES | 61 |

| | |
|---------------|----|
| APPENDIX..... | 76 |
|---------------|----|

ABSTRACT

Coomber C., Joseph V., Sabean C. and Ricard D. 2021. The Cape Breton Trough: a distinctive feature of the Western Cape Breton Ecologically and Biologically Significant Area (EBSA) of the southern Gulf of St. Lawrence, Canada. Can. Manuscr. Rep. Fish. Aquat. Sci. 3213: vi + 76 p.

This document is a compilation of the best available data on the marine environment of the Cape Breton Trough (CBT), a relatively deep channel located along the northwestern shore of Cape Breton Island, Nova Scotia, Canada. It comprises information from a literature review conducted primarily in 2016-2017 on the physical and biological components of the CBT, which is within the Western Cape Breton Ecologically and Biologically Significant Area (EBSA) of the southern Gulf of St. Lawrence (sGSL). Characterized by some of the deepest waters in the sGSL, the CBT is roughly defined by the 100 m isobath. Physical features of the trough, such as depth, water column stratification and upwelling activity provide habitat conditions that are favorable to biological production. As a result, several species inhabit the trough, either permanently or as seasonal occupants, and therefore rely on the ecological integrity of this marine environment. The CBT supports various biological functions, as many species pass through the area to enter/exit the GSL and/or occupy the area to conduct important activities, such as foraging, reproduction and possibly molting. The document is divided into two sections that describe the physical and biological components of the CBT separately. The first section (Physical System) covers details on the bathymetry, geology and physico-chemical parameters (e.g., water circulation, temperature, salinity, nutrients, sea-ice cover). The section on the biotic environment (Biological System) forms the larger portion of this document, describing plankton dynamics and benthic invertebrate populations, and providing an overview on status, distribution, preferred habitat and basic biology of a wide array of fish and mammal species, as well as the leatherback sea turtle (*Dermochelys coriacea*). It is to be noted that the use of information from a wider geographic area was often inevitable due to the limited availability of data specific to the CBT.

RÉSUMÉ

Coomber C., Joseph V., Sabean C. and Ricard D. 2021. The Cape Breton Trough: a distinctive feature of the Western Cape Breton Ecologically and Biologically Significant Area (EBSA) of the southern Gulf of St. Lawrence, Canada. Can Manuscr. Rep. Fish. Aquat. Sci. 3213: vi + 76 p.

Ce document est une compilation des meilleures données disponibles sur l'environnement marin du chenal du Cap-Breton (CCB), une vallée profonde située le long de la côte nord-ouest de l'île du Cap-Breton, en Nouvelle-Écosse, Canada. L'information présentée provient d'une revue de littérature effectuée en 2016-17 sur les composantes physiques et biologiques du CCB. Le chenal, dont les eaux figurent parmi les plus profondes du sud du golfe du Saint-Laurent (sGSL), est défini approximativement par l'isobathe de 100 m, et se retrouve à l'intérieur d'une zone d'importance écologique et biologique du sGSL. Les caractéristiques physiques du chenal, telles que sa profondeur, la stratification de la colonne d'eau et la remontée d'eaux profondes, sont favorables à la production biologique. Ainsi, un grand nombre d'espèces s'y retrouvent, soit de façon permanente ou temporaire, pour effectuer une variété de fonctions biologiques (p.ex. migration, alimentation, reproduction). Ce document est divisé en deux parties qui décrivent séparément les composantes physiques et biologiques du CCB. La première partie (*Physical System*) comprend des détails sur la bathymétrie, la géologie et les paramètres physico-chimiques (p.ex. circulation de l'eau, température, salinité, nutriments, couverture de glace). La partie décrivant l'environnement biotique (*Biological System*) constitue la plus grande partie du document, incluant des détails sur le plancton et les populations d'invertébrés benthiques, ainsi qu'un aperçu sur le statut, la distribution, l'habitat préféré et la biologie générale d'un large éventail d'espèces de poissons et mammifères, en plus de la tortue luth (*Dermochelys coriacea*). Il est à noter que l'utilisation d'information provenant d'une plus grande zone géographique fut souvent inévitable en raison de la disponibilité limitée de données spécifiques au CCB.

INTRODUCTION

In 2006, several areas within the southern Gulf of St. Lawrence (sGSL) were identified as Ecologically and Biologically Significant Areas (EBSAs), including the marine environment along western Cape Breton (DFO 2007; Appendix 1). EBSAs are geographically or oceanographically well-defined areas deemed significant because of structural properties and/or because of the functions they serve in the ecosystem (DFO 2004). Through the process of identifying EBSAs, the Cape Breton Trough (CBT), which lies within the boundaries of the Western Cape Breton EBSA, was recognized as an area of importance for several biological components (Figure 1). The physical structures and oceanographic processes of the CBT were considered important to primary and secondary production of the area. The trough was identified as an important migration corridor for several fish species (e.g., cod (*Gadus morhua*), white hake (*Urophycis tenuis*; deepwater stock component)), fundamental summer feeding grounds for small pelagic fishes (e.g., adult Atlantic herring (*Clupea harengus*), capelin (*Mallotus villosus*), silver hake (*Merluccius bilinearis*)) and demersal fishes (white hake and adult witch flounder (*Glyptocephalus cynoglossus*)), and as an area of high demersal fish diversity and biomass (Rondeau *et al.* 2016; McQuinn *et al.* 2012; Swain and Benoît 2007). The CBT was also noted for the aggregation and high abundance of benthic invertebrate species and as feeding grounds for several marine mammal species, including deep-divers (Savenkoff *et al.* 2007).

The objective of this document is to provide an overview of available data pertaining to the marine environment of the CBT. The document is divided into two sections that describe the physical and biological components of the CBT separately. The first section (Physical System) covers details on the bathymetry, geology and physio-chemical parameters (e.g., water circulation, temperature, salinity, nutrients, sea-ice cover). The section on the biotic environment (Biological System) forms the larger portion of this document, describing plankton dynamics and benthic invertebrate populations, and providing an overview on the status, distribution, preferred habitat and basic biology of a wide array of fish, and mammal species, as well as the leatherback sea turtle (*Dermochelys coriacea*). It is to be noted that the use of information from a wider geographic area was often inevitable due to the limited availability of data specific to the CBT.

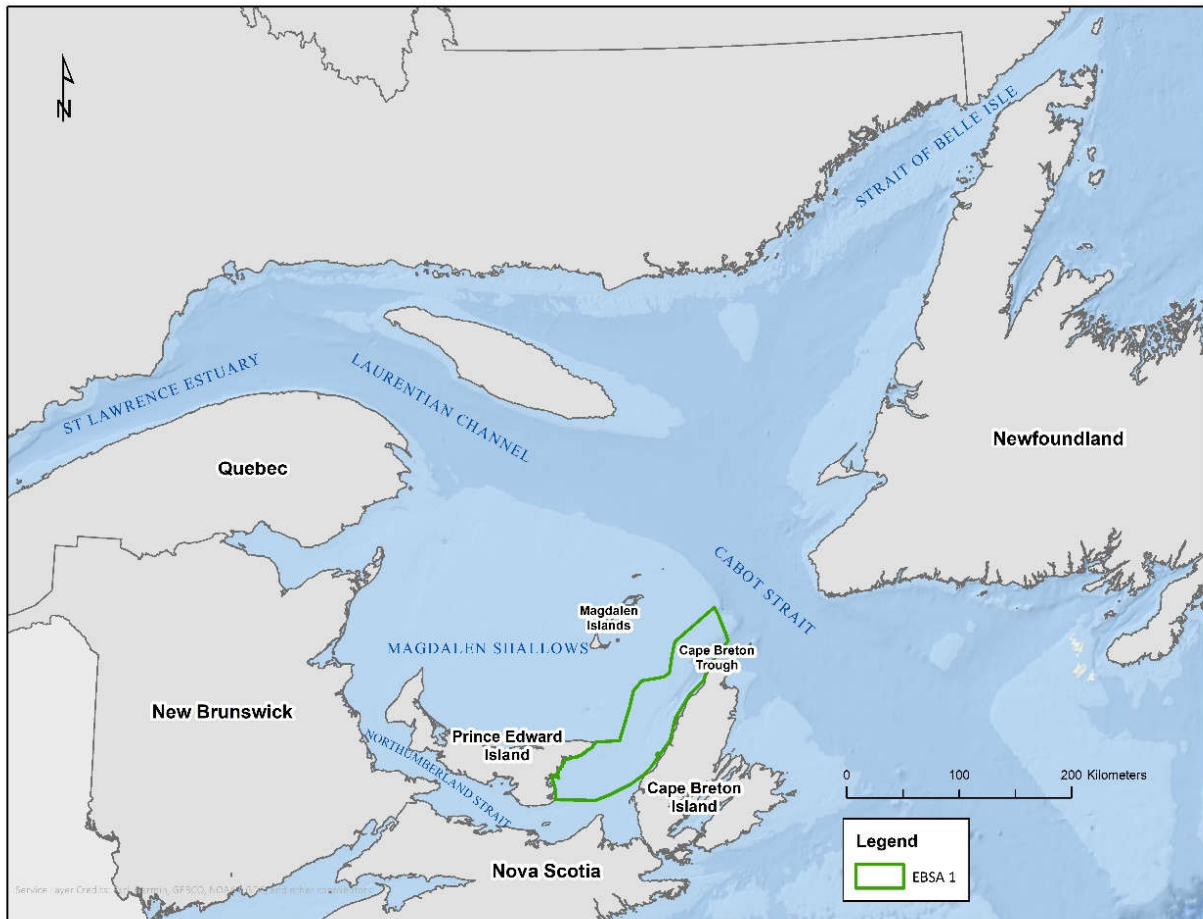


Figure 1. Area of the Cape Breton Trough considered for this overview report.

PHYSICAL SYSTEM

BATHYMETRY

With some of the deepest waters in the sGSL (Therrien *et al.* 2001), the CBT is roughly defined by the 100 m isobath and reaches the Laurentian Channel at a depth of ~200 m (Figure 2). It is characterized by relatively straight walls, a wide irregular base, floor elevations that are typically oval in shape and longitudinal profiles displaying reversed slopes resulting from a series of rimmed floor depressions along their length (Loring and Nota 1973).

Consequently, the general northward progression to greater depths is attenuated by the uneven relief of the trough, where elevations in the seafloor (e.g., north of Bay St. Lawrence) and a steeper slope to the northeast disrupt its gradual plunge towards the Laurentian Channel.

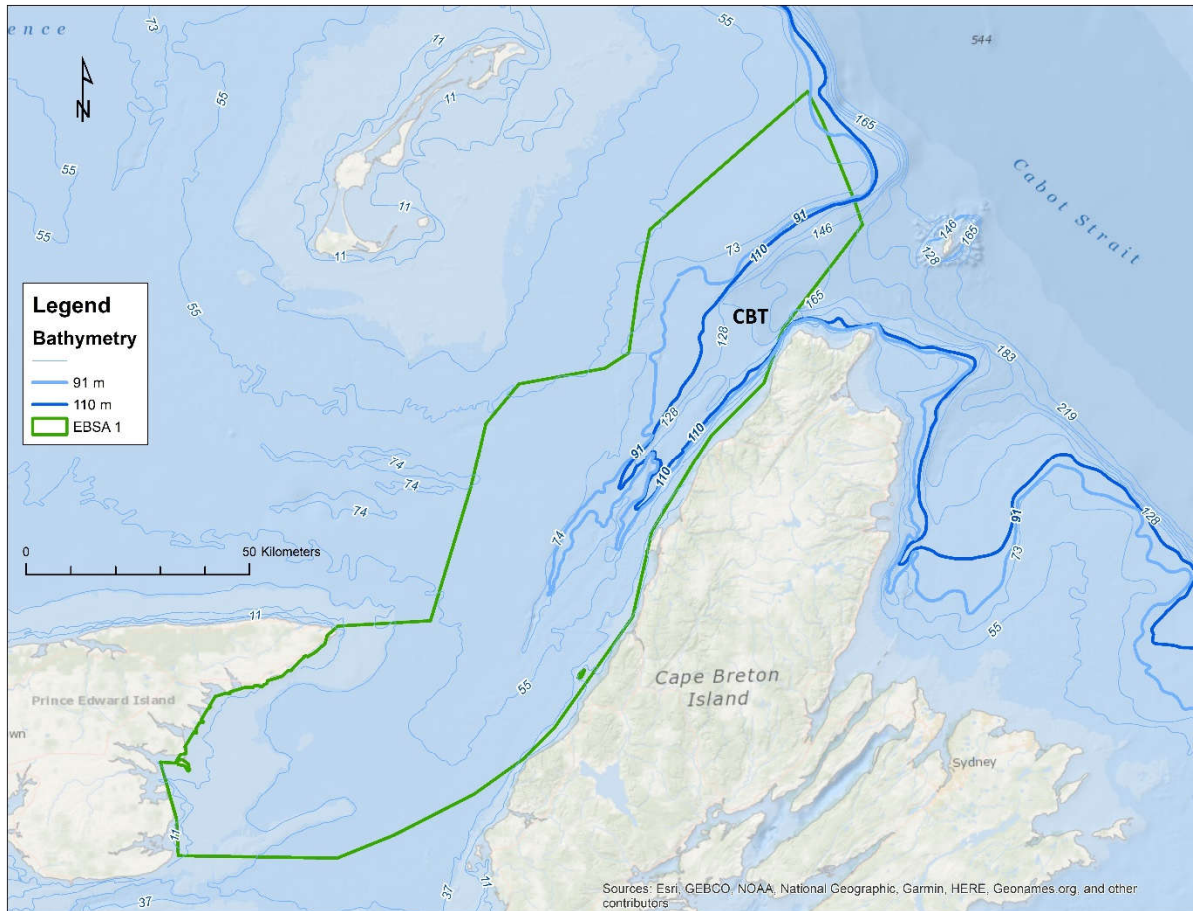


Figure 2. Bathymetry of the Cape Breton Trough.

GEOLOGY

Information on the geological characteristics of the CBT was taken from an extensive review of the morphology and sediments of the Gulf of St. Lawrence (GSL) conducted by Loring and Nota (1973). According to the review, the area comprising the trough is underlain by stratified bedrock of Permo-Carboniferous age resulting from the seaward extension of the Carboniferous lowlands of Nova Scotia (NS). These rocks are characterized by red sandstones and shales. The bedrock is covered in most places by a layer of unconsolidated sediments of varying thickness (2 to 70 m), comprising of 3 lithological units: glacial drift; sands (particles of 0.05 to 2 mm in diameter) and pelites (particles smaller than 0.05mm).

The surface sediment layer in the CBT consists mostly of extensive pelite deposits (very sandy pelite), which form an almost continuous cover on the slopes and between floor ridges that is broken by either the glacier drift or an irregular bedrock surface. These soft surface sediments contain up to 30% clay-size particles and as much as 40% very fine grained and well sorted material (less than 5 % over 0.12 mm). Most of these sand- and silt-size particles are between 0.02 and 0.1 mm. It is not unusual to find small amounts of gravel-size material resulting from ice-rafting within this pelite cover. The floor ridges of the trough are covered with a layer of glacial drift characterized by a rough hummocky surface (core samples have revealed the presence of a poorly sorted admixture of gravel, pelite, and coarse to medium-grained sands).

The minerals and rock fragments found within the drift originate mainly from the underlying bedrock.

PHYSICAL OCEANOGRAPHY

Water Circulation

To fully understand the water current patterns in the CBT, it is imperative to consider water circulation within the entire GSL, which, in a simplified context, can be described as follows: dense sea water enters through the eastern margin of the Cabot Strait (Newfoundland and Labrador (NL) side) in the Laurentian Channel at depths mostly > 200 m, as well as through the Strait of Belle Isle, and flows counterclockwise around the GSL to the head of the Laurentian Channel, where it mixes with surface waters as a result of tides and wind action. Water closer to the surface also displays a counterclockwise movement around the GSL, flowing northeastward along the coast of NL until it reaches the Strait of Belle Isle, where it partly mixes with intrusions from the strait. This flow continues westward along the north shore of the GSL, reaches the St. Lawrence Estuary (SLE) where it merges with freshwater from the St. Lawrence River, consequently forming the Gaspé Current, which flushes the Magdalen Shallows, flows along the western coast of Cape Breton Island, and finally, exits through the western margin of the Cabot Strait (NS side).

A focus on the water circulation within the CBT reveals the following: an eastward coastal jet crossing the Magdalen Shallows along the north shore of Prince Edward Island (PEI) veers southward once it reaches the eastern end of the island and merges with an eastward flow crossing the Northumberland Strait, consequently forming a northeastward coastal current along the west coast of Cape Breton (Chassé 2001). This current, known as the Cape Breton Current, flows around Cape North at speeds of 5 to 7 nautical miles per day, reaches Sydney (NS), and dissipates on the Scotian Shelf, off Scatarie Island. It is believed that the flow of the Cape Breton Current, combined with tidal action and the morphology of the CBT, generates a pumping mechanism that carries deep water closer to the surface layer. A portion of this “pumped” water has been observed to travel westward as far as the channel between Pictou Island, NS and PEI (Joel Chassé, DFO pers. comm.). The narrow passage between Cape North and St. Paul Island NS, located in the northeastern tip of the trough, restricts the flow originating from the Laurentian Channel and the western coast of Cape Breton, thus increasing the current velocity in this area (Galbraith *et al.* 2016; Saucier *et al.* 2003;).

Tidal Regime

Tides in the GSL enter through the Cabot Strait and the Strait of Belle Isle (albeit to a lesser extent) and progress around the Gulf in a counterclockwise direction (EC 2017). The tides in the CBT are mainly of the semi-diurnal type, and the tidal range is < 2.4 m (Dohler 2007; Chassé 2001).

Water Temperature and Salinity

Sea surface temperature (SST) in the CBT area typically reaches a maximum in early to mid-August (Galbraith *et al.* 2016), while sea surface salinity (SSS) is at a minimum due to the arrival of the spring runoff from the SLE (Chassé 2001). The mean SST in the summer (August) is ~16 to 18°C, while SSS is between 28 and 30 ‰ (Petrie 1996). The near-bottom water temperature ranges from ~1 to 5°C, reaching maximum values in the greater depths of the trough. Near-bottom salinity also increases with depth, varying between 32 to 35‰ (Chassé *et*

al. 2015; Petrie 1996). The water column is strongly stratified during the summer, with a thermocline sharply defined between 20 to 40 m depth (Chassé 2001).

In general, the water column in the deeper areas of the sGSL, such as the Cape Breton Trough, is divided into three layers in summer and early fall: 1) a thin, warm and relatively fresh surface layer; 2) a Cold Intermediate Layer (CIL) in the 30 to 150 m depth range; and, 3) a warm, relatively salty deep layer (Therrien *et al.* 2001; Gilbert and Pettigrew 1997). In the fall and early winter, gradual cooling of the surface layer and increased turbulent energy associated with strong wind events disrupt the water column stratification, leading to a progressively deeper and cooler surface mixed-layer that eventually merges with the CIL (Galbraith *et al.* 2016).

Consequently, the water column becomes a two-layer vertical structure (warmer water remains at the bottom). Reduced run-off and brine rejection associated with sea-ice formation also contribute to the deepening of the surface layer. In the spring, a new highly stratified surface layer is produced as a result of solar radiation, warming from the atmosphere, sea-ice melt waters and increased runoff from continental snow melt. The cold winter waters that become trapped below this lower-salinity, higher temperature surface layer eventually form the summer CIL.

Dissolved Oxygen

Data on the concentration of dissolved oxygen (DO) near the seafloor of the sGSL has been collected yearly since 1971 during the September DFO research vessel (RV) survey. Results from stations located within the CBT show DO concentrations of over 60% saturation but below 80%, with the exception of the northern portion, which shows a lower saturation level (> 40%), coinciding with the deeper areas (Benoît *et al.* 2012).

Nutrients

Given the lack of information on the distribution and concentrations of primary nutrients in the waters of the CBT, a review of information pertaining to the GSL is provided (taken from Yeats 1988).

The major nutrient constituents of ocean water are nitrate (NO_3^-), phosphate (predominantly HPO_4^{2-}), and silicate (predominantly $\text{Si}(\text{OH})_4$). Scarcity of these three nutrients, particularly the first two, can have detrimental effects on the growth of primary producers. In the temperate waters of the GSL, the lowest levels of nutrients are observed in surface waters during the summer months, as a result of spring phytoplankton blooms and the formation of a highly stratified water column. A subsequent release of nutrients in the intermediate and deeper water layers occurs as decaying material (plant and animal debris) sinks to the seafloor.

Consequently, nutrient levels increase relatively quickly with depth, and thus, tend to build up in subsurface waters. High levels of nitrate and phosphate are found in the 75 to 150 m depth range, and while their concentrations continue to rise with depth, the increase is much more gradual beyond this range. Silicate levels also increase with depth, although they do so in a much more uniform manner. Increasing concentrations of all three nutrients in the surface layer occur throughout the fall and winter as mixing processes disrupt the stratified structure of the water column and bring nutrient-rich waters to the surface. Other mechanisms responsible for the upward transport of nutrients include intense tidal mixing between freshwater and saltwater masses and current/wind-induced upwelling (Yeats 1988).

The highest nutrient concentrations (particularly nitrates) within the GSL are in the upper SLE, where input from the St. Lawrence River and entrainment of subsurface waters add nutrients to the surface layer (Yeats 1988), and a general decrease occurs from the SLE to the Cabot Strait (DFO 2005; White and Johns 1997). As a result, relatively low nutrient levels are characteristic

of the Magdalen Shallows on the eastern side of the sGSL. However, given the greater depths of the CBT, it might be expected that subsurface waters in this area are richer in nutrients compared to shallower areas of the Magdalen Shallows.

Sea-Ice Cover

Sea-ice formation in the GSL exhibits large inter-annual variations, with some winters showing heavy ice coverage and thickness (> 2m), while others are almost ice-free (Benoît *et al.* 2012). Ice begins to form in December in the SLE and shallower regions of the Gulf and extends to the Cabot Strait by March; as a result, the CBT area is typically ice-covered by mid-February (EC 2017). Sea-ice is generally present until the second week of April, although ice has been observed around Cape Breton Island at the end of April (Chassé 2001; EC 2017). Declining trends in ice cover severity have been observed in the GSL since 1990, with a few rebounds in 2003, 2014 and 2015 (Galbraith *et al.* 2016).

BIOLOGICAL SYSTEM

PLANKTON

Phytoplankton

Analyses conducted as part of the identification of Ecologically and Biologically Significant Areas in the GSL have revealed the occurrence of strong phytoplanktonic productivity in the northern portion of the CBT, and have highlighted the importance of its oceanographic processes and physical features to primary production (DFO 2007; Lavoie *et al.* 2007). As specific data on the phytoplankton community composition in the CBT remains unavailable, general information pertaining to the GSL (and more specifically to the sGSL/Magdalen Shallows, when possible) is provided.

The level of primary production in any given marine environment is dependent upon nutrient availability, light intensity and water temperature. Consequently, physical processes, such as cloud cover, sea-ice cover, tidal mixing, density-driven circulation and wind-induced coastal upwelling, will not only govern the maximum potential level of phytoplankton productivity, they will also determine its spatiotemporal distribution (Lefouest *et al.* 2003). The complex environment of the GSL is a primary example of a system exhibiting strong subregional heterogeneity in phytoplankton abundance due to differences in oceanographic conditions. Furthermore, the temporal variability of the various physical processes leads to seasonal and interannual differences in both magnitude and timing of phytoplankton blooms (Dufour and Ouellet 2007; Mei *et al.* 2010). In general, a peak bloom is observed in the spring when light intensity increases and the relentless winter mixing of the water column subsides. As summer stratification progresses in the euphotic zone, nutrients are quickly depleted, leading to a rapid decline in phytoplankton production. Subsequent peaks can be observed later in the summer, as was the case for the Magdalen Shallows in 2014, where the peak value in July almost reached the spring (late April) value (Devine *et al.* 2015). Fall blooms often occur in the GSL in response to increased mixing within the water column (i.e., breakdown of stratification), although they are generally lower in magnitude than spring blooms. This was observed in the Magdalen Shallows in 2014 when chlorophyll values, a proxy for phytoplankton biomass, increased again in September-October (Devine *et al.* 2015).

The phytoplankton community of the GSL is largely dominated in biomass by varying concentrations of diatoms and dinoflagellates/flagellates (Dufour and Ouellet 2007; Devine *et al.* 2015). Stratification of the water column strongly influences the composition of the community,

as diatoms are associated with a nutrient-rich well-mixed environment, while dinoflagellates/flagellates seem to thrive in a nutrient-poor stratified environment. Consequently, a seasonal succession of species that varies with the progressive depletion of nutrients is typically observed and can be summarized as follows: the abundance of some of the large, fast-growing diatoms characteristic of the spring bloom (e.g., *Thalassiora*, *Chaetoceros*) decreases as nutrients are depleted, whereas several important dinoflagellates (e.g., *Peridinium*, *Alexandrium*, *Ceratium*) that are better at surviving on low levels of nutrients, become numerically dominant. In the summer, diversity remains high, although, as mentioned previously, chlorophyll concentrations and productivity usually remain low, particularly in the shallow waters of the Magdalen Shallows. However, since 1998, there has been a tendency toward gradual but significant increases in near-surface chlorophyll concentrations in the Magdalen Shallows (and areas in the northwest GSL) that are driven by the late-summer/fall blooms (Devine *et al.* 2015).

In addition to influencing the magnitude and timing of blooms, changes in physical processes can also lead to changes in community composition. This phenomenon was observed in the GSL (Shediac Valley) in 2014, where warmer temperatures and stronger stratification of the water column in the summer were likely conducive to lower diatom abundances (compared to the long term average), while flagellates showed strong positive anomalies (Devine *et al.* 2015).

Zooplankton

Similar to primary production, results from analyses conducted as part of the identification of EBSAs within the GSL recognized the importance of the oceanographic processes and physical features of the CBT for secondary production (DFO 2006; Savenkoff *et al.* 2007). Available information suggests that the deeper valley waters of the trough present a marked potential for the accumulation of strong biomasses of mesozooplankton (< 1 mm) and macrozooplankton (DFO 2007; Plourde and McQuinn 2010). During the EBSA analyses, the waters along the west coast of Cape Breton Island were noted as important for meroplankton (fitness consequences dimension) and a strong aggregation potential for meroplankton within the trough was also reported (DFO 2007).

As in most northern temperate waters, the zooplankton community in the GSL is dominated by copepods. The composition and size characteristics of the copepod community in the sGSL differ from other areas of the Gulf as small species of mesozooplankton with rapid turnover rates tend to dominate during the summer-fall period (mainly the calanoids *Temora longicornis* and *Pseudocalanus spp.*) (Plourde and McQuinn 2010; Morissette *et al.* 2009; DFO 2001). Early developmental stages (C1-3) of *Calanus* species also form an important component of the mesozooplankton community. This group, typically observed in shallow and warm waters, is an essential part of invertebrate and fish larval diet. The larger-sized (>1 mm) mesozooplankton community of the GSL is dominated by copepod species of the genus *Calanus* (*C. finmarchicus*, *C. hyperboreus* and *C. glacialis*) (Plourde and McQuinn 2010; Plourde *et al.* 2014). *C. finmarchicus* is a key zooplankton species of the open Gulf, especially in the deeper waters (Dufour and Ouellet 2007). In general, *Calanus* species are transported to shallower areas (depth <100 m), such as the sGSL, from their deeper (>100 m) overwintering habitat during their active growth period in spring and early summer (Plourde *et al.* 2014). The species forming the larger mesozooplankton community of the GSL represent important prey for juvenile and adult stages of pelagic fish species (e.g., sandlance, capelin, herring, mackerel), as well as some species of marine birds and mammals (e.g., North Atlantic right whale) (Plourde and McQuinn 2010). The macrozooplankton community (non-copepod zooplankton >5 mm) is largely dominated by euphausiids (krill) and mysids, but also includes amphipods, chaetognaths and various gelatinous organisms (Plourde and McQuinn 2010). Recent studies have reported a

high biomass of krill in the CBT, with *Thysanoessa raschii* suggested as the dominant species in this region (Plourde *et al.* 2016; McQuinn *et al.* 2015;). The Magdalen Shallows appear to be a nursery area for the euphausiids *Meganyctiphanes* and *Thysanoessa*, which mature in deeper, colder waters of the GSL (Dufour and Ouellet 2007). In the sGSL, jellyfish, namely *Cyanea capillata* and *Aurelia aurita*, can occur in large, near-surface swarms that form an important component of the summer community (Dufour and Ouellet 2007). In a study conducted in St. Georges Bay NS (southwestern shore of Cape Breton), jellyfish preyed on a variety of meroplankton species, including gastropod, crustacean and bivalve larvae (Short *et al.* 2013). A review of zooplankton species inhabiting the coastal waters of Cape Breton Island highlighted the presence of the mysids *Erythrops erythrophthalma*, *Pseudomma truncatum* and *Meterothrips robusta* in the troughs of the sGSL, including the CBT (Locke 2002). Organisms within the macrozooplankton group, particularly krill, are key prey to several species of pelagic fish, as well as marine birds and mammals (Plourde and McQuinn 2010).

Nozères *et al.* (2015) reported a greater diversity in the zooplankton community of the CBT compared to adjacent waters of the sGSL. This is likely associated with the bathymetric features of the trough, as greater depths provide various habitats with different environmental conditions that should support different species of zooplankton (Stéphane Plourde, DFO pers.comm.). In a study looking at zooplankton data collected from various DFO spatial surveys (1982-2012), the CBT was highlighted as an area of recurrent high *Calanus* biomass, with a relatively high average biomass in June and less interannual variability compared to other areas of the sGSL (DFO 2016).

Zooplankton biomass within the sGSL is characterized by large seasonal and interannual variability as it is governed by both physical (e.g., temperature, circulation patterns, ocean currents) and biological (e.g., nutrient availability, growth, mortality/predation, life cycle traits) forcing (Plourde *et al.* 2014; Plourde and McQuinn 2010). A peak in biomass is observed in June in the sGSL, as a result of advection of large *Calanus* species (>1 mm) from upstream and deeper areas as well as local production (Stéphane Plourde, DFO pers.comm.). Biomass is greatly reduced later in the season. The seasonal variation in biomass is largely associated with the increased diversity of larval and immature forms of fish and invertebrates, which are characteristic of the summer zooplankton community (DFO 2001). Results from Plourde *et al.* (2014) demonstrate how variations in physical environmental conditions of the GSL can strongly influence zooplankton abundance, composition and phenology at different temporal scales. For instance, long term (20 years) warming of upper and deep waters combined with decreased ice coverage were shown to result in a reduction of cold/arctic copepod species, an increase in large-bodied and lipid-rich *C. hyperboreus* and smaller calanoids (e.g., *Pseudocalanus spp.*, *T. longicornis*), and, a change in the phenology of *Calanus* species. Macro-Invertebrates

Analyses performed as part of an exercise to determine EBSAs identified the CBT and its surrounding area as an Important Area (IA) for benthic invertebrates due to high aggregations of various taxa (Chabot *et al.* 2007). More specifically, the exercise described this IA as having “very significant” concentrations of species or aggregations that are “widespread” (brittle stars, *Ophiopholis aculeata*) and “very widespread” (e.g., starfish, basket stars, hermit crab), as well as “significant” concentrations (but less extensive in the area) of “very widespread” species (e.g., anemones, sponges, shortfin squid, lesser bobtail squid, sea urchins, striped pink shrimp, arctic argid shrimp, snow crab (*Chionoecetes opilio*)) or “widespread” species (e.g., sevenline shrimp, arctic eualid shrimp, Iceland scallop, sand dollar, ascidians).

According to the EBSA exercise, a few other species are worth mentioning for their relatively high densities either throughout or within a specific location of the CBT. Whelk, sea cucumbers, and toad crab are among the group distributed throughout the area, while spoonarm octopus and spiny crab form the group occupying a smaller range. The highest concentrations of

spoonarm octopus in the GSL occur near the Cabot Strait on the southern side of the Laurentian Channel (i.e., where the CBT connects to the channel). Spiny crab, which are particularly fond of muddy bottoms, also show highest numbers in the deeper portion of the CBT, as they are mainly concentrated in the vicinity of the northern tip of Cape Breton Island, near the Cabot Strait. Northern shrimp have also been reported in the CBT, although numbers are not nearly as high as those observed in the northern GSL (nGSL), where the commercial fishery occurs.

Snow crab are located in deeper waters, generally inhabiting bottom depths of 20 to 420 m, although in the GSL, they are more abundant at depths between 70 and 140 m (Moriyasu *et al.* 2001). One of the main snow crab Fishing Areas (Area 19) corresponds very closely to the portion of the sGSL covered by the CBT (Appendix 1). Consequently, several studies have been conducted on the snow crab population occupying this area. Based on analyses of cod stomach contents, the CBT represents one of the main snow crab nurseries in the GSL (others are the west coast of NL, American Bank, and Shediac Valley) (Chabot *et al.* 2007). In the sGSL, nurseries are associated with depths of approximately 40 to 80 m and 130 to 170 m, and temperatures ranging from -0.5 to 3°C (Chabot *et al.* 2007). Furthermore, a study looking at data obtained from the annual DFO RV survey revealed unusually high numbers of small crab (≤ 15 mm) in several areas of the sGSL, including the CBT (Benoît and Cardigan 2016). This is seemingly part of a general increase in small crab abundance in the sGSL since the early 2000s. Finally, an increase in the mean catch per unit effort of commercial crab (male with carapace width ≥ 95 mm) was reported in Area 19 between 2010 and 2015, with high values being mostly observed in this area (Hébert *et al.* 2016). The occurrence of marked densities of commercial-sized snow crab reflects the presence of optimal habitat conditions for this species.

A study on the distribution of sea pens, sponges, stalked tunicates and soft corals within the GSL was recently conducted to assist with the identification of significant benthic areas (Murillo *et al.* 2016). Data available for analysis was collected over a period of 13 to 15 years, between 2001 and 2015. All taxa were observed within the CBT, although results are variable in terms of presence and mean biomass (kg per grid cell). Sea pens were predominant in the nGSL, with the highest mean biomass (up to ~130 kg/grid cell) observed mainly along the Laurentian Channel, while presence in the area of the CBT was mostly limited to the northern portion, with a mean biomass of less than 9 kg/grid cell. Distribution and biomass of sponges and a soft coral (sea cauliflower, *Gersemia rubiformis*) within the CBT were generally similar to those observed throughout the sGSL, with a presence across the entire region, and mean biomass values reaching up to ~71 kg/grid cell (but mainly <12 kg/grid cell) and 0.74 kg/grid cell, respectively. The sea potato (stalked tunicate, *Boltenia ovifera*) was observed throughout the sGSL, including the CBT, where mean biomass was mostly under 7 kg/grid cell with a maximum of ~91 kg/grid cell.

FISH

The waters of the southern Gulf support several species of diadromous and marine fish species that are mostly seasonal residents occupying the area for multiple biological functions (e.g., feeding, spawning, migration, refugia). A study aiming at identifying Important Areas based on fish and invertebrate species in coastal waters of the sGSL highlighted the significance of the CBT as a migration corridor (spring and fall) for several fish species (Rondeau *et al.* 2016). This migration route appears to be between summer feeding and spawning grounds within the sGSL and overwintering refuges located in deeper waters that are warmer than shallower waters in winter months. Figure 3 (adapted from Figure 18 in Rondeau *et al.* 2016) illustrates the migration corridor and the highly significant “choke point” between the northern tip of Cape Breton Island and St. Paul Island where most species are thought to pass to enter/exit the

sGSL. As shown, fishes presumably swim along the west coast of Cape Breton Island, between the shore and the edge of the Laurentian Channel. According to the study, species following this migration route include: American eel (*Anguilla rostrata*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), butterfish (*Peprilus triacanthus*), Atlantic saury (*Scomberesox saurus*), spiny dogfish (*Squalus acanthias*), Atlantic cod (*Gadus morhua*), Atlantic mackerel (*Scomber scombrus*), bluefin tuna (*Thunnus thynnus*) and white hake (*Urophycis tenuis*). Some of these species undergo long-distance migrations to overwinter well outside of the sGSL (e.g., alewife, blueback herring, American shad, Atlantic mackerel, bluefin tuna, spiny dogfish), while others migrate into warmer deep waters of the Laurentian Channel or along its slopes, including the Cabot Strait area (e.g., Atlantic herring, Atlantic cod, white hake). Migration into and out of the sGSL occurs predominantly during the months of May to November (Dufour and Ouellet 2007).

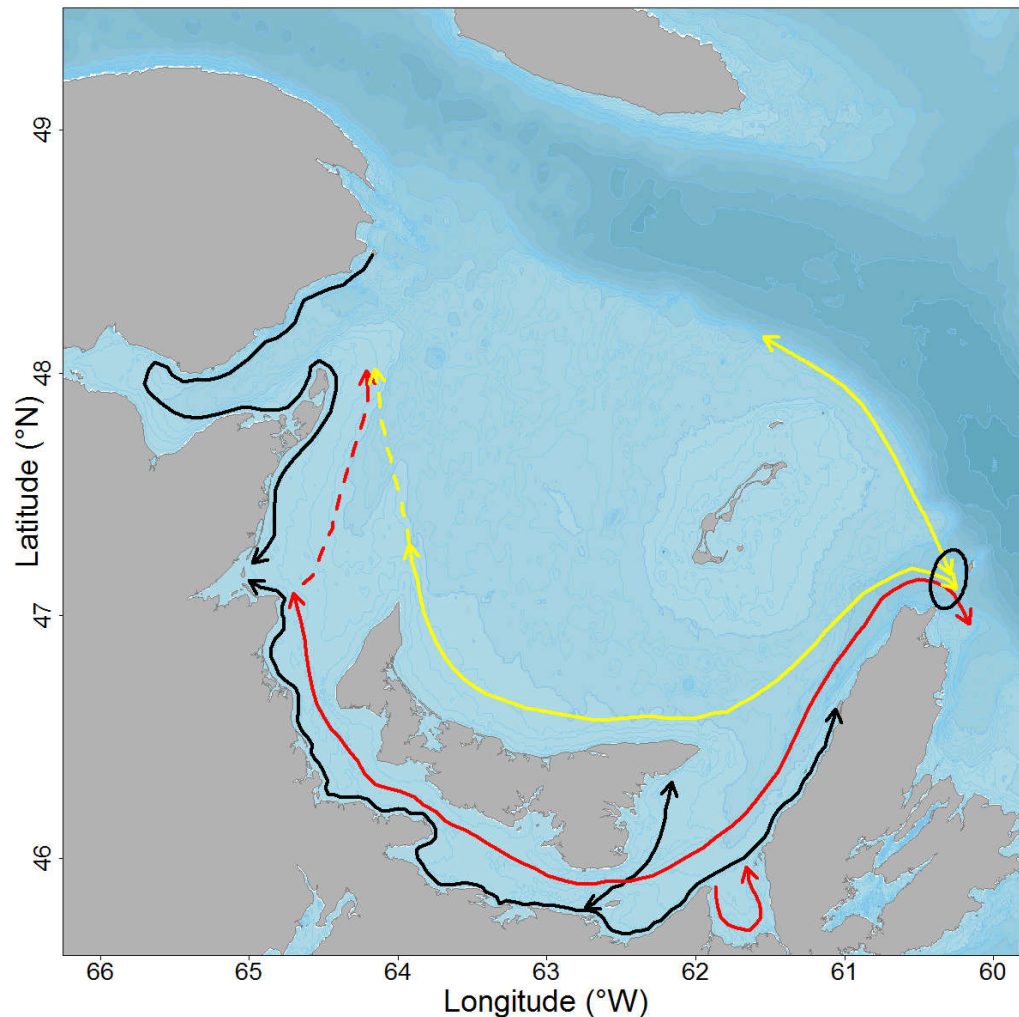


Figure 3. Major known (solid lines) and possible (dashed lines) migration corridors for striped bass (black) and long distance migrants (red and yellow) with the most important route for anadromous species shown in red. The choke point through which most migratory species presumably pass to exit the Gulf of St. Lawrence (southern route) is indicated by a dark black ellipse between the tip of Cape Breton and St. Paul Island. NB. Striped bass migrate very close to shore, usually within several hundred meters, but this could not be shown to scale. (adapted, by Daniel Ricard DFO Gulf Region, from Figure 18 in Rondeau et al. 2016).

Analyses conducted as part of an exercise to establish ecologically and biologically significant habitat for small pelagic fishes within the GSL revealed that the CBT is of particular importance for a number of species (McQuinn *et al.* 2012). Specifically, the CBT was confirmed to be a fundamental summer feeding ground for adult Atlantic herring, capelin and silver hake.

The importance of the CBT to various fish species was also emphasized during an analysis aiming at identifying EBSAs specific to demersal fishes in the southern Gulf (Swain and Benoît 2007). The analysis focused on a subset of commercially-fished species (e.g., Atlantic cod, white hake, American plaice (*Hippoglossoides platessoides*)), species at risk (e.g., northern wolffish (*Anarhichas denticulatus*), Atlantic wolffish (*Anarhichas lupus*), thorny skate (*Amblyraja radiata*)) and species regularly caught in the annual DFO September RV survey, but having limited distribution (e.g., haddock (*Melanogrammus aeglefinus*), fourbeard rockling (*Enchelyopus cimbrius*), cunner (*Tautoglabrus adspersus*)). The CBT was identified as one of seven EBSAs specific to demersal fishes in the sGSL because of its importance as: 1) a migration corridor for cod and other species (e.g., white hake); 2) summer grounds for witch flounder and white hake; and, 3) an area of high biodiversity. Juvenile and adult witch flounder typically occur in the deep waters of the channels in the northern Gulf in the winter, with adults moving to feeding grounds in shallower waters (100 to 200 m) in the summer. It was noted that the CBT represents their principle feeding grounds in the sGSL, containing most of the adults that move into this area in the summer. Highest concentrations of the deepwater stock component of white hake in the sGSL were also reported to occur in the trough in summer and early fall. In regards to fish diversity, the analysis revealed relatively high demersal biomass and diversity during the summer and early fall feeding season. Species at risk observed in the area of the CBT included thorny and smooth skates (*Malacoraja senta*), both listed as *Special Concern* by COSEWIC, and Atlantic wolffish, listed as *Special Concern* under the *Species at Risk Act* (SARA). Northern and Spotted wolffish (*Anarhichas minor*) (both Threatened under SARA) were not considered in the identification of EBSAs because they were infrequently observed in the RV survey. Both species are relatively rare in the GSL, particularly in the southern portion (DFO 2015a), as they tend to occupy deeper waters (Kulka *et al.* 2007). As a result, Northern and Spotted wolffish will not be discussed further in this document. An updated version of results on demersal fish diversity from the RV survey presented in Swain and Benoît (2007) is shown in Figure 4. As illustrated, the area of the CBT has remained a “hotspot” for diversity of demersal fish species in the sGSL, particularly in recent years.

An analysis on the occurrence of fish eggs and larvae in the GSL and Estuary system proposed eight areas of ecological and biological significance (Ouellet 2007). The CBT consists of a relatively small portion of EBSA 5 (“Southern Gulf Area”) which includes most of the sGSL, with the exception of the central portion northwest of the Magdalen Islands. The review of available data pertaining to EBSA 5 revealed a great abundance of fish eggs and larvae of various species (e.g., Atlantic cod, winter flounder (*Pseudopleuronectes americanus*), American plaice, yellowtail flounder (*Limanda ferruginea*)). Additionally, the area was described as having the highest concentrations of eggs and larvae in the Gulf. Although specific details on the CBT are lacking, it was noted that witch flounder larvae appear to be present only off northern Cape Breton Island, while witch flounder eggs have been observed in the eastern portion of EBSA 5 (Appendix 1), offshore from Cape Breton. The analysis also mentioned the presence of cod and sandlance larvae off the Island’s northern shore.

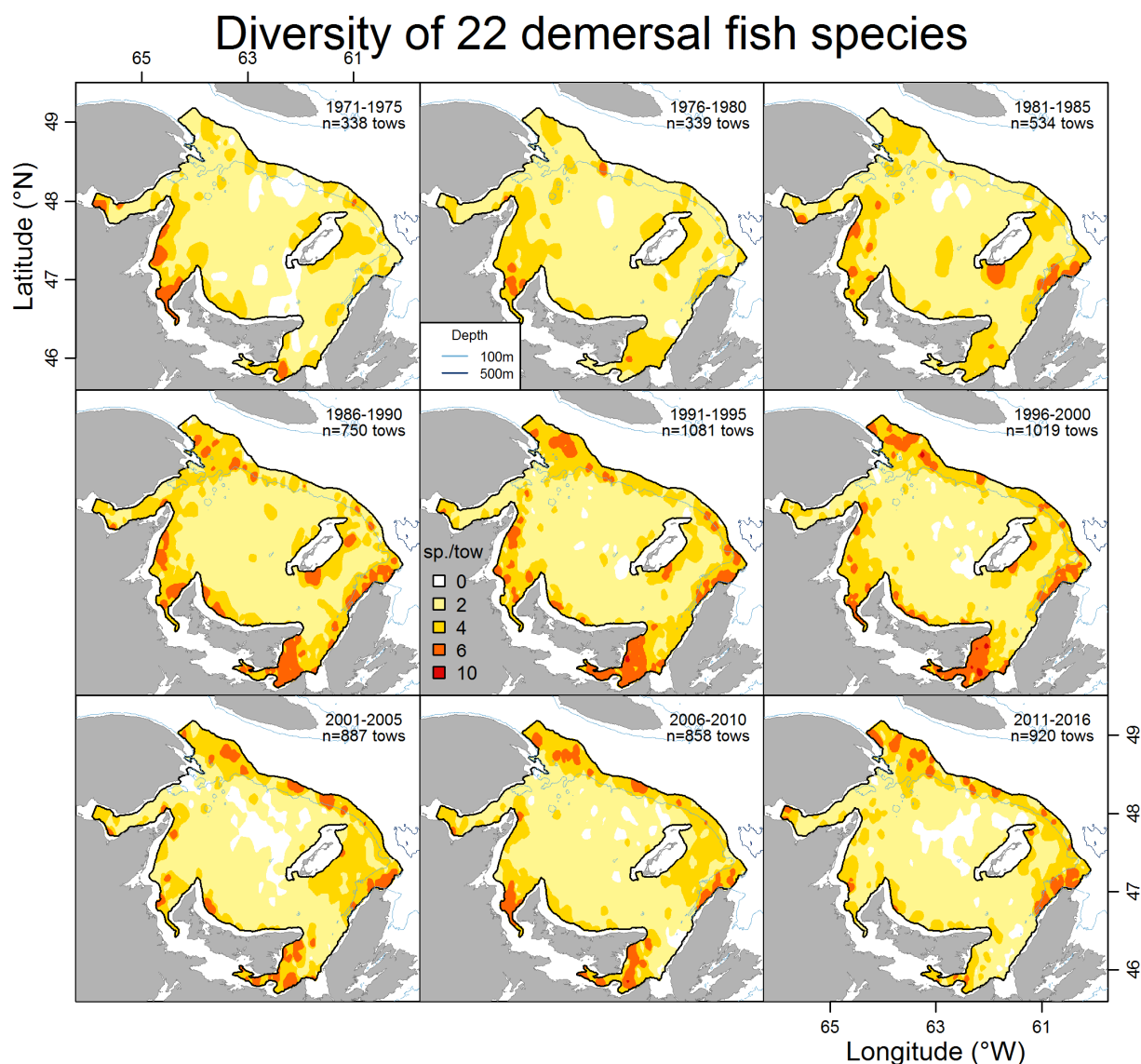


Figure 4. Demersal fish diversity (number of different species per tow) in the southern Gulf of St. Lawrence based on the annual DFO September RV survey (1971-2016). The number of different demersal species per trawl samples is shown for the 22 most commonly observed fish species (updated from Figure 18 in Swain and Benoît 2007).

As it would be beyond the scope of this overview to provide detailed descriptions of all fish species occurring in the CBT, nine species of special importance (i.e., designated under COSEWIC/listed under SARA) are discussed in the remaining portion of this section (TABLE 1). Eight species have been designated by COSEWIC: four species as Endangered (Atlantic bluefin tuna, Atlantic cod, white hake, and winter skate (*Leucoraja ocellata*); two species as Threatened (Acadian redfish and American plaice); and, two species as Special Concern (smooth skate and thorny skate), while Atlantic wolffish is listed as Special Concern under SARA.

Table 1 Fish species designated under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and listed under Species at Risk Act (SARA).

| Fish species | | COSEWIC | | | SARA | | Special Concern | Presence |
|-----------------------|-------------------------------------|------------|------------|-----------------|------------|------------|-----------------|----------|
| Common Name | Latin Name | Endangered | Threatened | Special Concern | Endangered | Threatened | Special Concern | CBT |
| Striped bass | <i>Morone saxatilis</i> | | | x | | | | x |
| Atlantic bluefin tuna | <i>Thunnus thynnus</i> | x | | | | | | x |
| Atlantic cod | <i>Gadus morhua</i> | x | | | | | | x |
| White hake | <i>Urophycis tenuis</i> | x | | | | | | x |
| Winter skate | <i>Leucoraja ocellata</i> | x | | | | | | x |
| American plaice | <i>Hippoglossoides platessoides</i> | | x | | | | | x |
| Smooth skate | <i>Malacoraja senta</i> | | | x | | | | x |
| Thorny skate | <i>Amblyraja radiata</i> | | | x | | | | x |
| Atlantic wolffish | <i>Anarhichas lupus</i> | | | x | | | x | Unknown |
| Northern wolffish | <i>Anarhichas denticulatus</i> | | | | | x | | Unknown |
| Spotted wolffish | <i>Anarhichas minor</i> | | | | | x | | Unknown |
| Acadian redfish | <i>Sebastes fasciatus</i> | | x | | | | | Unknown |
| Porbeagle shark | <i>Lamna nasus</i> | x | | | | | | Unknown |
| Basking shark | <i>Cetorhinus maximus</i> | | | x | | | | Unknown |
| Shortfin mako shark | <i>Isurus oxyrinchus</i> | | | x | | | | x |
| Spiny dogfish shark | <i>Squalus acanthias</i> | | | x | | | | x |
| Great white shark | <i>Carcharodon carcharias</i> | x | | | x | | | Unknown |

Atlantic Bluefin Tuna (pelagic)

In May 2011, the Atlantic bluefin tuna (*Thunnus thynnus*) in Canada was determined to be Endangered by COSEWIC. This designation was the result of the occurrence of lowest observed abundance of spawning individuals and the significant decline (69%) in abundance of spawning fish over the past 2.7 generations (COSEWIC 2011).

Bluefin tuna are widely distributed in both the Atlantic and Pacific Oceans. In the western Atlantic, their range extends from Newfoundland to the Caribbean, Venezuela and Brazil. Results from electronic tagging studies have indicated movement patterns that vary considerably between individuals, years and areas (Anon 2011). In Canadian waters, occurrences are reported in the Bay of Fundy, in Georges Bank, along the Scotian Shelf, in the Gulf of St Lawrence, and in the Grand Banks off Newfoundland, extending from coastal waters to the boundary of Canada's Exclusive Economic Zone (DFO 2011a). According to tagging studies, Atlantic bluefin tuna tolerate a wide range of temperatures (3 to 30°C) and are not limited to surface/subsurface waters as collected data reveal diving depths of 500 to 1000 m (Rooker *et al.* 2008; Block *et al.* 2009). Fish migrate to feeding grounds in Canadian waters from southerly latitudes between July and December (Maguire and Lester 2012). As mentioned previously, evidence suggests that the CBT is part of their migration route to and from important summer foraging habitat in the sGSL. While no specific habitat requirements have been defined for this species, migration and aggregation characteristics have been linked to oceanographic fronts and distribution of prey (Fromentin and Powers 2005; Rooker *et al.* 2007), with the latter having shown a higher explanatory value (Schick and Lutcavage 2009).

The bluefin tuna is a large pelagic species (> 300 cm, Cort *et al.* 2013) that is rarely captured during RV surveys conducted by DFO, and thus specific information on the population occurring in the sGSL is lacking. However, feeding aggregations within the area can be inferred from reported commercial fisheries data. According to reported landings, the largest number of bluefin tuna occurs along the north coast of PEI, at the eastern end of the Northumberland Strait, and within the Shediac Valley, where they feed actively (Rondeau *et al.* 2016). The fishing season for bluefin tuna in Canada generally occurs from July to November, coinciding with the migratory pattern of the species.

Bluefin tuna are opportunistic predators. Observations on the northwestern Atlantic shelf have revealed a diet of high-lipid content prey, consisting mostly of Atlantic herring, Atlantic mackerel, saury, and capelin, but also squid, sandlance, haddock, krill, whiting, butterfish, and spiny dogfish (Chase 2002; Estrada *et al.* 2005; Logan *et al.* 2011). In Canadian waters, herring and mackerel are believed to be the primary prey (Wilson *et al.* 2010; Hanke *et al.* 2015). Other prey include hagfish, jellyfish, salps, octopus, crabs, lobster, and sponges (ICCAT 2008, Hanke *et al.* 2015). Reported predators of bluefin tuna include killer whales (*Orcinus orca*), pilot whales and mako sharks (Scott and Scott 1988).

In 2011, COSEWIC identified overfishing (historical and present-day) as the single largest threat to the western population of Atlantic bluefin tuna, while fisheries on forage species in Atlantic Canadian waters were identified as a potential threat. Anthropogenic noises such as those related to seismic activity, underwater explosions, naval sonar operations, and shipping also have the potential to cause harm to bluefin tuna. Increases in oil and gas development and seismic testing in the Gulf of St Lawrence could lead to serious threats to bluefin tuna and their prey as associated noises may have detrimental effects on fish behaviour and physiology (McCauley *et al.* 2003; Weilgart 2007). Potential threats to habitat occupied by this species include marine pollution (COSEWIC 2011) as well as climate change (DFO 2011a).

Atlantic Cod (demersal)

The Maritimes Designatable Unit (DU) of Atlantic cod (*Gadus morhua*) was designated Special Concern under COSEWIC in May 2003. At the time of the assessment, the southern Gulf stock was part of this DU. In April 2010, COSEWIC re-assessed Atlantic cod and split the previous Maritimes DU into two populations – the Laurentian South DU and the Southern DU. The Laurentian South DU, which includes the sGSL cod stock, was designated Endangered, a higher risk category than *Special Concern*, due to a 90% decline in abundance over three generations (COSEWIC 2010a).

The distribution of Atlantic cod in the Laurentian South DU extends from the sGSL to the eastern Scotian Shelf (COSEWIC 2010a). As mentioned previously, the sGSL stock exhibits seasonal movements between summer and winter grounds. Cod from this population overwinter in dense aggregations covering a relatively small area in the warm deeper waters along the southern slope of the Laurentian Channel in the sGSL and the neighbouring Cabot Strait/St. Paul Island area (Swain and Benoit 2007). During this time, the fish feeding activity decreases and their declining condition makes them particularly susceptible to perturbation. In mid-April, the stock begins its migration into the southern Gulf to spawn and feed, returning to the overwintering grounds in November. The CBT is the main route taken by sGSL cod during their migrations in and out of the southern Gulf. Consequently, the majority of this population funnels through the CBT in dense aggregations each spring and fall (Swain *et al.* 2015). Physical habitat associations are strongest at the juvenile stage (4 to 35 cm long) as this stage is the most habitat-dependent period in the life-cycle of Atlantic cod (DFO 2011b). Evidence suggests that structurally complex habitats, particularly in the form of vertical components (e.g., seafloor relief, vegetation, rocks, corals), are preferred by juveniles due to their utility as protection from predators (DFO 2011b; Gotceitas *et al.* 1995, 2011). Additionally, heterogeneous habitats can serve as important feeding grounds as they are typically occupied by a variety of small fish and invertebrates. Juvenile fish seemingly settle near the seafloor for up to 4 years in areas ranging from very shallow coastal waters (< 10 to 30 m) to moderately deep waters on offshore banks (50 to 150 m). Adult and sub-adult Atlantic cod are most widely distributed during the summer feeding season, occupying a range of depths, temperatures and bottom types. Individuals in the southern Gulf are generally observed at median temperatures that vary between about 1 and 3.5°C in summer and 5 and 6°C in winter, while depths occupied within the Magdalen Shallows during the summer generally range from 25 to 100 m, and those typical of overwintering grounds vary between 200 and 350 m (DFO 2011b).

In the portion of the Gulf covered by the CBT, two bottom-trawl surveys occur each year: the DFO RV survey in September (mentioned previously) and the August mobile sentinel (MS) survey initiated in 2003. Data from these surveys show a dramatic change in the geographic distribution of cod over the long term (DFO 2016a). As shown in Figure 5 (RV survey: 1971 to 2016), there has been a progressive shift in distribution, with fish moving out of inshore areas and into deeper water along the slope of the Laurentian Channel, including the northern portion of the CBT. This trend is also apparent in Figure 6 (MS survey: 2003 to 2016), although in this case, cod distribution covers a larger extent of the CBT. This shift into deeper offshore waters appears to be a response to increased risk of predation by grey seals, as cod are moving away from areas where this risk is now high (Swain *et al.* 2015). Substantial temporal declines in biomass (kg/tow) are also evident in Figure 5 and Figure 6. Biomass indices from the September RV survey and the August MS survey indicate that the stock is at or near a record-low level and continues to decline. Both indices have declined by 75 to 80% from the already low levels in the late 1980s and early 2000s (DFO 2016a).

According to available data, spawning of sGSL cod occurs from late April to early July in areas outside of the CBT (Shediac Valley and around the Magdalen Islands) (DFO 2016a).

The diet of Atlantic cod includes a wide array of prey species (Savenkoff *et al.* 2004). Juvenile fish have been reported to consume large zooplankton, shrimp, benthic invertebrates, capelin and small planktivorous pelagics (mainly Atlantic herring). The diet of adults consists mostly of small fish (primarily herring, American plaice and capelin), shrimp and large zooplankton. Changes in diet tend to occur gradually with increasing fish length. Southern Gulf cod of age 4+ generally represent fish ≥ 35 cm of length, the size at which they become more piscivorous. Reported predators of small cod include seals (grey, harp, harbor and hooded), larger cod and cetacea (mainly toothed whales, a group that includes dolphins, porpoises and whales that have teeth), whereas predators of larger cod consist mostly of seals (Savenkoff *et al.* 2006).

The directed fishery for sGSL cod has remained closed since 2009. A total allowable catch of 300 t has been provided to cover by-catch in other groundfish fisheries, a limited recreational fishery, for scientific purposes, and to cover negotiated Aboriginal food, social and ceremonial agreements (DFO 2016b).

The lack of recovery (and continued decline) of the sGSL cod stock, despite the closure of the directed fishery, has been associated to the extremely high natural mortality (M) of cod 5 years and older (DFO 2016a). Annual M for adult cod, which is considered normal at ~18%, has been increasing over the past 35 years and is now estimated to be 52 to 58% annually. A number of factors have been considered to explain the occurrence of high M (i.e., unreported catches, emigration, disease, increased predation, contaminants, and environmental conditions), but increased predation by grey seals, in particular, has been reported as being a major contributing factor (Swain *et al.* 2015). Grey seal abundance has escalated dramatically in the sGSL, an increase that coincides with increases in M of adult cod. Natural mortality of demersal juveniles, on the other hand, can increase significantly with the loss of habitat structure (DFO 2011b). Habitat alteration resulting from the disturbance of structural components (e.g., bottom relief, vegetation, rocks, corals) can have severe impacts on critical habitat functions relied upon by juveniles. Anthropogenic activities that pose a threat to habitat include: fishing activities, particularly those employing mobile bottom-contact gear; pollution; and activities associated with oil and gas development.

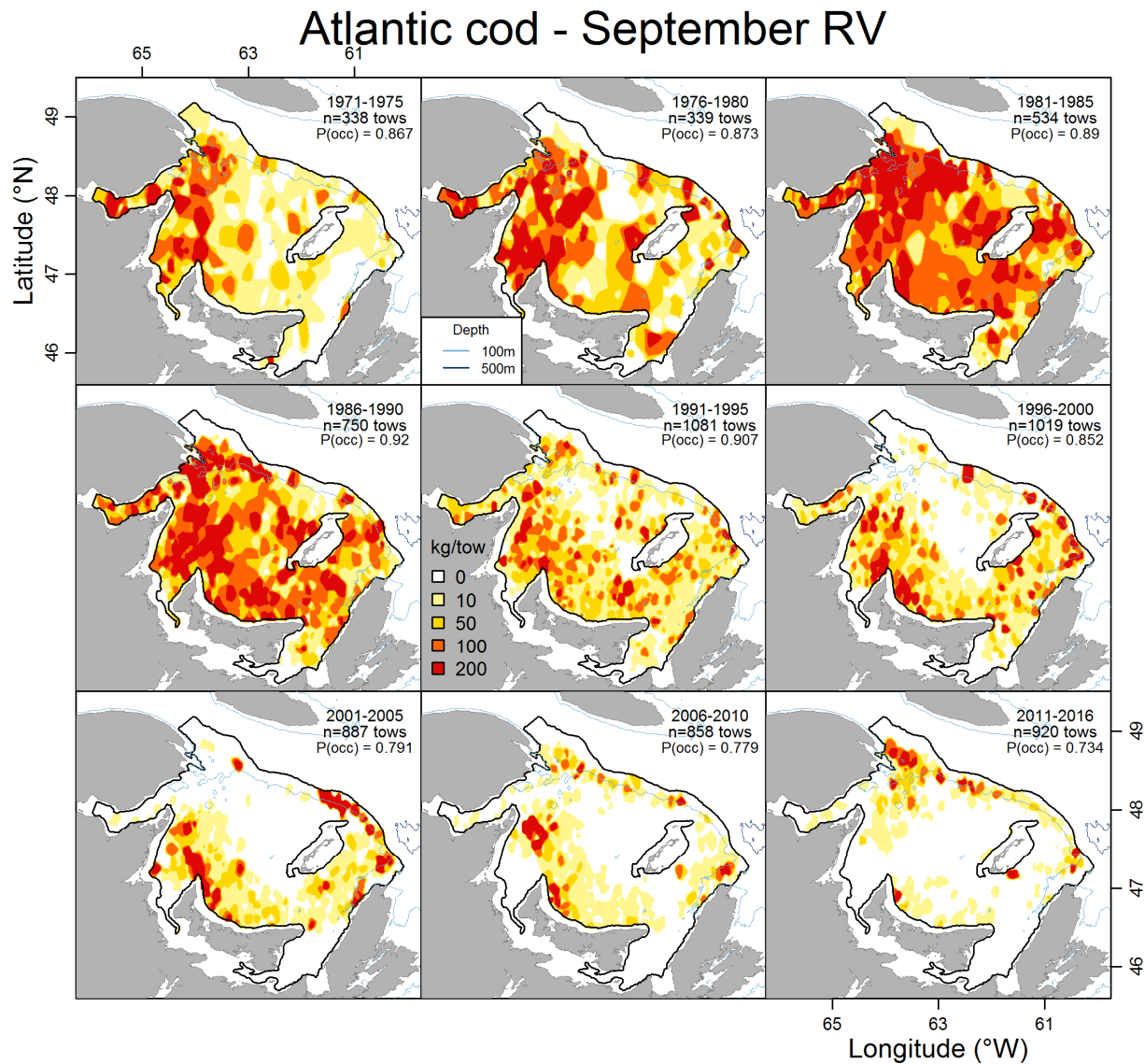


Figure 5. Changes in the distribution of cod in September over the past 46 years as indicated by the spatial distribution of biomass indices (kg per tow) by five year groups, 1971 to 2016 (with the exception of the 2011-2016 six year group). $P(occ)$ = Probability of occurrence and n = the number of trawl tows.

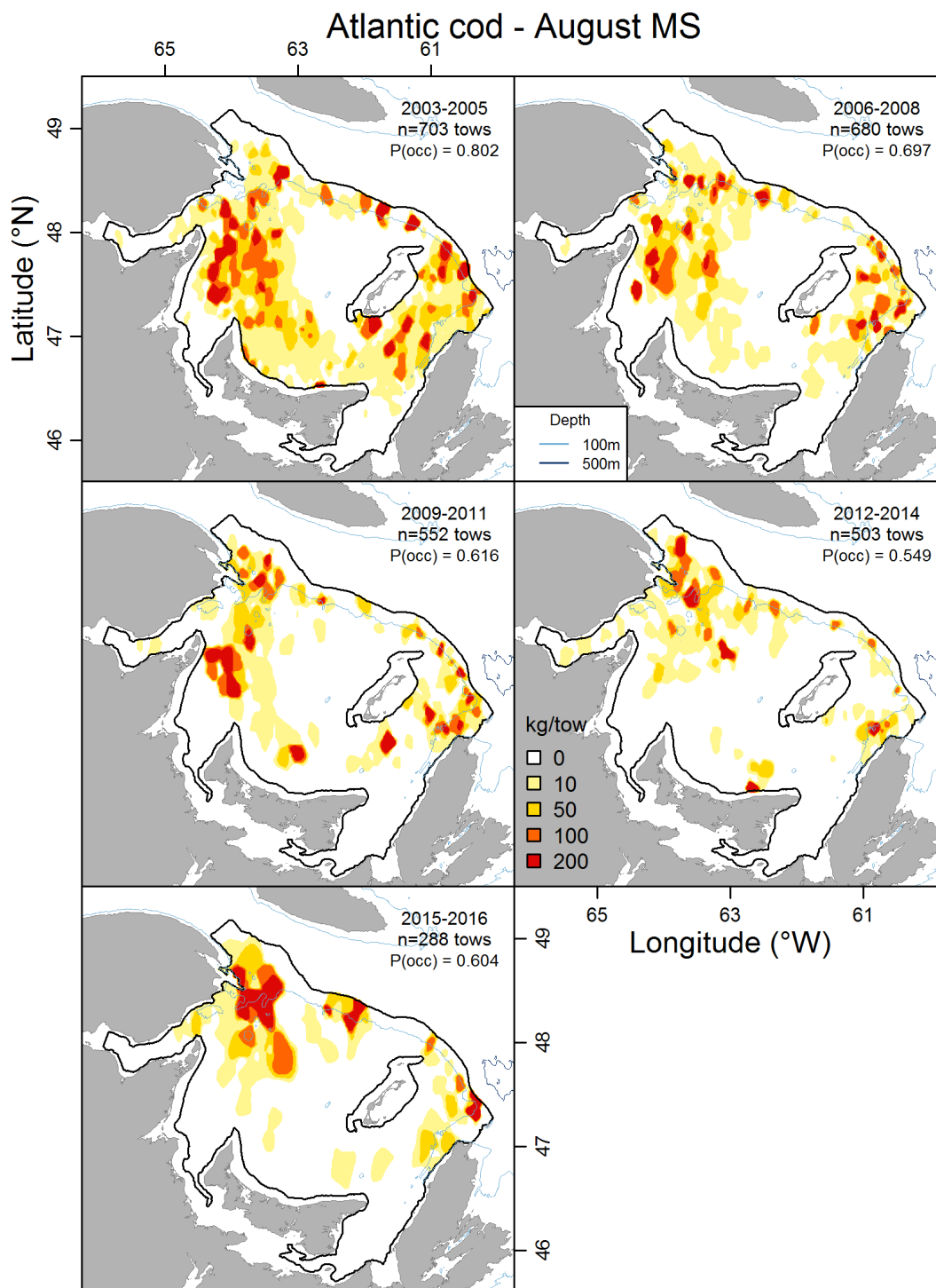


Figure 6. Changes in the distribution of cod in the August sentinel trawl surveys over the past fourteen years as indicated by the spatial distribution of biomass indices (kg per tow) by three year groups, 2003 to 2014 (with the exception of the 2015-2016 two year group). $P(occ)$ = Probability of occurrence and n = the number of trawl tows.

White Hake (demersal)

In November 2013, COSEWIC assessed the sGSL DU of white hake (*Urophycis tenuis*) as Endangered due to the significant overall decline (90%) over the past three generations (COSEWIC 2013a).

As mentioned previously, white hake in the sGSL exhibit seasonal migrations between summer feeding and spawning grounds in the sGSL and overwintering refuges in the Laurentian Channel. The migration to summer grounds begins in April/May and proceeds rapidly until June; while the return migration to overwintering grounds in the deeper waters (> 200 m) of the Laurentian Channel (including the Cabot Strait) takes place in November/December (Swain *et al.* 2016). White hake occurring in the southern Gulf in summer and early fall have historically exhibited a bimodal distribution with respect to depth, either inhabiting shallow (< 50 m) inshore waters along the Gulf coasts of NB, PEI, mainland NS and southwestern Cape Breton Island, or deep areas (> 100 m) along the slope of the Laurentian Channel and in the CBT. However, as illustrated in Figure 7, the proportion of white hake occurring in inshore areas in September has declined over time, with hake virtually absent from these areas in recent years. Inshore catches from the August MS survey (Figure 8), which started when hake were already rare in inshore areas, also show a near-absence by 2012-2013. In the 1970s, the highest proportion of white hake in September occurred at depths less than 50 m (68% adults; 44% juveniles; 58% of all sizes). Since the 2000s, less than 10% of hake have occurred in shallow waters (6% adults; 8% all sizes). The opposite is true for deeper areas (150 to 250 m), where the proportion of hake increased from 29% (1970s) to 67% (2000s) for adults, and from 45% to 65% for juveniles (Swain *et al.* 2016). The area occupied by adults has declined since the 1980s, from peak values near 25,000 km² in the early 1980s to approximately 5,000 km² in more recent years. The trend is different for juveniles, with the area occupied remaining relatively constant at values near 10,000 km², although a slight decrease has been observed in more recent years. Data from the RV survey (1971 to 2010) indicate that white hake have mainly occurred at temperatures between 4 and 6°C, showing an increased proportion in the 2000s (21% in the 1970s and 86% in the 2000s for adults; 27% to 73% for juveniles) that was accompanied by sharp declines in temperatures above 6°C (Swain *et al.* 2016). These changes in temperature associations reflect the shift in distribution from shallow inshore waters to deeper waters of the CBT and along the slope of the Laurentian Channel. There is a consistent presence of white hake in the CBT compared to other areas of the sGSL (Figures 7 and 8). Abundance and biomass indices from the RV survey show sharp declines for adults between 1985 and 1995, with continued declines throughout the remaining time series. In 2013, the estimated adult abundance showed a decline of 86.7% from the late 1970s and early 1980s, while the estimated adult biomass (SSB) exhibited a decline of 92.7%. In contrast, abundance and biomass indices for juvenile hake have fluctuated without trend throughout the time series (1971 to 2014). As a result, recruitment remains strong in this population despite very low spawning stock biomass (Swain *et al.* 2016).

Important inshore spawning grounds are located in the sGSL, most notably in St. Georges Bay and the Northumberland Strait, where spawning has historically occurred with a peak in June to September. In contrast, the deepwater stock of white hake is thought to spawn in late-winter/early spring in the Laurentian Channel. According to available data, white hake appear to be abandoning the inshore spawning grounds, a phenomenon that could lead to detrimental impacts on the productive potential of the stock. However, two scenarios remain possible: 1) they continue to spawn in these inshore areas in late spring or early summer and move to offshore feeding grounds by August; or 2) there is little to no spawning inshore, with the inshore juveniles produced by offshore spawning (Swain *et al.* 2016).

The diet of juvenile white hake consists mainly of shrimp, marine worms and small crustaceans, whereas adult hake consume shrimp, euphausiids and fish (e.g., herring, Atlantic cod, haddock, sandlance, winter flounder) (DFO 2010). A study on stomach samples of white hake from the sGSL revealed a relatively narrow diet and an abrupt ontogenetic diet change: fish < 35 cm total length (TL) consumed benthic invertebrates (mainly sevenspine bay shrimp, gammarid amphipods, or polychaetes), while fish \geq 35 cm TL were strongly piscivorous (Hanson 2011). In this latter group, Atlantic herring was the main prey species, while Atlantic mackerel represented an important part of white hake diet in individuals > 50 cm. Diet studies indicated that Atlantic cod were rarely consumed by white hake. Reported predators include seals, Atlantic cod and larger white hake (DFO 2010).

Several potential threats to white hake population recovery in the sGSL have been identified, including habitat suitability (e.g., temperature, depth), fishing mortality, offshore oil development and natural mortality (Swain *et al.* 2016). Given the broad distribution of waters suitable for white hake in the sGSL, and the negligible levels of fishing mortality since 2006 (directed fishery closed since 1995), the first two are not considered to be limiting for this population. Natural mortality (M) has increased to very high levels since 2000, averaging 87% annually for white hake aged 4 to 5 years and 78% annually for ages 6+. The high M of larger fish and the shift in distribution from inshore waters to deeper areas are thought to be the result of increased grey seal populations in the southern Gulf. Consequently, predation by grey seals is presumed to be the major factor preventing the recovery of sGSL white hake (Swain *et al.* 2016).

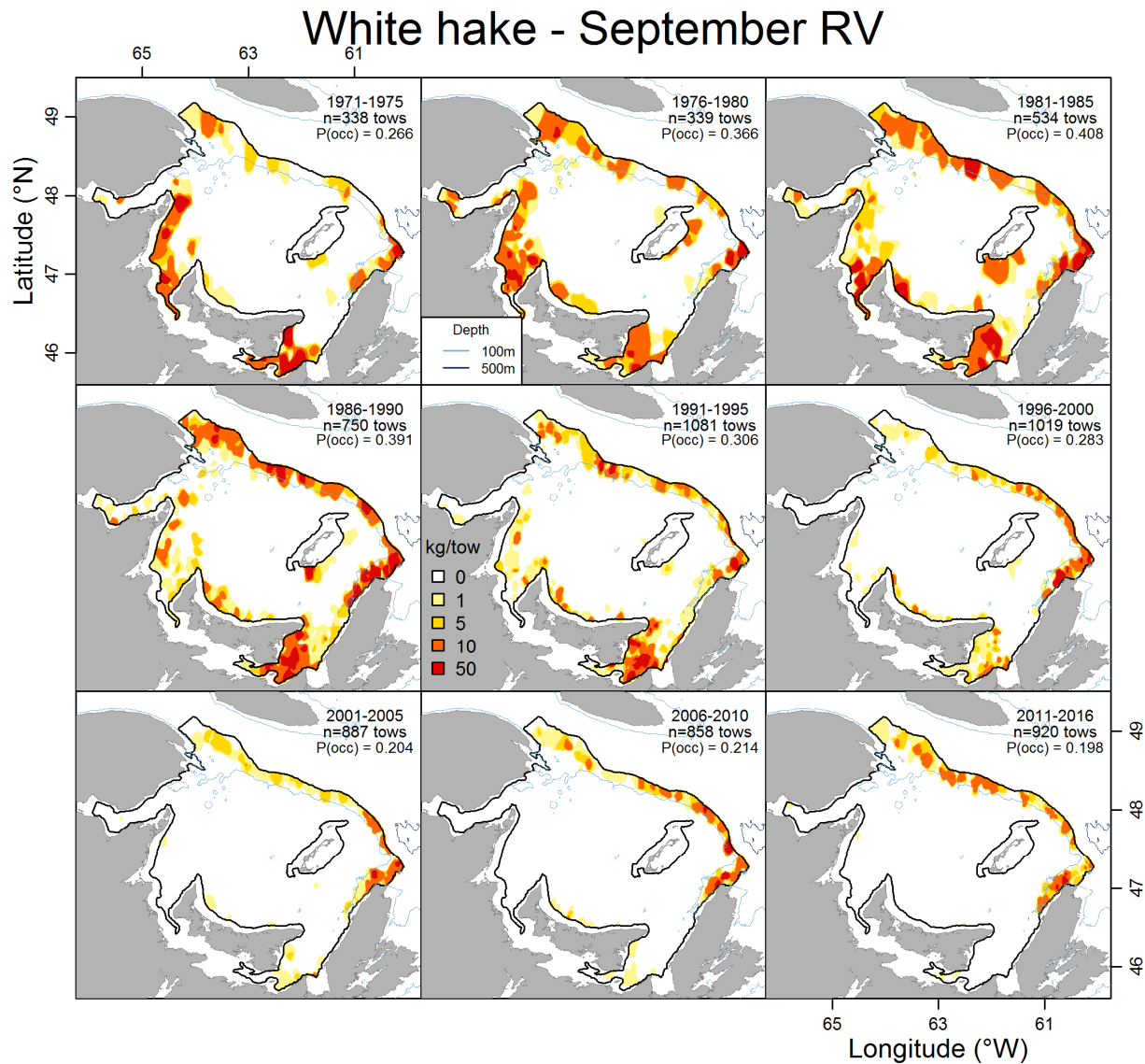


Figure 7. Changes in the distribution of white hake in September over the past 46 years as indicated by the spatial distribution of biomass indices (kg per tow) by five year groups, 1971 to 2016 (with the exception of the 2011-2016 six year group). $P(occ)$ = Probability of occurrence and n = the number of trawl tows.

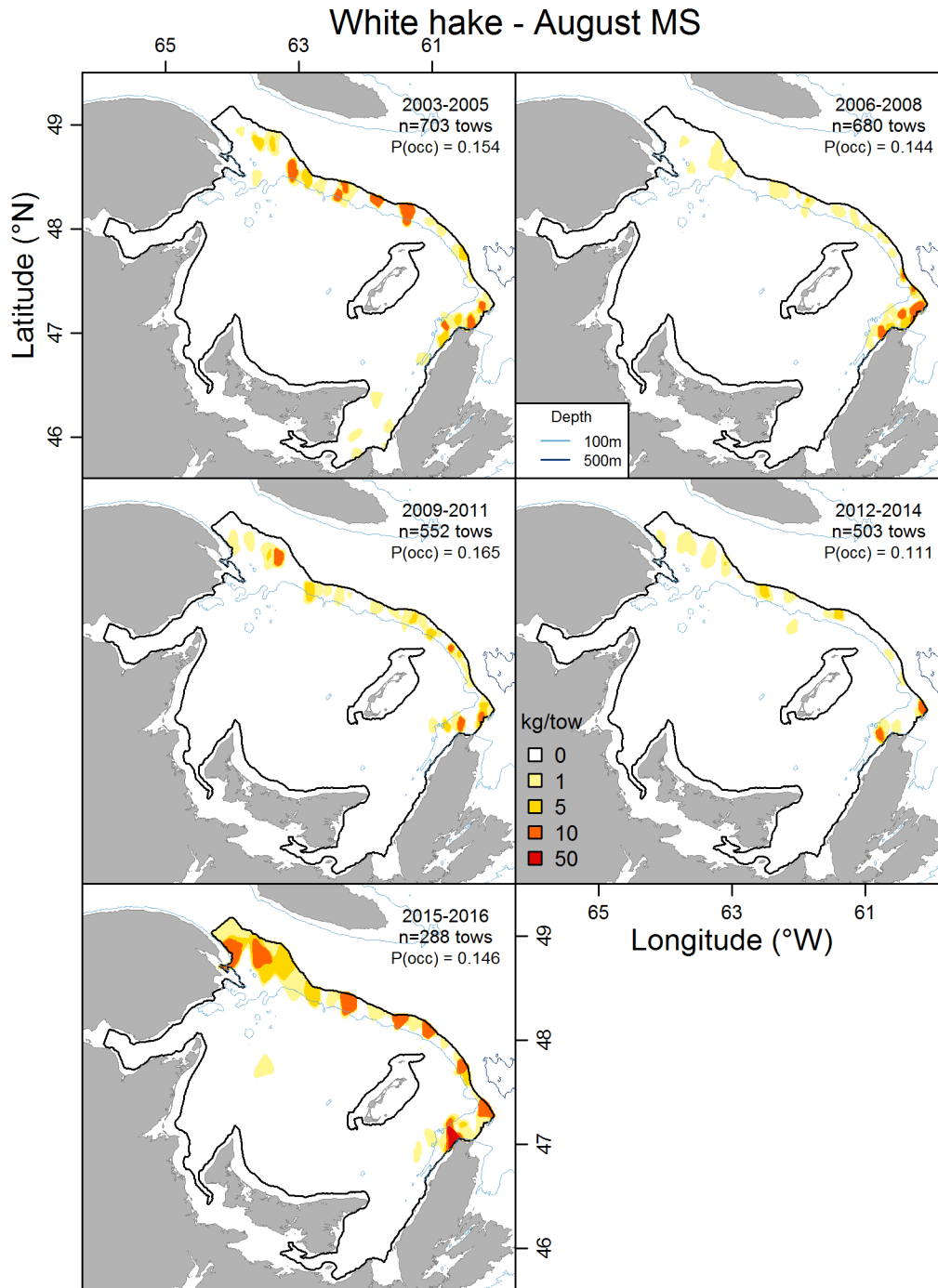


Figure 8. Changes in the distribution of white hake in the August sentinel trawl surveys over the past fourteen years as indicated by the spatial distribution of biomass indices (kg per tow) by three year groups, 2003 to 2016 (with the exception of the 2015-2016 two year group). Updated from Figure 28 in Swain et al. 2016. $P(occ)$ = Probability of occurrence and n = the number of trawl tows.

Winter Skate (demersal)

In May 2005, the sGSL DU of winter skate (*Leucoraja ocellata*) was assessed as Endangered by COSEWIC due to a substantial decline in the abundance of mature individuals (COSEWIC

2015). With a decline that was estimated at 98%, the population was considered at a historically low level. In its second assessment of winter skate in Canadian waters conducted in April 2015, COSEWIC revised the population structure of the GSL and created a new DU – the GSL population – which is composed of the former sGSL population and parts of the former Northern Gulf/Newfoundland population. This newly-formed DU was designated as Endangered due to a historical low in the abundance of mature individuals since the early 1980s (estimated decline of 99%). A severe reduction in range size was also reported (COSEWIC 2015).

The population of winter skate in the southern Gulf is endemic to this area and may represent a distinct species that remains undescribed (Benoît *et al.* 2011). In the summer and early fall, winter skate occur in shallow coastal waters where recorded median temperatures have been as high as 16.5°C (Northumberland Strait), but generally ~9°C for fish caught in the September RV survey (DFO 2017a). Reported median depths have varied between 12 and 32 m. Distribution maps (Figure 9) obtained from data collected during the annual RV surveys (1971 to 2016) illustrate the extent of their coverage area in September. In the 1970s and 1980s, winter skate were widely distributed in shallow (< 50 m) coastal waters of the sGSL, but a contraction in their geographic range began in the late 1980s (DFO 2017a). Catches were rare by the end of the time series (2011-2016), with minimal numbers caught in the area of Shediac Valley and along the western margin of PEI. Estimates indicate that habitat occupied by adults in the summer has declined by 94%. Analyses of data from the RV survey and the DFO Northumberland Strait bottom-trawl survey (conducted annually in late July/early August since 2000) suggest that the only important area where detectable winter skate are observed in the sGSL in the summer is the western portion of the central Northumberland Strait (DFO 2017a). According to data accumulated from the RV survey, the biomass index of all sizes combined has declined by an estimated 99% between 1980 and 2014 (35 years; 3 generations), whereas data from the Northumberland Strait survey have revealed a 78% decline over 15 years (2000 to 2014). Estimates of natural mortality have indicated a large increase in *M* of adults since the 1990s. According to population models, adult abundance in 2014 represented 3% of the average level in the 1970s (DFO 2017a). In contrast, juvenile *M* has fluctuated with no apparent trend. Recruitment rates of winter skate have also fluctuated without displaying a specific trend.

Although this species is presumably absent in the CBT in the summer/fall, there are indications of possible use as overwintering grounds. Adult winter skate migrate from shallow waters to deeper (40 to 200 m), warmer waters of the sGSL/Magdalen Shallows and along the slope of the Laurentian Channel in the winter (DFO 2017a). Analysis of bottom-trawl survey data conducted in the southeastern GSL between September 1986 and 1987 was performed to describe the seasonal distribution of various marine fish, including winter skate (Hurlbut and Benoît 2001). While data from this study are not recent, they do provide some insight on possible movements associated to overwintering migrations. According to results, winter skate were observed in shallow waters of the sGSL in September (1986 and 1987) and moved to deeper, warmer waters in December, when the densest concentrations occurred in the CBT and along the slope of the Laurentian Channel. In January, distribution was reduced as winter skate were mostly concentrated at the entrance of the trough, while a large sparse aggregation remained in shallow waters between PEI and Cape Breton Island. The return migration was evident in May, with most individuals settled within their summer grounds by June. It was reported that distributions of smaller and larger (≥ 50 cm) skates were similar.

The diet of winter skate varies with fish size, as larger individuals prey mostly on large rock crab, squid and fishes, including other small skates and American sandlance, while juveniles feed primarily on crustaceans (COSEWIC 2015). The consumption of annelid worms and razor clams has also been reported. Available information on winter skate predators, albeit limited, suggests that they are preyed upon by several species, including sharks, other skates (e.g., little

skate) and grey seals (COSEWIC 2015). The identification of predators and estimation of accurate ingestion rates are problematic due to the absence of hard parts, such as bones and otoliths, in skates. However, Quantitative Fatty Acid Signature Analysis (QFASAs) has proven to be useful in detecting winter skate in grey seal diet (Benoît *et al.* 2011).

The main threat to the sGSL winter skate population appears to be an unsustainably high level of non-fishing mortality in adults, possibly due to predation by grey seals (COSEWIC 2015). Evidence for a variety of factors potentially contributing to high levels of adult natural mortality (*M*) in sGSL winter skate, including capture in fisheries, poor condition of individuals, life history changes, and consumption by various predators (fish, seabirds, cetaceans and seals) was evaluated by Benoît *et al.* (2011). According to their results, predation by grey seals is likely the main cause for high levels of *M* in adults. Other threats identified by COSEWIC (2015) include mortality of discarded by-catches from fisheries targeting other species (no fishery for skates in the sGSL since 2006) and reduced availability of important prey species (e.g., rock crab) as a result of competition with invasive green crabs. According to Swain *et al.* (2006), fishing activities (e.g., trawling, dredging) can pose a threat to skate egg capsules (purses) given their long residency on the seafloor (development period inside the capsule has been observed to vary from a couple of months to over a year (DFO 2017b)). The availability of suitable physical habitat does not appear to be a limiting factor to winter skate abundance in the sGSL; however, increased risk of predation by grey seals in inshore areas in the summer seems to be restricting access to habitat typically occupied by winter skate (DFO 2017a).

Figure 1 displays nine maps of the western North Atlantic region, showing the spatial distribution of winter skate catch rates (kg/tow) over time. The maps are arranged in a 3x3 grid, with each map representing a different time period. The y-axis represents Latitude (°N) from 46 to 49, and the x-axis represents Longitude (°W) from 65 to 61. A legend indicates catch rates in kg/tow: 0 (white), 0.1 (light yellow), 0.5 (yellow), 1 (orange), and 5 (red). A depth legend shows 100m and 500m contours. Each map includes the number of tows (n) and the probability of occurrence (P(occ)).

| Time Period | n (tows) | P(occ) |
|-------------|----------|--------|
| 1971-1975 | 338 | 0.098 |
| 1976-1980 | 339 | 0.112 |
| 1981-1985 | 534 | 0.094 |
| 1986-1990 | 750 | 0.151 |
| 1991-1995 | 1081 | 0.099 |
| 1996-2000 | 1019 | 0.089 |
| 2001-2005 | 887 | 0.051 |
| 2006-2010 | 858 | 0.035 |
| 2011-2016 | 920 | 0.017 |

Acadian Redfish (semi-pelagic)

Acadian redfish are only found in the western Atlantic, with a range extending from the Gulf of Maine to the southern Labrador Sea, including the St. Lawrence Estuary, the Gulf of St. Lawrence, the Laurentian Channel and the Grand Banks (COSEWIC 2010b). Redfish in the GSL migrate to their overwintering grounds at the entrance of the Laurentian Channel (Cabot

Strait and off southern Newfoundland) in the fall/winter and return to the Gulf in the spring/summer (DFO 2011c). As illustrated in Figure 10, occurrence in the southern Gulf in September is mostly observed along the southern slope of the Laurentian Channel, but also in the deep areas of the CBT. No distinction is made between the two redfish species captured during the sGSL RV survey (Acadian and Deepwater redfish); however, according to COSEWIC (2010b) and as the name suggests, deepwater redfish inhabit much greater depths (350 to 500 m). The temporal maps in Figure 10 suggest that the general area occupied by redfish species in the sGSL has remained constant over the time series. In contrast, stock biomass has experienced substantial declines over time, although an increase is observed in more recent years (DFO 2016c). While data obtained from the sGSL RV survey provide some insight on stock trends within the GSL, data collected every August during the DFO RV survey in the northern Gulf allow for a more in-depth analysis of these trends. According to the 2016 assessment of Acadian Redfish in the GSL (DFO 2016c), abundance and biomass indices of mature individuals have been increasing slightly since 2009. A high abundance of immature fish was observed between 2013 and 2015, with values being four times higher than the average value observed between 1993 and 2012. However, despite the potential for improved recruitment, the spawning stock biomass remains in the critical zone. In general, smaller Acadian redfish prefer sheltered areas and occur at depths ranging from 75 to 175 m, whereas adults occur in cool waters along slopes of banks and channels at depths between 150 and 300 m, inhabiting deeper areas as they increase in length (DFO 2011c). In the GSL and the Laurentian Channel, adult redfish seemingly prefer temperatures of 4.5 to 6°C. As they age, individuals tend to reduce their mobility and settle into deeper waters.

The migration to overwintering grounds coincides with the mating season, suggesting that aggregations in these areas are motivated by reproduction (DFO 2011c). In contrast to most other marine cold-water fish species, fertilization occurs internally and females carry the developing embryos until they are extruded as free swimming larvae in the late spring/early summer.

Although they generally live near the seafloor, redfish are considered semi-pelagic species as they exhibit long daily vertical migrations in search of prey. The diet of both redfish species occurring in the GSL are thought to be similar and consists mostly of fish and invertebrate eggs at the larval stage (largest larvae also consume copepods and euphausiids) while juveniles and adults prey on copepods, euphausiids and fish (DFO 2011c). Redfish are preyed upon by several species of large fish, including Greenland halibut, thorny skate, Atlantic cod, black dogfish, monkfish, pollock and wolffishes (COSEWIC 2010b). They also form a significant part of the diet of seals, including grey seals, hooded seals and harp seals.

Life history characteristics, including a long lifespan (up to 75 years), late sexual maturation (7 years for males; 9 years for females), and slow growth (7 to 8 years on average to reach commercial size of 22 cm), have encumbered the recovery potential of this species (DFO 2016c). Furthermore, recruitment is highly variable, with strong year-classes produced every 5 to 12 years in unexploited/lightly exploited populations. The main threat to the survival and recovery of Acadian redfish remains directed fisheries, while other threats include: by-catch in other fisheries; unfavorable environmental conditions; activities associated to oil and gas exploration; and, seal predation (COSEWIC 2010b). Existing information on habitat requirements, albeit limited, suggests that redfish abundance is not restricted by the availability of suitable physical habitat in Atlantic Canadian waters.

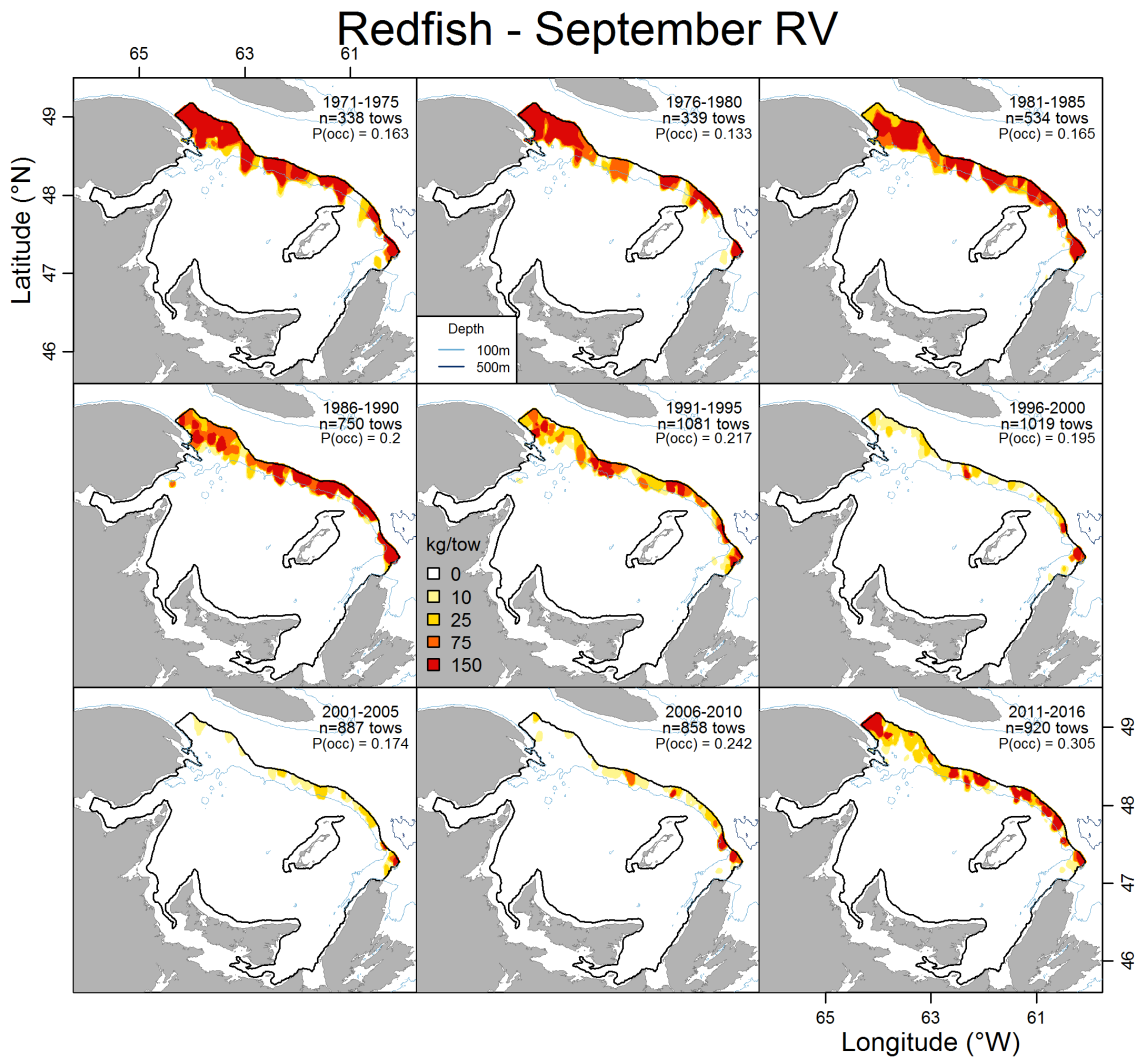


Figure 10. Changes in the distribution of redfish species (Acadian and Deepwater redfish) in September over the past 46 years as indicated by the spatial distribution of biomass indices (kg per tow) by five year groups, 1971 to 2016 (with the exception of the 2011-2016 six year group). $P(occ)$ = Probability of occurrence and n = the number of trawl tows.

American Plaice (demersal)

In 2009, the Maritime DU of American plaice (*Hippoglossoides platessoides*) was assessed as Threatened by COSEWIC. The rationale for this designation was the significant declines in the abundance of mature individuals over a 36 year time series (approximately 2.25 generations), estimated at 86% for the GSL stock (COSEWIC 2009a).

The Maritime population of American plaice occurs in the Gulf of St. Lawrence, the Scotian Shelf, the Bay of Fundy and Georges Bank (COSEWIC 2009a). American plaice in the GSL are divided into two stocks – the northern GSL and southern GSL. The sGSL stock is broadly distributed at various depths in the southern Gulf from spring (April-May) to fall (November-December) (DFO 2011d). This stock exhibits a vernal migration from wintering grounds of the deeper waters along the edge of the Laurentian Channel to inshore feeding and spawning grounds within the sGSL (COSEWIC 2009a). Data from the sGSL RV surveys have revealed highest densities of American plaice at intermediate depths of 70 to 90 m, with little variation

due to age or year (DFO 2011d). According to these surveys, plaice tend to select colder temperatures (average = 1.34°C) relative to those available, and although temperature selection did not vary greatly with age, females tended to occupy warmer water than males. Distribution maps of sGSL plaice (Figure 11) obtained from data collected during the RV surveys (1971 to 2016) illustrate the extent of their coverage area in September. Significant declines in stock biomass are evident in these maps. Beginning in the early 1990s, abundance and biomass indices declined to the lowest levels observed and have remained at historically low levels despite showing some minor increases since 2012 (DFO 2016d). American plaice biomass in the CBT has also fluctuated over the years, but to a lesser extent than that observed throughout the sGSL. According to RV survey data, there has been no apparent change in spatial distribution of American plaice in the sGSL over the time series as all size groups and both sexes show a sustained widespread distribution. However, differences in catch rates have been observed between smaller (< 30 cm) and larger (≥ 30 cm) fish from the beginning of the time series, suggesting a stronger mortality rate in older fish. Estimates that include data up to 2015 show that *M* for smaller plaice (ages 4 to 9) has decreased from ~53% per year (1970s) to ~39% per year (since 2005), while *M* for older plaice (aged 10+) has increased from ~22% per year (1970s) to >39% per year since 1995 (DFO 2016d). According to these estimates, *M* for age 10+ plaice has exceeded that for plaice ages 4 to 9 years since 2008.

Spawning of American Plaice generally occurs throughout its range, but certain areas are associated with much greater spawning activity, possibly owing to a greater abundance of fish rather than selection of spawning grounds. In the southern Gulf, the major spawning grounds appear to be east and west of the Magdalen Shallows and extending into Chaleur Bay (DFO 2011d).

American Plaice are highly opportunistic feeders throughout their life cycle, feeding on any prey items that are available in appropriate sizes for ingestion and varying with fish size, locality and season (COSEWIC 2009a). Adults and juveniles have been reported to feed on polychaetes, echinoderms (e.g., brittle stars, sand dollars, sea urchins), molluscs, crustaceans and fish (e.g., capelin, sandlance, other flatfish). By the time plaice reach 30 to 50 cm in length, upwards of 80% of their diet is composed of fish. American plaice are consumed by several animals that vary according to developmental stages. Eggs and larvae are prey items for most species that feed in the upper pelagic zone during the spring. As mentioned previously, large cod (≥ 35 cm) are well-known predators of American plaice, particularly smaller sizes. In the GSL, plaice can be an important component of the diet of harp and grey seals.

Landings in the sGSL have shown a steady decline, reaching their lowest historical level in recent years. Despite a current total allowable catch (TAC) of 250 t, total landings in 2015 only reached 40 t. The current exploitation of American plaice is mostly as by-catch in the witch flounder fishery by mobile gear off Cape Breton Island, and the Greenland halibut fishery exploited by gillnetters off the Gaspé coast (Ricard *et al.* 2016).

Knowledge on habitat requirements for American plaice remains limited. However, the wide range of environmental conditions from which they have been caught suggests that the species is a generalist without tightly constrained habitat requirements. Consequently, the availability of suitable physical habitat does not appear to be a limiting factor for recovery in the GSL. American plaice burrow in the sediment as a means of predator avoidance, and possibly concealment from prey as ambush predators. Therefore, it is probable that sediment type is an important habitat consideration, particularly for smaller fish as they are likely only capable of burying in finer sediments (DFO 2011d).

Under current conditions, the rebuilding prospects for the sGSL stock of American plaice remain low due to a high level of natural mortality (Ricard *et al.* 2016). Although causes of high

M are not fully understood, available evidence suggests that predation by grey seals, most notably on larger fish, plays a major role in observed mortality increases. Current and future activities such as oil and gas exploration and development, as well as the impacts of climate change, pose potential threats to American plaice abundance, particularly through detrimental effects on the larval and early juvenile stages (DFO 2011d). However, there is no evidence available to predict the degree or likelihood of occurrence associated to these threats.

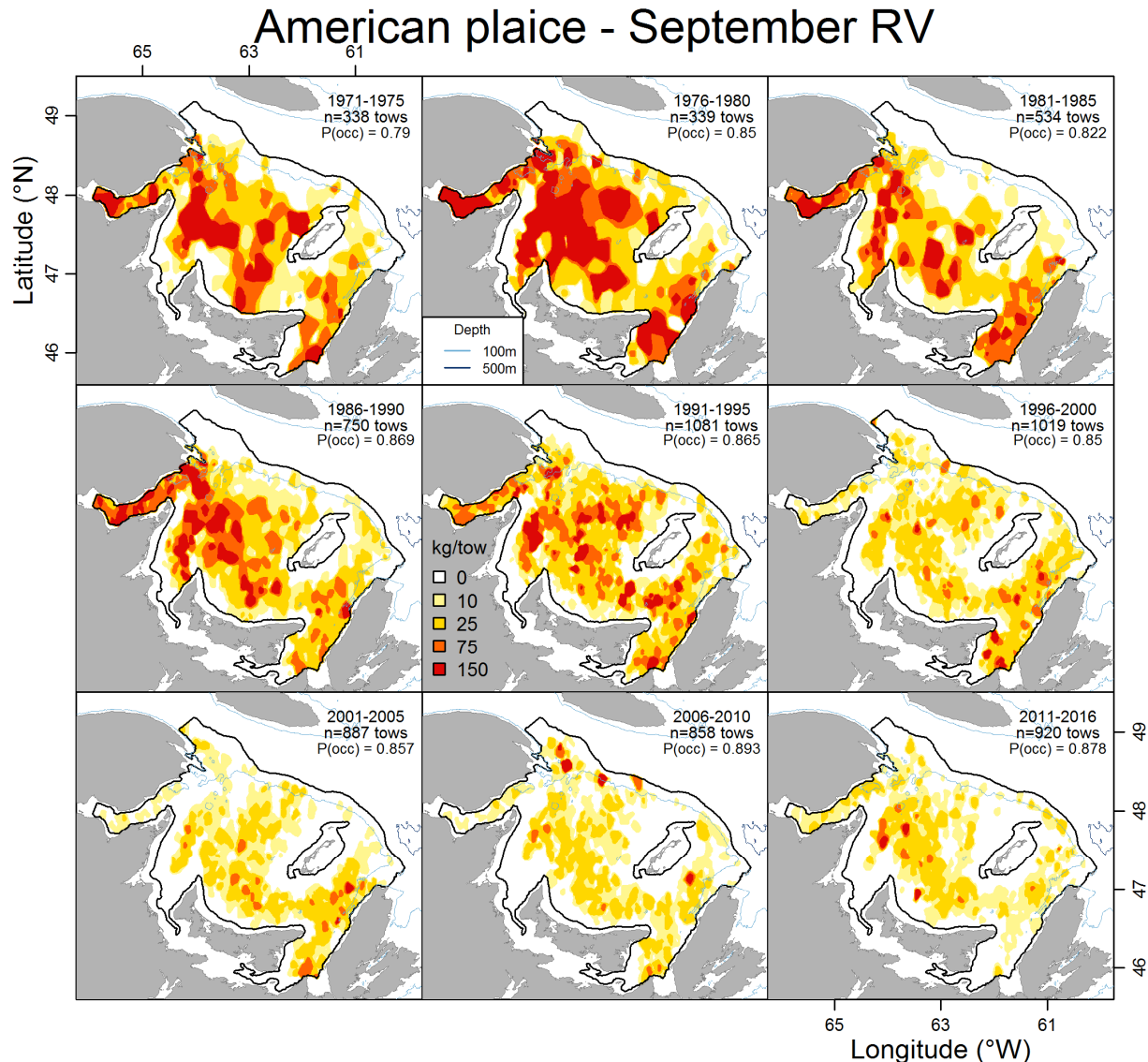


Figure 11. Changes in the distribution of American plaice in September over the past 46 years as indicated by the spatial distribution of biomass indices (kg per tow) by five year groups, 1971 to 2016 (with the exception of the 2011-2016 six year group). $P(occ)$ = Probability of occurrence and n = the number of trawl tows.

Smooth Skate (demersal)

The Laurentian-Scotian DU of smooth skate (*Malacoraja senta*) was designated Special Concern by COSEWIC in May 2012. This large DU historically accounts for 90% of the species' estimated abundance in Canada and 70% of the Canadian range. The rationale for the designation was the pronounced decline in abundance and area of occupancy observed since

the 1970s, and the persisting low numbers on the Scotian Shelf. Recent increases in natural mortality of adults in the southern Gulf were also highlighted. Although trends within the DU vary among regions, numbers in more recent years are suggesting a general increase (COSEWIC 2012a).

The Laurentian-Scotian DU falls almost exclusively in Canadian waters, with areas including the southwest Grand Banks, the Gulf of St Lawrence, the Scotian Shelf, the Bay of Fundy, and Georges Bank (COSEWIC 2012a). The DFO September RV survey forms the basis for determining the occurrence/status of smooth skate in the sGSL. According to accumulated data, these fish are distributed in relatively deep waters along the slope of the Laurentian Channel and in the CBT (DFO 2017c). Figure 12 illustrates the temporal geographic distribution of catches from the RV survey (1971 to 2016). Considerable interannual fluctuations have been observed in catch rates (abundance and biomass) of smooth skate in the RV survey, which are presumably due, in part, to the restricted distribution of the species within the survey area. A general decline in abundance was observed from the mid 1970s to early 1980s, followed by an increase in the mid 1980s, and relatively high values throughout the 1990s. Abundance declined again in the early 2000s, but has slightly recovered since then. Trends for biomass are similar, although increases are not as substantial in the 1980s and recent years (Swain *et al.* 2012a). An estimated decline of 67% in total numbers of mature individuals has been reported for the period between 1971 and 2010 (39 years; 2.4 generations). According to the most recent status update on smooth skate in the sGSL (DFO 2017c), biomass estimates in 2015 were near the long-term average, but below the short-term average, while abundance of adults remained relatively stable since the increases observed in the mid-2000s. Little geographic segregation between length classes and little seasonal variation in the geographic distribution occur in the southern Gulf. Smooth skate seem to prefer soft substrates (silt and clay) and a relatively narrow range of bottom temperatures (2.7 to 10°C) (COSEWIC 2012a). According to the RV survey, the mean temperatures occupied by the sGSL stock have varied between ~2 and 5°C, while highest densities of catches have generally been observed at depths between 150 and 300 m (Swain *et al.* 2012a). Consequently, much of the Magdalen Shallows are devoid of smooth skate due to limiting physical features (i.e., bottom temperatures < 2°C, sandy substrates and shallow depths). No strong interannual trends are evident in the depths and temperatures occupied by smooth skate in September in the southern Gulf. Although it is evident that physical factors such as temperature and depth influence their distribution, specific dynamics remain poorly understood. Smooth skate are relatively sedentary during all life stages, a behavior that is typical of skates (COSEWIC 2012a).

Abundance trends in the sGSL have shown important differences between juvenile and adult skates, suggesting disparities in mortality rates (Swain *et al.* 2012a). The above-average abundance of juveniles throughout much of the 1990s and 2000s, despite below average numbers of spawners, suggests relatively low mortality. The opposite is true for adults, as below-average abundance during the same periods, despite strong recruitment, indicates relatively high mortality. The low mortality of juveniles is thought to reflect the release from predation following declines in the biomass of large demersal fishes in this area beginning in the early 1990s due to overfishing. On the other hand, increased mortality in adults, despite reduced fishing effort, is likely the result of increased predation by the growing population of grey seals in the sGSL.

Reproduction appears to be widespread throughout the species' range, with egg cases having been found on the seafloor at various times of the year within the various DUs (COSEWIC 2012a).

Feeding studies indicate that smooth skate are very selective in their diet, preying mostly on small invertebrates throughout their life, and only adding fish when they reach maximum sizes.

Analyses of nearly 600 stomachs of smooth skate caught in winter and summer off the Scotian Shelf between 1999 and 2008 showed little variation in diet among seasons and areas (Simon *et al.* 2012). The most common prey items were crustaceans, including shrimps, krill and crabs. Older individuals preyed on fishes as well as invertebrates. It is not clear whether this limited prey selection further constrains their distribution. Little information on smooth skate predators is available. Analyses conducted by Simon *et al.* (2012) on over 156,000 stomachs of 68 species of potential predators, largely from the Scotian Shelf, did not reveal any evidence of smooth skate ingestion. Analyzed data spanned four decades (1958-1969; 1981-1990, 1991-1998 and 1999-2008). Other sources of information have reported that skate purses are subject to predation by Atlantic halibut, goosefish, Greenland shark and gastropods while potential predators of adult skates include marine mammals such as grey seals (COSEWIC 2012a). Limited evidence for predation by greys seals (and other predators) is likely due to the absence of hard parts (spines) remaining in the gut or scat of animals consuming skates (Swain *et al.* 2012a).

Information on threats to survival and recovery of smooth skate in Atlantic Canadian waters suggests that the main threats to smooth skate in the sGSL are incidental captures in fisheries targeting other species (no directed fishery for skates in the sGSL) and the high rate of natural mortality of mature individuals, presumably associated to increased predation by grey seals (Swain *et al.* 2012a). As mentioned previously, skate purses have been reported as particularly vulnerable to various fishing activities due to their long residency on the seafloor, however information specific to sGSL smooth skate remains unavailable.

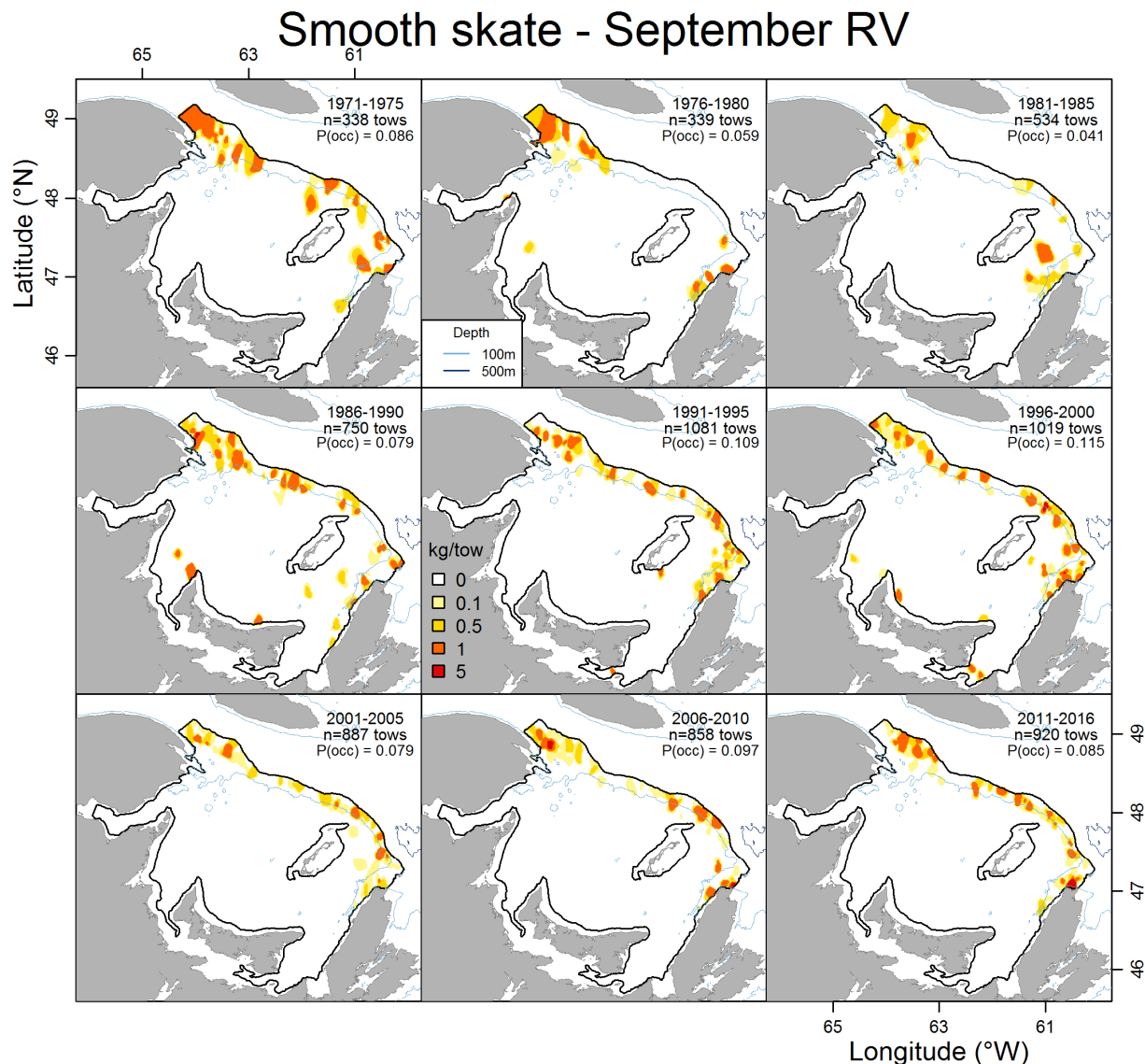


Figure 12. Changes in the distribution of smooth skate in September over the past 46 years as indicated by the spatial distribution of biomass indices (kg per tow) by five year groups, 1971 to 2016 (with the exception of the 2011-2016 six year group). $P(occ)$ = Probability of occurrence and n = the number of trawl tows.

Thorny Skate (demersal)

In May 2012, thorny skate (*Amblyraja radiata*) in Canada were designated Special Concern by COSEWIC due to severe population declines over the southern part of their distribution, including range contractions. A single DU was considered for the assessment, due to a lack of obvious disjunctions in the distribution of this species in Canadian waters and the absence of genetic differentiation studies across Atlantic Canada (COSEWIC 2012b).

Thorny skate are the most widely distributed and abundant skate species in the North Atlantic. In Canadian waters, their range extends from Baffin Bay to Georges Bank, including nearly all of the shelf waters of Canada (COSEWIC 2012b). The geographic distribution of catches in the sGSL resulting from the September RV survey (1971 to 2016) is illustrated in Figure 13. As shown, thorny skate were widely distributed throughout the southern Gulf in the 1970s and

1980s, extending into the western portion of the Magdalen Shallows (i.e., Chaleur Bay and Shediac Valley). A striking contraction in the distribution of both juveniles and adults occurred in the 1990s and 2000s, with distribution now largely restricted to the warmer and deeper waters of the sGSL, such as the slope of the Laurentian Channel and the northeastern regions of the Magdalen Shallows, including the CBT (Swain *et al.* 2012b). As such, a true shift from shallow to deep water has occurred in the distribution of the sGSL population of thorny skate. It has been estimated that the area occupied by mature individuals for the period 2006 to 2010 represents 10% of the area occupied at the beginning of the survey (1971 to 1975). Abundance of adult skates has declined steadily since the beginning of the survey, reaching an estimated decline of 95%, although evidence suggests that this decline has ceased in more recent years (DFO 2017c). Contrary to adults, juvenile abundance has exhibited important fluctuations through the time series, showing a sharp decline in the mid-late 1990s followed by a sharp increase since the mid-2000s. The rate of decline for juvenile skates for the 1971 to 2010 period was estimated at 32% (COSEWIC 2012b). A plausible explanation for the occurrence of increasingly large numbers of juveniles despite the small numbers of adults is discussed below. Thorny skate are relatively sedentary during all life stages, a behavior that is typical of skates. Limited seasonal cross-shelf movements have been observed in the Grand Banks and the southern Gulf areas (COSEWIC 2012b). The RV survey data show peak densities occurring at depths between 150 and 250 m since the 1990s, with relatively low densities at depths over 300 m (Swain *et al.* 2012b). Thorny skate are typically observed in water temperatures between 0 and 10°C, although in the sGSL, they seem to prefer a narrower range of 0 to 5°C (COSEWIC 2012b). Individuals are found on a variety of substrates, including sand, gravel, soft mud and broken shells.

According to COSEWIC (2012b), reproduction occurs year-round in waters off Atlantic Canada, with a peak spawning that seems to take place in the fall and winter.

Studies on thorny skate diet have reported a wide prey spectrum, especially compared to other skates (COSEWIC 2012b). An analysis on stomach contents of individuals from Georges Bank to Greenland revealed a diet consisting mostly of fish (sandlance and capelin), decapods (shrimp, spider and hermit crabs), cephalopods, polychaetes and amphipods. Smaller skates contained higher proportions of cephalopods, polychaetes and amphipods. Observations revealed a clear difference in diets between regions and size of skates. The amount of fish in thorny skate diet is seemingly proportional to fish size, with individuals becoming more piscivorous as they increase in size. A study conducted on the Grand Banks also revealed a diversified diet (90 species identified) consisting mostly of fish and crustaceans with sandlance and snow crab identified as the two most important prey items. Direct evidence for predation on thorny skate in the sGSL remains limited; however it is likely that juvenile and adult skates are preyed upon by various species of marine mammals and fish, while their egg capsules are consumed by Atlantic halibut, goosefish, Greenland sharks and burrowing gastropods. An analysis examining over 156,000 stomachs of 68 species of potential predators, largely from the Scotian Shelf, found only 8 individuals of this species in the following predators: Atlantic halibut, sea raven, American plaice, Atlantic cod, and porbeagle shark (Simon *et al.* 2012). As mentioned for smooth skate, limited evidence for predation by greys seals (and other predators) is likely due to the absence of hard parts (spines) remaining in the gut or scat of animals consuming skates. Nevertheless, thorny skate have been detected in NW Atlantic grey seal diets inferred using quantitative fatty acid signature analysis (Swain *et al.* 2012b).

Thorny skate are no exception to the unusual productivity regime exhibited by the sGSL demersal fish community (i.e., unusually high productivity at early life stages and unusually low at later stages). Similar to species previously discussed, the lower mortality of small fish is thought to be the result of release from predation following declines in the abundance of large

demersal fishes in this area beginning in the early 1990s, whereas higher mortality rates of adults is likely due to the combination of their low abundance with increasing abundance of grey seals in the sGSL (Swain *et al.* 2012b). Grey seal foraging grounds in the summer are concentrated in shallower waters of the Magdalen Shallows, which, combined with increased numbers of seals, could explain the shift in skate distribution from shallow to deep water in the sGSL (i.e., away from the increased risk of predation). As a result, the main threat to the sGSL thorny skate population appears to be an unsustainably high level of non-fishing mortality in adults that is likely associated to increased predation by grey seals. Incidental capture in fisheries targeting other species has also been identified as a potential threat, although reported skate landings in the sGSL have been relatively low in recent years (<20 t), representing only a small fraction of the adult biomass in the area (COSEWIC 2012b). Similarly to other skates, fishing activities pose a threat to thorny skate purses as these egg capsules can reside on the seafloor for an extended period of time. In terms of habitat suitability, physical characteristics of the sGSL are not considered to be limiting to thorny skate abundance, however, as already mentioned, increased risk of predation by grey seals in inshore areas in the summer seem to be restricting access to habitat typically occupied by thorny skate.

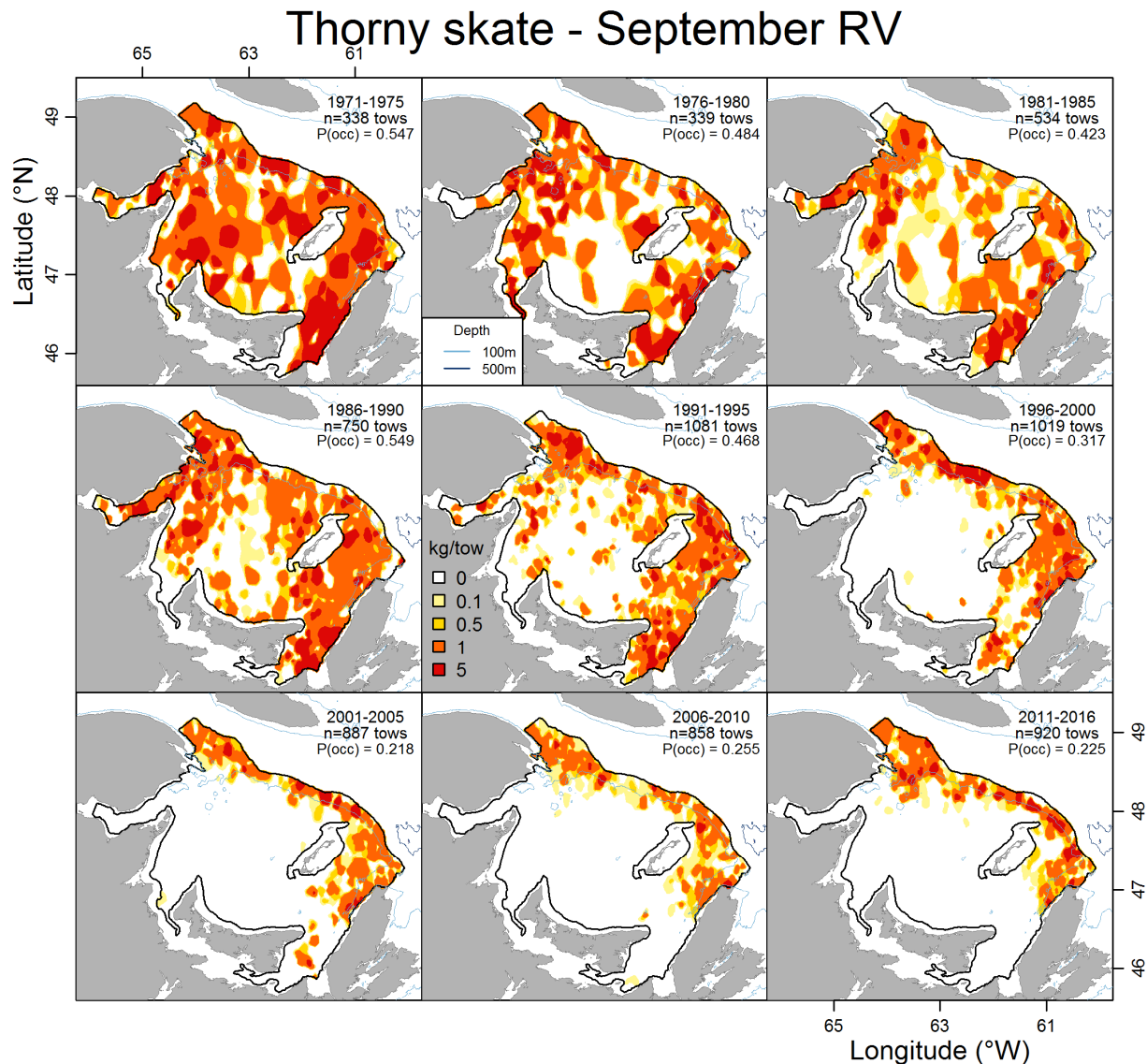


Figure 13. Changes in the distribution of thorny skate in September over the past 46 years as indicated by the spatial distribution of biomass indices (kg per tow) by five year groups, 1971 to 2016 (with the exception of the 2011-2016 six year group). P (occ) = Probability of occurrence and n = the number of trawl tows.

Atlantic Wolffish (demersal)

In November 2000, the Atlantic wolffish (*Anarhichas lupus*) in Canada was assessed as Special Concern by COSEWIC. It was later included in Schedule 1 of the *Species at Risk Act* (SARA), at the time of the Act's proclamation in June 2003. COSEWIC reassessed this species in 2012 and, despite some signs of population recovery, recommended that the designation remain unchanged (i.e., *Special Concern*). The reason for designation was associated to the dramatic declines observed in the relative abundance and area of occupancy over much of its range from the 1980s until the mid-1990s. Although a general increase in abundance and area of occupancy has been observed since, this species remains at low abundance compared to the early 1980s. Furthermore, continued declines in abundance are observed on the Scotian shelf and in the southern Gulf (COSEWIC 2012c).

In Canadian waters, Atlantic wolffish (also known as striped wolffish) occur off Baffin Island, in the Labrador Sea, off Newfoundland, in the Gulf of St Lawrence, on the Scotian Shelf, in the Bay of Fundy and in the Gulf of Maine (COSEWIC 2012c). As shown in Figure 14, data from the DFO RV survey indicate that relative occurrence is generally low in the sGSL (September), with greater presence in the deeper areas, including the CBT, where this species has been reported throughout the time series (1971-2016). Atlantic wolffish seemingly prefer intermediate depths of approximately 100 to 200 m (Collins *et al.* 2014). According to available data, Atlantic wolffish tolerate temperatures from -1 to 10°C, with largest concentrations occurring between 1 and 5°C (Kulka *et al.* 2007; COSEWIC 2012c). It has been suggested that water temperature has an important influence on habitat selection. According to diving observations, these fish prefer a complex bottom relief formed of rocks or large stones, allowing for use of shelters during feeding, mating and egg guarding (Dutil *et al.* 2011; Novaczek *et al.* 2017). They are most abundant below the thermocline, at depths where there is little action by tidal and coastal currents. Atlantic wolffish are not associated to long migrations, as their movements seem generally limited to short (few km) seasonal migrations that occur between offshore waters and shallow spawning grounds.

The large lateral molars of Atlantic wolffish allow them to crush hard-shelled prey living on the seafloor (e.g., crabs, echinoderms, mollusks). Although their diet seems to consist mostly of invertebrates, fish are also consumed and presumably become a higher proportion of their diet as they mature. Atlantic wolffish have been observed in the stomach contents of various fish species, including sea raven, Atlantic halibut, spiny dogfish, longhorn sculpin, Atlantic cod, white hake, and haddock. Seals are also known predators, including grey seals, harp seals, hooded seals and harbour seals. (COSEWIC 2012c)

The identification of threats to Atlantic wolffish in the Canadian Atlantic remains a challenge due to the limited research on populations occurring in this area. This lack of information is possibly the result of the absence of a directed fishery in Canadian waters. Incidental capture in fisheries targeting other fish species is considered to be the main cause of mortality for Atlantic wolffish in Atlantic Canada (Kulka *et al.* 2007; COSEWIC 2012c). Other reported potential threats leading to the decline of this species include: activities associated to offshore oil, gas and mining activities; ocean dumping in the form of sewage sludge, fish waste and dredge spoils; military activity; installation of physical structures such as cables and pipelines; marine and land-based pollution (e.g., excessive nutrients, pathogens, toxins, oils); natural mortality (parasite, disease, predation and environment-related); and, scientific research (Kulka *et al.* 2007). Finally, climate change has been recognized as a potential threat to many marine organisms, including Atlantic wolffish, as associated changes in the marine environment (e.g., temperature) could have an impact on their distribution and abundance (COSEWIC 2012c).

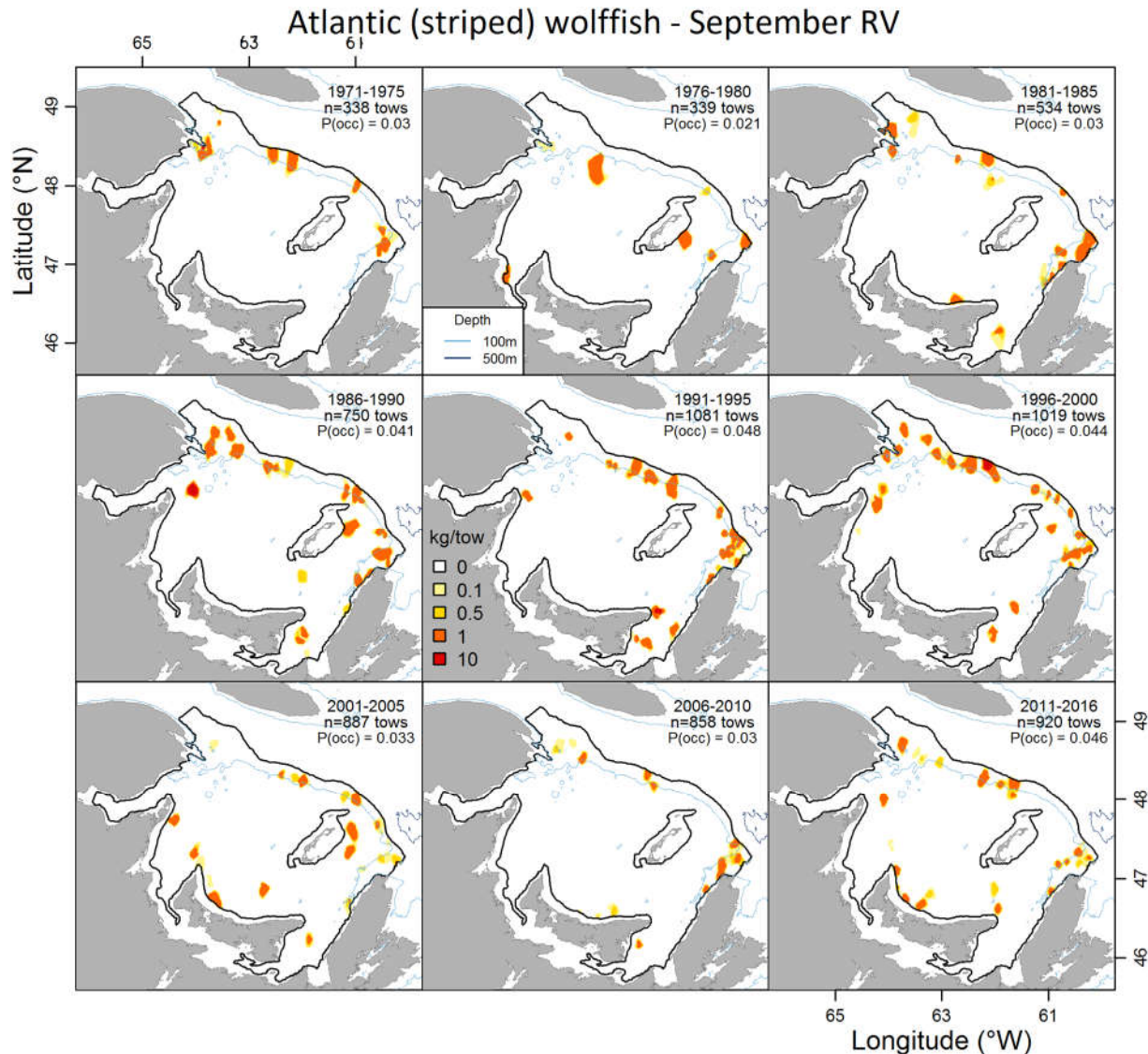


Figure 14. Changes in the distribution of Atlantic wolffish in September over the past 46 years as indicated by the spatial distribution of biomass indices (kg per tow) by five year groups, 1971 to 2016 (with the exception of the 2011-2016 six year group). $P(occ)$ = Probability of occurrence and n = the number of trawl tows.

SHARKS

Available data on shark species occurring in the CBT is very limited. At least six shark species are known to occupy waters around Nova Scotia, including basking shark, spiny dogfish shark, shortfin mako shark, porbeagle shark, blue shark and white shark (*Carcharodon carcharias*). The first four species have been designated by COSEWIC as Special Concern (basking, shortfin mako and spiny dogfish) or Endangered (porbeagle), while the white shark is listed as Endangered under SARA. These shark species are distributed throughout the North West Atlantic and tend to be highly migratory. At a minimum, they are expected to transit through the area around northern Cape Breton and into the Gulf, as tag recaptures have included both of these areas (Heather Bowlby, DFO pers. comm.). The amount of time spent in these locations

and the proportion of each population that transits through are expected to be highly variable and species-specific, with no current estimations.

In a study looking at significant habitats for marine species in the PEI and NS regions of the Gulf, the CBT was highlighted as an important migration path for several species of fish, including porbeagle, mako and blue sharks (Therrien *et al.*, 2001).

As apex predators, sharks help control many fish and marine mammal populations and therefore, are important to the proper functioning of marine ecosystems. Due to their life history characteristics, such as longevity, late age at maturity and low fecundity, shark populations that have reached low abundance cannot easily recover and thus, are particularly vulnerable to overexploitation. The following pages provide an overview of available information on shark species of special importance (i.e., listed under COSEWIC/SARA) expected to occur in the area of the CBT. The North Atlantic population of blue shark (*Prionace glauca*) was assessed as Special Concern by COSEWIC in April 2006, however, this status was re-examined and designated as Not at Risk in November 2016. As a result, this species will not be discussed further.

Porbeagle Shark

Designated as Endangered by COSEWIC in May 2004, the porbeagle shark (*Lamna nasus*) population in Canada was re-examined in May 2014 with the conclusion that it maintains its current status. As stated in the assessment (COSEWIC 2014), the population has remained stable in the last decade, however the low numbers resulting from significant declines in the 1960s and 1990s is hindering this species' recovery.

Porbeagle shark are widely distributed in inshore and offshore waters throughout Atlantic Canada, including the Gulf of St. Lawrence, Newfoundland and Labrador, the Scotian Shelf and the Bay of Fundy (DFO 2015b). They undertake long-distance, seasonal migrations along the east coast of Canada and the United States (U.S.) each year, typically reaching the GSL in the summer and fall (Campana *et al.* 1999; 2012). The return migration to the southwest occurs in late fall.

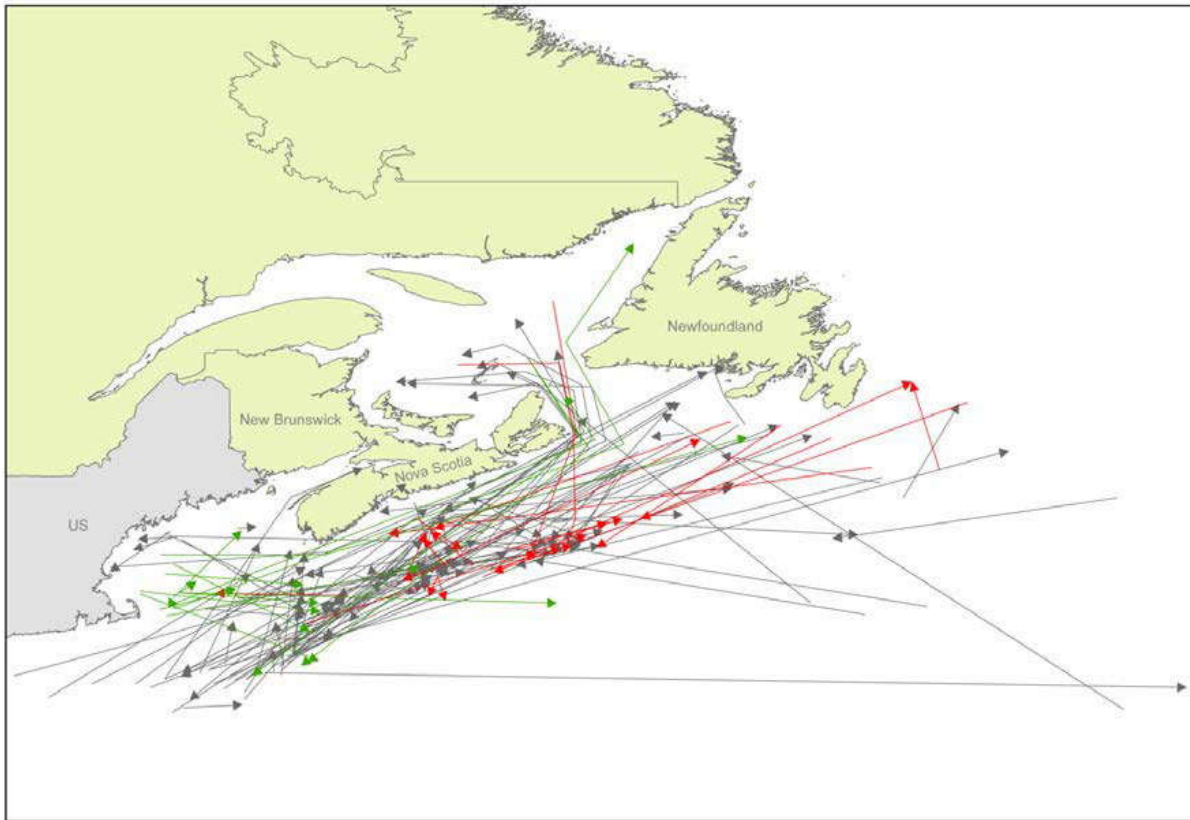


Figure 15 illustrates observations of porbeagle movement within the GSL resulting from tagging studies conducted between 1961 and 2008 (DFO 2015b). As shown, the northern area of the CBT was part of their trajectory. Porbeagle seem to prefer relatively cold waters throughout the year, occurring at temperatures between 5 and 10°C in Canadian waters (Campana and Joyce 2004a). Evidence suggests that their distribution is only limited by temperature and not salinity or depth, as they appear tolerant to temporary exposure to estuarine waters and have been recorded at depths ranging from the surface to 1360 m (DFO 2015b). In Canada, porbeagle are mainly encountered in the deeper basins, and along the shelf edge in depths less than 200 m (Campana *et al.* 2012). During the directed commercial fishery in Atlantic Canada (closed since 2013), porbeagle were usually caught at a depth of 50 to 150 m.

Many aspects of a shark's life are linked to its diet, including habitat location, the time of day that it is active, the depths occupied and the type of teeth and jaw that it possesses. Sharks that eat fish are usually pelagic, swimming throughout the water column in search of prey. Porbeagle shark are opportunistic predators that fall under this category, preying mostly on fishes (e.g., lancetfish, mackerel, herring, redfish, flounders, lumpfish, Atlantic cod) and cephalopods, particularly squid (Joyce *et al.* 2002). Seasonal changes in diet composition associated with the migration from deep to shallow waters have been reported by Joyce *et al.* (2002). In the spring, when individuals are located on the Scotian Shelf, their diet is dominated by pelagic fish and cephalopods. As they move closer inshore to shallower waters of the GSL in the summer/early fall, they tend to consume increased amounts of groundfish. Predators other than humans may include orcas and large sharks, such as white sharks (Compagno 2001).

Porbeagle shark have a life expectancy that is estimated to be over 40 years (Natanson *et al.*, 2002), and a generation time of ~18 years (COSEWIC 2014). Maximum total length (TL) has

been recorded at ~350 cm (Campana *et al.* 1999). Males reach sexual maturation at 6 to 10 years (50% at 8 years), while age at maturity for females is 12 to 16 years (50% at 13 years) (Jensen *et al.* 2002; Natanson *et al.* 2002). Once females reach sexual maturity, they give birth every year. The gestation period lasts 8 to 9 months and 2 to 6 pups measuring 60 to 80 cm (TL) are produced in a litter (Jensen *et al.* 2002).

Bycatch from fishery interactions remains the main threat to porbeagle in Canadian waters, with impacts on both survival and recovery (DFO 2015b). Potential threats to their habitat include: anthropogenic activities such as noise associated with offshore petroleum exploratory seismic surveys; marine pollution including that associated with a catastrophic offshore petroleum exploration or development spills; and, large-scale marine development projects (e.g., pipelines and submarine cables).

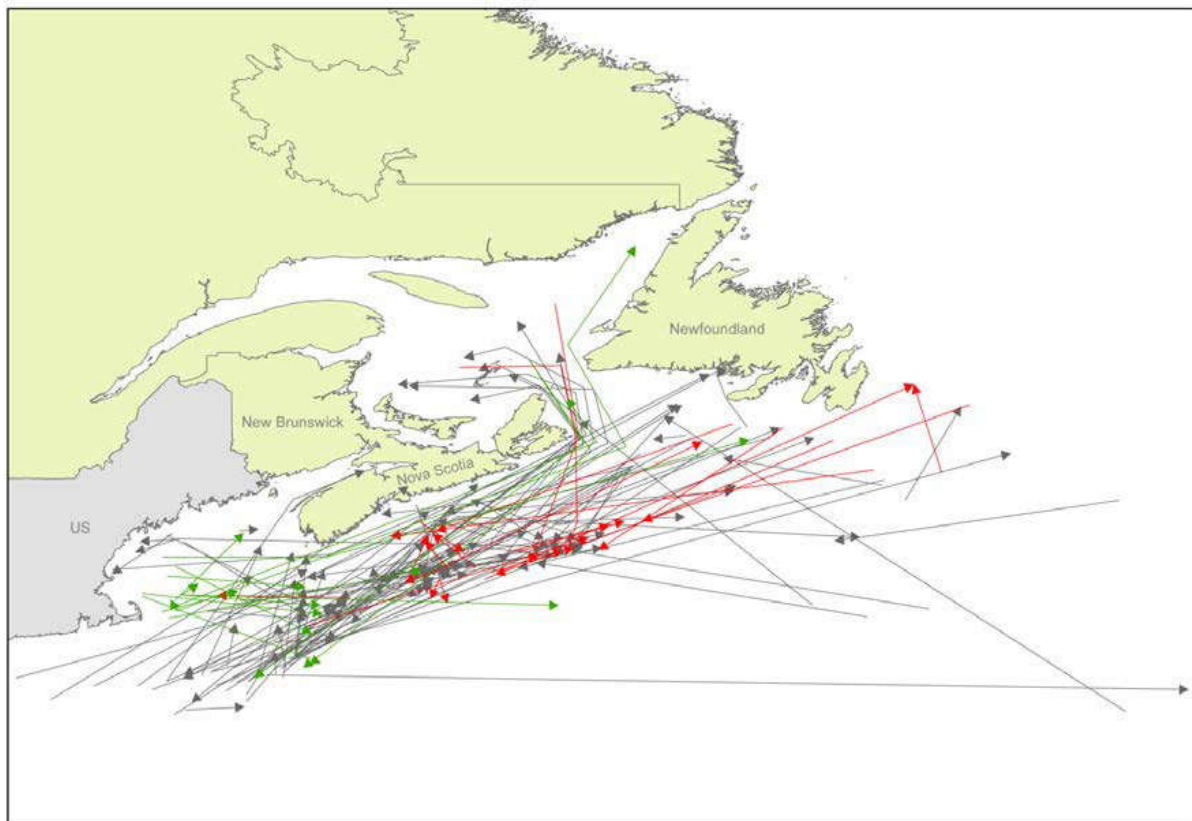


Figure 15. Summary of Porbeagle tag movements from tagging location (line origin) to recapture location (arrowhead) between 1961 and 2008. Norwegian tags in green; Canadian tags in red; U.S. tags in grey (from DFO 2015b).

Basking Shark

The Atlantic Canadian DU of basking shark (*Cetorhinus maximus*) was designated as Special Concern by COSEWIC in November 2009. This status is the result of available information suggesting substantial population declines in the northeast Atlantic. Based on tagging information, individuals in Canada are considered to be part of an Atlantic population shared with the USA, Europe, the Caribbean, and northern South America (COSEWIC 2009b).

According to aerial and ship-based surface observations, basking shark in Atlantic Canada are widely distributed in the Gulf of St Lawrence, off southern Newfoundland, on the Scotian Shelf

and in the Bay of Fundy (Campana *et al.* 2008). They are commonly observed swimming near the surface in coastal waters from early summer to fall (May to September) and appear to be highly migratory (DFO 2016e). Figure 16 illustrates sightings of basking shark in the GSL, including the CBT, between 1977 and 2007 resulting from Observer Programs (source: Campana *et al.* 2008) . Their distribution seems restricted to water temperatures between 6 and 16°C, whereas depth does not seem to be a limiting factor as they have been observed in both coastal and oceanic waters. Although basking shark appear to prefer shallow coastal waters, tagging studies have provided evidence for utilization of deepwater habitats (200 to 1000 m) (Gore *et al.* 2008; Skomal *et al.* 2009).

Summer habitat “hotspots” seemingly comprise areas where oceanographic events concentrate zooplankton, the main prey of basking shark (COSEWIC 2009b). As they swim near the surface with their mouths open, their specialized gill rakers allow for the retention of prey items while the water is filtered through and exits via the gill slits. Other reported prey include deepwater pelagic shrimp and herring. It is expected that newborn basking sharks are large enough to escape predation by most marine organisms, an assumption that is corroborated by a study where length-at-birth of six pups from a single litter was reported to be 1.5 to 1.7 m (Compagno 2001). It is possible that large marine species, such as the white shark and killer whale, prey on basking shark; however such observations have never been documented (COSEWIC 2009b).

Although life history characteristics of basking shark tend to be assumed and not measured, it remains evident that this species is relatively unproductive (i.e., low population growth rates), and therefore, particularly vulnerable to overexploitation. Basking shark are the largest fish that regularly occupy Canadian waters (second largest in the world following the whale shark (*Rhincodon typus*), with individuals in Atlantic Canada attaining an average size of 7 to 9 m (WWF 2012). Longevity is expected to be ~50 years and generation time between 22 and 33 years (UK 2002; COSEWIC 2009b). Age at maturity is presumably 12 to 16 years for males and 16 to 20 years for females (UK 2002). The gestation period has been estimated at 2.6 to 3.5 years, the longest recorded period of any animal (COSEWIC 2009b). As mentioned previously, only one observation on litter size has been reported, where one female gave birth to six young.

Despite the absence of a directed fishery, the main threat to basking shark survival and recovery is fishery-related interactions, including by-catch, ship collisions and entanglement in fishing gear (e.g., longlines, gillnets, traps, seines) (COSEWIC 2009b). Their slow movement and occurrence in surface waters not only render them particularly vulnerable to fishing-induced mortalities, but also to injuries from boat propellers.

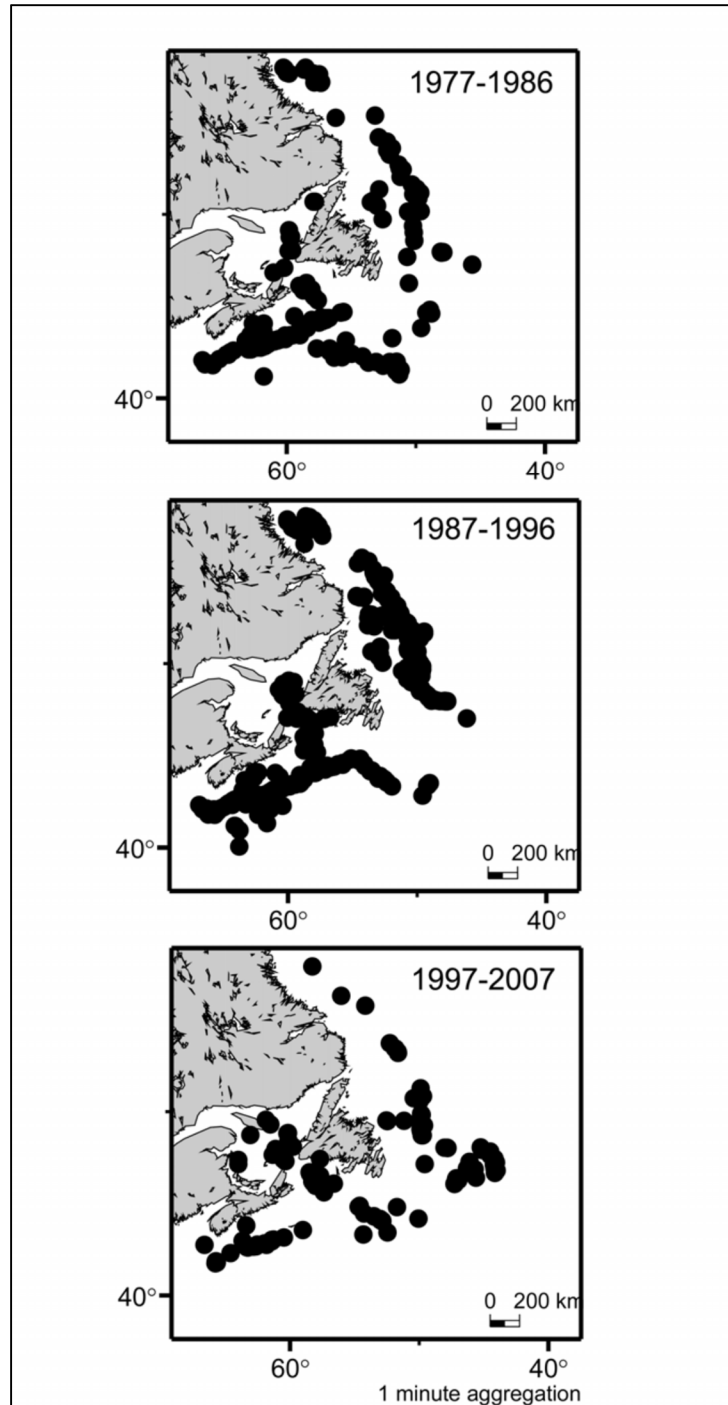


Figure 16. Distribution of basking sharks between 1977 and 2007 as recorded in the Newfoundland and Maritimes Observer Programs. It appears that at least some of the recorded sharks were Greenland sharks, rather than basking sharks (from Campana et al. 2008).

Shortfin mako shark

The Atlantic population of shortfin mako (*Isurus oxyrinchus*) in Canada was designated as Threatened by COSEWIC in April 2006, due to evidence indicating declines in the North Atlantic as a whole (40% 1986-2001; 50% 1971-2003) related to fishing activities (COSEWIC 2006a).

Despite this designation, a *Species at Risk Act* Schedule 1 listing decision was never completed. In April 2017, this population was reassessed as Special Concern as it was showing signs of recovery (COSEWIC 2017).

The shortfin mako is a large (maximum length of 4.2 m) pelagic shark species that is widely distributed in all temperate and tropical oceans (COSEWIC 2006a). Tagging studies suggest that shortfin mako in the North Atlantic are part of a single well-mixed population (Campana *et al.* 2004b). In Canadian Atlantic waters, individuals are typically associated with warm waters, such as those of the Gulf Stream. Records indicate a seasonal (late summer and fall) occurrence in several areas, from Georges and Browns Bank, along the continental shelf of Nova Scotia, in Grand Banks, and within the Gulf of St. Lawrence (COSEWIC 2006a). The presence of this highly migratory species in Canadian waters is limited by its preferred temperature range, reported to be between 17 and 22°C (Compagno 2001). Consequently, Atlantic Canada represents the northern extension of its range, with most individuals likely residing in warmer waters (Campana *et al.* 2004b). According to Showell *et al.* (2017), the portion of shortfin mako occurring in Canadian waters represents approximately 2.5% of the North Atlantic population. Furthermore, it has been reported that a high proportion of this species in Atlantic Canada consists of juveniles. Other than temperature restrictions, knowledge on specific habitat requirements remains limited. Observations of shortfin mako have been recorded from the surface to 500 m in depth, and are typically well offshore, although individuals have occasionally been reported in the littoral zone (COSEWIC 2006a). In the western North Atlantic, shortfin mako move onto the continental shelf when surface temperatures exceed 17°C. As illustrated in Figure 17, occurrences in the CBT have been reported, with higher densities occurring in the northern portion (Showell *et al.* 2017).

Shortfin mako prey on a wide variety of species, consisting mostly of fish (e.g., tunas, mackerels, bonitos, swordfish), and squid. According to Stillwell and Kohler (1982), bluefish comprise over 75% of their diet in the western North Atlantic. Evidence suggests that larger mako consume larger prey, including other sharks, small cetaceans and turtles. Due to their size and ability for high speed, shortfin mako have few natural predators (COSEWIC 2006a). Visible scars and injuries observed on caught individuals indicate interactions with sailfish and swordfish. Evidence for predation by white sharks has also been reported.

Knowledge on the life history characteristics of shortfin mako remains limited. Age at 50% maturity has been estimated at 7 to 9 years for males and 18 to 21 years for females (Natanson *et al.* 2006; Bishop *et al.* 2006). Females give birth from late winter to mid-summer with litters consisting of 4 to 25 free-swimming young measuring ~70 cm in length (Campano 2001). As noted by Showell *et al.* (2017), estimates of the gestation period have varied greatly, ranging from 9 to 21+ months. After parturition, females are thought to rest for a period of 18 months (Mollet *et al.* 2000). According to O'Boyle *et al.* (1996), mating and pupping grounds are likely south of Canada's Exclusive Economic Zone, in warm waters of the Gulf Stream. Longevity estimates remain controversial, but have been reported to be at least 24 years in the Northwest Atlantic (Campana *et al.* 2002), while generation time is believed to be between 26 and 30 years (Showell *et al.* 2017).

Commercial fishing activities occurring in Canadian waters and throughout the Northwest Atlantic Ocean remain the main threat to the shortfin mako shark population (Showell *et al.* 2017). Mako sharks are mostly caught in large pelagic longline fisheries, although rod and reel catches in the US recreational fishery are thought to be significant. Impacts of other anthropogenic activities (e.g., seismic surveys, oil and gas drilling, marine pollution) on shortfin mako and/or their habitat remain unknown. Additionally, an assessment on impacts associated to climate change (e.g., warming water temperatures, increasing ocean acidification) has yet to be completed.

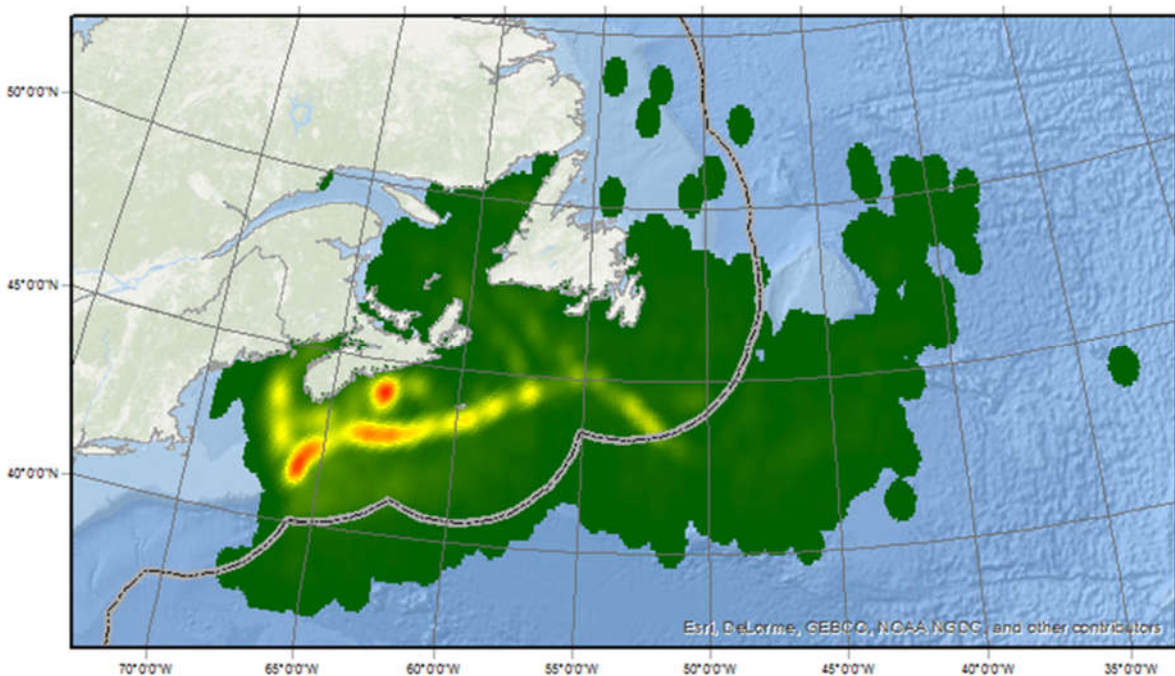


Figure 17. Aggregated reported catch locations from the ZIFF/MARFIS data sources for all area and gear types by Canadian fishers (DFO-NL (1995-2014), DFO-Maritimes (1988-2014), and DFO Gulf (1997-2013) for shortfin mako sharks. Relative density is indicated by colour, with green representing low, yellow medium and red high density (taken from Showell et al. 2017).

Spiny Dogfish Shark

The Atlantic Ocean DU of spiny dogfish (*Squalus acanthias*) was designated by COSEWIC as Special Concern in April 2010. In the Assessment and Status Report (COSEWIC 2010c), it is noted that although the species remains relatively abundant in Canada, its life history characteristics combined with the uncertainty regarding abundance of mature females and demonstrated vulnerability to overfishing in adjacent U.S. waters are causes for concern.

The spiny dogfish has been recognized as the most common and numerous shark in Atlantic Canada (WWF 2012). Data from tagging studies and RV surveys suggest the occurrence of several non-independent spiny dogfish stock components in the northwest Atlantic, and provide evidence supporting the existence of a metapopulation in Atlantic Canada (Campana *et al.* 2007). According to observations, several largely separated, more or less well-defined 'groups' of spiny dogfish occupy Atlantic Canadian waters, including the southern Gulf of St. Lawrence, areas around Newfoundland, the eastern and central Scotian Shelf, the Bay of Fundy, and southwest Nova Scotia. Most of these groups undertake small seasonal migrations between inshore (summer-fall) and offshore (winter-spring) areas, but remain in Canadian waters. Evidence strongly suggests that the sGSL group is a "sink" population that was colonized in the mid-1980s, making this area its permanent home with no evidence of outside immigration or recruitment. Spiny dogfish are small (~1 m, WWF 2012) schooling shark that exhibit both demersal and pelagic habits, although juveniles seem to remain in the water column (DFO 2015c). On the Scotian Shelf, they have been collected at depths from 0 to 350 m and temperatures between 0 and 12°C, with most observations occurring at 50 to 200 m and 6 to 11°C (Campana *et al.*, 2007). Spiny dogfish seem tolerant to a wide range of salinities, including estuarine waters (Compagno 1984).

As opportunistic feeders, spiny dogfish are capable of adjusting their prey selection based on locally and seasonally abundant species. They have been reported to feed on a large array of fish species, including herrings (several species), Atlantic mackerel, American sandlance and codfishes (e.g., Atlantic cod, haddock, silver hake, red hake, white hake and spotted hake) (COSEWIC 2010c). Other important prey items include invertebrates such as squids, octopuses, crabs, shrimps, amphipods, euphausiids, sea snails, polychaetes, sea cucumbers, jellyfishes and comb jellies (Compagno 1984). Spiny dogfish predators identified in the Atlantic include several shark species (mackerel, great white, tiger, blue and porbeagle), barndoor skate, lancetfish, swordfish, bluefin tuna, tilefish, goosefish and seals (COSEWIC 2010c).

Available data suggests that spiny dogfish are long-lived and slow growing with low reproductive productivity. Age at 50% maturity of individuals caught off the Atlantic coast of Canada has been estimated at 10 years for males and 16 years for females (Campana *et al.* 2009). The gestation period is up to 2 years (18 to 24 months) with the average litter consisting of 5 to 6 pups, each measuring ~20 to 30 cm in length (Compagno 1984; Campana *et al.* 2009; WWF 2012). Validated ages based on spine growth bands of individuals from Eastern Canada indicated a longevity of 31 years (Campana *et al.*, 2009), while USA sampling and aging extend it to 40 years (DFO 2014a). Generation time for Atlantic spiny dogfish is expected to be 23 years (COSEWIC 2010c).

Life history characteristics increase this species' vulnerability to overfishing, which is the only proximate threat to spiny dogfish at a population level, both globally and in Canada (COSEWIC 2010c). Populations in Canada are managed through established total allowable catches (TACs) and associated quotas; however, there are no restrictions on discarding and bycatch in other fisheries. Several threats to spiny dogfish habitat have been recognized, including coastal development, pollution, non-point source pollution, and seafloor disturbance by mobile fishing gear (ASMFC 2002).

Great White Shark

The Atlantic population of great white shark (*Carcharodon carcharias*) was first assessed as Endangered by COSEWIC in April 2006 and was listed as Endangered under SARA in 2011. As stated in the Assessment and Status Report (COSEWIC 2006b), numbers have been estimated to have declined by approximately 80% over 14 years (less than one generation) in areas of the Northwest Atlantic Ocean, outside of Canadian waters. Information on abundance trends for Atlantic Canada remains unavailable, however the status of the population occurring in these waters is considered to be the same as that of the broader population.

White shark are highly mobile, suggesting that individuals in Atlantic Canada are likely seasonal migrants belonging to a widespread Northwest population (COSEWIC 2006b). Although they have been reported in several areas off eastern Canada, including the Gulf of St Lawrence, records remain very low. As mentioned previously, it is likely that white shark occur in (or near) the CBT, however, the biological aspects surrounding this occurrence are poorly understood as research in Atlantic Canada remains limited.

MARINE MAMMALS

As part of an analysis aiming at identifying EBSAs in the Estuary and Gulf of St. Lawrence (EGSL) in relation to marine mammals, Lesage *et al.* (2007) identified the CBT as one of eleven significant areas. Based on the seasonal occupancy and identity of species and the likeliness of food resources to aggregate in this deep channel, it was determined that the trough serves mainly as a feeding function for marine mammals during the ice-free period. Reproductive and possibly molting functions for pinnipeds during winter and early fall were also reported. The CBT

EBSA was considered unique for the following reasons: 1) its physical and oceanographic features that favour biological productivity; 2) its support for what is suspected to be moderate biomasses of marine mammals, some of which have few alternate habitats in the GSL (e.g., pilot whales); and, 3) it supports a diverse megafauna (at least 12 species) and newborns from three species of seals following whelping, which have very few alternative habitats in the GSL or the Northwest Atlantic. Furthermore, the trough was considered moderately important for marine mammal aggregation, given the high diversity of species and moderate biomasses of species using this area. Finally, it was concluded that a loss of access to this EBSA would likely result in a moderate to high fitness consequence, particularly for pinnipeds during the winter, as these animals rely on this area to support the production of the year.

Cetaceans (whales, dolphins and porpoises)

According to the analysis performed by Lesage *et al.* (2007), eight of the twelve or more cetacean species that frequent the EGSL have been sighted in the CBT, including: fin whale (*Balaenoptera physalus*); humpback whale (*Megaptera novaeangliae*); minke whale (*Balaenoptera acutorostrata*); long-finned pilot whale (*Globicephala melas*); harbour porpoise (*Phocoena phocoena*); Atlantic white-sided dolphin (*Lagenorhynchus acutus*); white-beaked dolphin (*Lagenorhynchus albirostris*); and, striped dolphin (*Stenella coeruleoalba*). More recently, increased sightings of the North Atlantic right whale (*Eubalaena glacialis*) have been reported in the vicinity of the CBT (NOAA 2017; Diane Amirault-Langlais, DFO pers comm.). Based on their preference for deep waters, sperm whales are likely to occur in the CBT; however, their presence has not been documented. It is important to note that the absence of marine mammal sightings does not exclude a species from existing in a given region.

The following pages provide an overview of available information on four cetacean species of special importance (i.e., listed under COSEWIC/SARA) expected to occur in the area of the CBT. Of the four species, one is designated Special Concern by COSEWIC (harbour porpoise), while the remaining three species are listed under SARA as Special Concern (fin whale) or Endangered (blue whale and North Atlantic right whale) (Table 2).

Table 2: Marine mammal species designated under Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and listed under Species at Risk Act (SARA).

| Marine mammal species | | COSEWIC | | | SARA | | | Presence |
|----------------------------|------------------------------|------------|------------|-----------------|------------|------------|-----------------|----------|
| Common Name | Latin Name | Endangered | Threatened | Special Concern | Endangered | Threatened | Special Concern | CBT |
| Harbour porpoise | <i>Phocoena phocoena</i> | | | x | | | | Unknown |
| Blue whale | <i>Balaenoptera musculus</i> | x | | | x | | | x |
| North Atlantic right whale | <i>Eubalaena glacialis</i> | x | | | x | | | x |
| Fin whale | <i>Balaenoptera physalus</i> | | | x | | | x | Unknown |

Harbour Porpoise

The harbour porpoise (*Phocoena phocoena*) in Canada was first assessed as Threatened by COSEWIC in April 1990, a status that was re-examined and confirmed in April 1991. In May 2003, the status was downgraded to Special Concern, and remained unchanged upon re-examination by COSEWIC in April 2006. The reason for designation was related to the absence of reliable abundance information in certain areas of the range and the lack of bycatch monitoring and mitigation measures (COSEWIC 2006c). Currently, there are no estimates of abundance in eastern Canada.

The harbour porpoise is widely distributed over the continental shelves in the temperate waters of the Northern Hemisphere (COSEWIC 2006c). The Northwest (NW) Atlantic population consists of four distinct sub-populations of which three are in eastern Canadian waters: 1) Bay of Fundy/Gulf of Maine; 2) Gulf of St. Lawrence; and, 3) Newfoundland-Labrador. As its name suggests, this species can be found in bays and harbours, particularly in the summer. As mentioned previously, the harbour porpoise has been sighted in the CBT, likely occupying the area for foraging purposes and possibly other functions (Lesage *et al.* 2007). The harbour porpoise is well adapted to cold temperatures and is rarely observed in waters warmer than 16°C (Gaskin 1992). It is a relatively solitary species that has been observed to form small groups of a few individuals, although large aggregations have been reported (Hoek 1992). These larger groups are likely temporary formations driven by unusually high prey concentrations. Given their limited ability to store energy, individuals are required to feed frequently and thus remain relatively close to patches of prey (COSEWIC 2006c). Consequently, harbour porpoises tend to occur in areas where physiographic features enhance prey concentration and facilitate their capture.

There are no known published descriptions of the reproductive biology of female harbour porpoises inhabiting the GSL. Much of the research on life history characteristics has been conducted on harbour porpoises in the Bay of Fundy and the Gulf of Maine. In these areas, evidence suggests that conception occurs in early to late summer and the gestation period is 10 to 11 months (Börjesson and Read 2003). According to available data, harbour porpoises have a lactation period that lasts 8 to 12 months (Gaskin *et al.* 1984). Females in the Bay of Fundy are thought to reach sexual maturity at ~3.4 years of age, while sexual maturity in males is estimated at ~2.6 years of age (COSEWIC 2006c). Harbour porpoises are among the smallest cetaceans, rarely exceeding 1.7 m (TL) in eastern Canada. This species is sexually dimorphic, as females tend to be larger than males. In the Bay of Fundy, females have been reported to reach ~160 cm and 65 kg, while males do not typically exceed 145 cm and 50 kg (Read and Tolley 1997). Harbour porpoises are relatively short-lived, with individuals rarely reaching 20 years of age.

In the GSL, the diet of adult harbour porpoises has included capelin, herring, cod, redfish, mackerel and squid (COSEWIC 2006c), while calves in the Bay of Fundy have been observed to consume euphausiids (Smith and Read 1992). According to available data, harbour porpoises are preyed upon by great white sharks, killer whales, bottlenose dolphins and grey seals (COSEWIC 2006c; Bouveroux *et al.* 2014; Leopold *et al.* 2015).

In its 2006 assessment, COSEWIC identified bycatch in fishing gear as the most important recent and current threat to harbour porpoises in eastern Canada. Although this threat has decreased substantially with the depletion of groundfish stocks and consequent reductions in fishing effort, it remains non-negligible. Loss of habitat in the form of exclusion resulting from the use of acoustic harassment devices (AHDs) was also identified as a threat, but is not likely to be an issue as AHDs are used to deter pinnipeds from approaching salmon mariculture sites, which are not present in the CBT. Loss and degradation of habitat associated to petroleum

exploration and production is another potential threat in several areas of eastern Canada, particularly in parts of the GSL and along the Scotian Shelf. Finally, the depletion of important prey species (e.g., herring) as a result of overfishing was also identified as a potential limiting factor to harbour porpoises.

Blue Whale

The blue whale (*Balaenoptera musculus*) in Canada was first designated as Special Concern by COSEWIC in April 1983. In May 2002, the Canadian range was split into two populations, Atlantic and Pacific, at which time the Atlantic population was up-listed to Endangered. In January 2005, the Atlantic blue whale was listed as Endangered on Schedule 1 of the Species at Risk Act (Beauchamp *et al.* 2009). Its status was re-examined and confirmed in May 2012 (COSEWIC 2012d). The reason for designation is associated to the significant reduction of the original population as a result of whaling, leaving fewer than 250 mature individuals in Canada, as well as strong indications of low calving and recruitment rates.

Blue whales can be found in coastal and oceanic habitats in all of the world's oceans (Lesage *et al.* 2016). In the North Atlantic, blue whales are divided into 2 populations: the Northwest (NW) and Northeast (NE) populations. NW Atlantic blue whales are most frequently sighted off eastern Canada, typically occurring in waters of the northern GSL, including the SLE and areas off the Gaspé Peninsula, off the coasts of NS and NL, and in the Davis Strait, between Baffin Island and Greenland. Individuals from the NW Atlantic population are often observed in estuaries and shallow coastal zones where the mixing of water masses ensures high productivity of krill, their preferred prey. In a study conducted by Lesage *et al.* (2016), satellite-tagged blue whales in the GSL were often associated with slope habitats along the Laurentian Channel in the EGSL, where krill aggregations were also reported. Seasonal movements of NW Atlantic blue whales and their habitat use, including the location of breeding and wintering areas, remain poorly understood. Blue whales are known to migrate seasonally between high latitude areas in the summer and tropical/subtropical regions in the winter, although increasing evidence suggests that certain areas, such as the GSL, are occupied year-round (Lesage *et al.* 2016; Simard *et al.* 2016). In eastern Canada, blue whales are most common in the summer and fall, with migrating individuals typically leaving by early winter. Their return to Canadian waters in the spring is assumed to be driven by the high zooplankton production that occurs in the summer months. Information on spatial and temporal distribution of the blue whale in the EGSL is sparse due to limited, uneven or systematic observations. Recently, Simard *et al.* (2016) conducted a study using long-term recordings of blue whale calls to provide insight on time-space frequentation in the EGSL. Results revealed the following: a year-round presence in the sGSL and an almost year-round presence in the Lower SLE; no clear lag between the appearance and disappearance of whales at stations along the inland route from the Atlantic, suggesting an absence of a seasonal synchronous migration; and, the co-occurrence of detections at all sites during a large part of the annual cycle, indicating a dispersed population over numerous sites of interest within the GSL system. Blue whales are generally observed alone or in pairs, although significantly large groups (up to 40 whales) have been reported, most likely corresponding to the occurrence of substantial amounts of prey (krill). According to available data, migrating individuals transit in and out of the GSL through the Cabot Strait. As illustrated in Figure 18, the study conducted by Lesage *et al.* (2016) provides evidence for the occurrence of blue whales in the northern portion of the CBT during their seasonal migrations.

In the Northern Hemisphere, mating and birth of young occur from late fall to mid-winter. Evidence suggests that blue whales give birth to a single calf every 2 to 3 years following a 10 to 11 month gestation period (Beauchamp *et al.* 2009). Nursing of young lasts 7 to 9 months, followed by the weaning period, which is thought to occur at, or on route to, summer feeding areas. Both males and females attain sexual maturity between 5 and 15 years of age. Females

are generally larger than males, attaining a length of 21 to 23 m, whereas males do not exceed 21 m. Adult weight varies between 73,000 and 136,000 kg. Blue whales have an estimated generation time of 31 years (Taylor *et al.* 2007) and an estimated lifespan of at least 80 years (Yochem and Leatherwood 1985).

Blue whales are known to feed almost exclusively on euphausiids (krill) throughout their range. In the North Atlantic, *Thysanoessa inermis*, *T. raschii*, *T. longicaudata*, and *Meganctiphanes norvegica* are considered their principal prey (Sears and Calambokidis 2002). As mentioned previously, findings have shown high concentrations of krill in the CBT, with results suggesting *T. raschii* as the dominant species in this area (McQuinn *et al.* 2015; Plourde *et al.* 2016). Given their high energy requirements, it is imperative that blue whales feed exclusively in areas of substantial krill aggregations. Daily consumption of krill is estimated at 1,800 to 3,600 kg (Yochem and Leatherwood 1985). Various species of fish and copepods are also consumed; however, their contribution to blue whale diet is considered minimal. While the killer whale is the only species reported to attempt predatory attacks on blue whales (Sears and Calambokidis 2002; Ford and Reeves 2008), calves are likely also targeted by large sharks.

The Recovery Strategy for the NW Atlantic population of blue whales listed a total of nine anthropogenic threats to the recovery of this population, highlighting that activities impacting even a small number of animals could threaten this species' survival in the Atlantic (Beauchamp *et al.* 2009). Among the threats described, two represented a potential high risk for the population due to their probability of occurrence or the severity of their effect: 1) anthropogenic noises, known to degrade the underwater acoustic environment and alter animal behaviour; and, 2) reduction in food availability due to the commercial exploitation of krill, climate change, and an increasing number of krill-consuming pelagic fishes (e.g., capelin and herring) associated to the depletion of their predators caused in part by overfishing. Medium risk threats included: 1) persistent marine contaminants from various sources (e.g., agricultural, industrial and municipal waste; shipping; dredging; gas and oil exploitation; aquaculture); 2) collisions with vessels; and, 3) disturbances caused by whale-watching activities (tourists and scientists). Lower risk threats included: 1) physical harm caused by anthropogenic noise (e.g., temporary or permanent alteration of hearing thresholds; production of stress hormones; internal lesions that can be fatal); 2) accidental entanglements in fishing gear; 3) epizootics and toxic algal blooms, which can lead to mass mortalities; and, 4) toxic product spills, as: toxic fumes can harm sensitive tissues (e.g., eyes, mouth, lung membranes); ingestion can lead to gastro-intestinal and pulmonary intoxications; and, obstruction of whalebones can result in feeding problems and lead to ingestion of petroleum products.

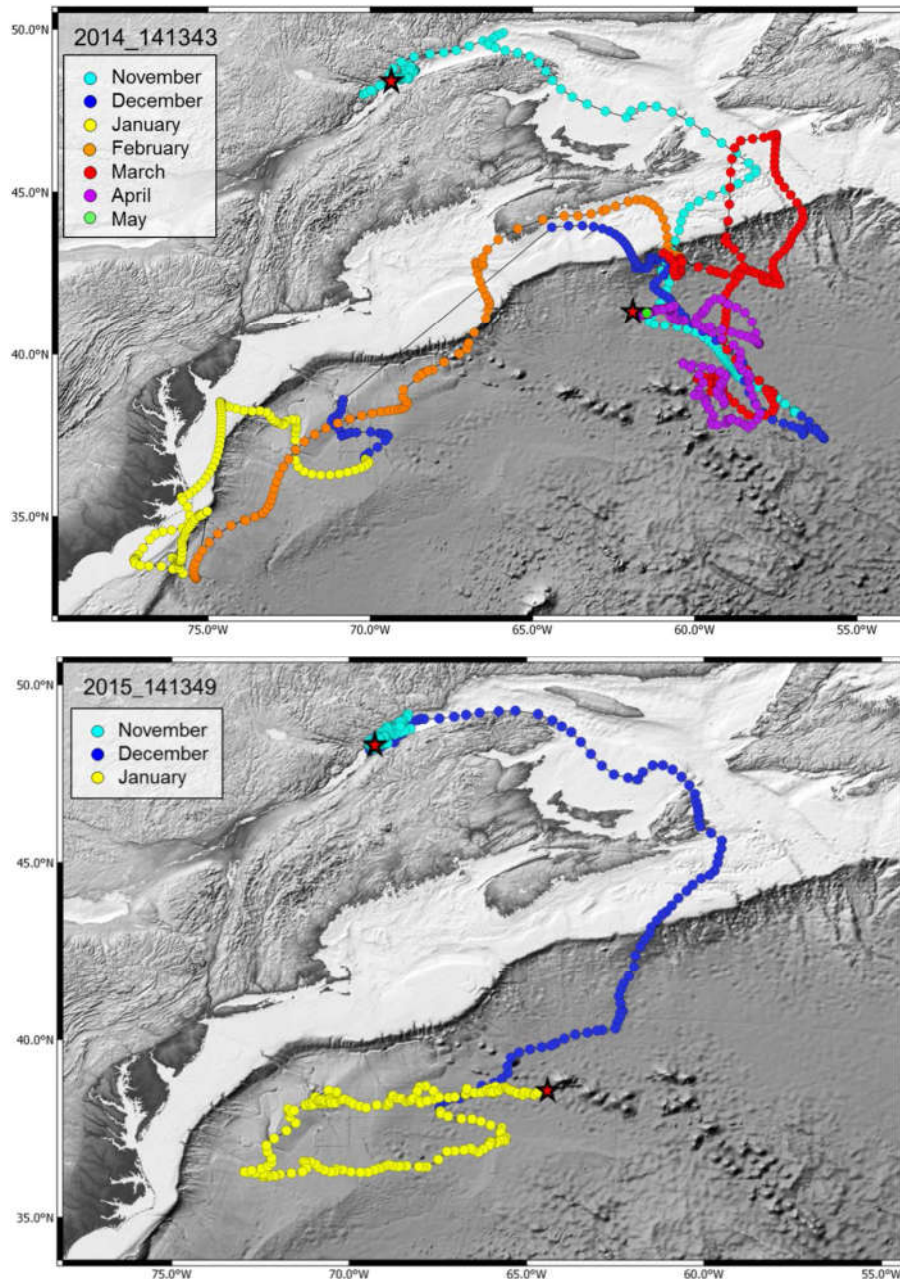


Figure 18. Switching state-space model-estimated positions for two female blue whales tagged on November 4, 2014 (B244 Upper panel) and November 3, 2015 (B197 Lower panel) in the St. Lawrence Estuary, Quebec. Stars indicate where tag was deployed in the St. Lawrence Estuary, and where transmissions ceased (1 May 2015 and 30 January 2016, respectively) off the mid-Atlantic Bight (taken from Lesage et al. 2016).

North Atlantic Right Whale

The North Atlantic right whale in Canada was designated as Endangered by COSEWIC in 1980. In 2000, the International Whaling Commission (IWC) Science Committee recognized two species in Canadian waters: the North Atlantic right whale (*Eubalaena glacialis*) and the North Pacific right whale (*E. japonica*). COSEWIC adopted the taxonomic status of these two distinct species for its decision-making in 2003. In May 2003 and November 2013, COSEWIC assessed

the North Atlantic right whale as Endangered, noting that the population was nearly driven to extinction by commercial whaling (1600s to 1935), and that the rate of recovery was limited by mortalities related to ship strikes and entanglements in fishing gear. In 2005, the North Atlantic right whale was designated Endangered under the Species at Risk Act (COSEWIC 2013b). The total population (including all age classes) in 2010 was estimated at 468 animals, of which between 122 and 136 were adult females. Right whales have shown a declining abundance trend since 2010 (Pace *et al.* 2017). The best estimate of catalogued North American right whales in 2015, provided by Pettis and Hamilton (2016), was 524 individuals. However because this estimate was based on the number of photographed whales and thus, excluded potential unphotographed whales, the authors cautioned that it should not be considered a “population estimate”. According to the most recent assessment by COSEWIC (2013), the North Atlantic right whale is one of the most endangered large whales in the world.

North Atlantic right whales are found in the temperate waters of the eastern and western North Atlantic. They occupy a wide range of depths and distances from shore as they are observed in both shallow and deep coastal waters, as well as offshore waters (COSEWIC 2013b). In the western North Atlantic, right whales range from Florida to Newfoundland and the GSL (DFO 2014b). A portion of the population (mainly reproductively mature females, calves and some juveniles) migrates each year from the winter calving grounds in coastal waters off Florida and Georgia to Canadian waters, where it spends all or part of the summer and fall months. This northward migration occurs in the late winter and early spring, with some mother-calf pairs moving along the shore. North Atlantic right whales have historically been observed feeding, nursing and socializing in Grand Manan Basin, located in the lower Bay of Fundy, and feeding and socializing in Roseway Basin, on the western Scotian Shelf. Consequently, these two areas have been identified as critical habitat for the North Atlantic right whale (DFO 2014b). However, a shift in distribution has been observed since ~2010, where individuals have been increasingly present in the sGSL, including the area of the CBT (Diane Amirault-Langlais, DFO pers. comm.; NOAA 2017). It is assumed that the distribution and movements of right whales during much of the year are driven primarily by the distribution of their prey (large zooplankton) that in turn, are governed by physical features and processes, such as frontal boundaries, vertical stability and stratification in the water column, as well as bottom topography (DFO 2014b; Woodley and Gaskin 1996). Accordingly, observations of satellite-monitored right whales in the Bay of Fundy have suggested a preference for edges of banks and basins, upwellings, and thermal fronts (Mate *et al.* 1997). At least a few individuals may be present in Canadian waters in early winter, as right whale calls have been recorded until the end of December on the Scotian Shelf (Mellinger *et al.* 2007). Sightings of North Atlantic right whales in the Bay of Fundy and in the southeastern GSL have also been reported into late December (DFO 2014b). A Schedule of Studies has been proposed to refine and identify critical habitat in Canadian waters, highlighting the GSL as an area of potential interest, as well as determining migratory routes of right whales into and out of Canadian waters as avenues for further study.

The coastal waters along the southeastern United States are recognized as the calving grounds where most North Atlantic right whales are born; however, observations of mothers with very young calves have suggested the existence of calving grounds further north, possibly off Massachusetts (COSEWIC 2013b). The estimated age at first parturition has ranged from 5 to 21 years, with a mean of ~10 years (Kraus *et al.* 2007). According to genetic analysis, paternity does not occur until ~15 years of age, which is likely due to mate competition where older males prevent younger ones from reproducing (Frasier *et al.* 2007). The gestation period for North Atlantic right whales is unknown, while a period of ~12 months has been estimated for southern right whales (Best 1994). Females give birth to a single calf at highly variable intervals, ranging from 2 to 13 years, and averaging 3 to 5 years (Kraus *et al.* 2007). Calves are nursed for approximately one year, but this can extend into a second year. Reproductive output, measured

by numbers of calves born, has shown a high degree of inconsistency throughout the years (COSEWIC 2013b). Recently, Kraus *et al.* (2016) reported a decrease of almost 40% in North Atlantic right whale calving rates since 2010. Generation time is estimated at 16 to 36 years and longevity is expected to reach at least 70 years (COSEWIC 2013b; DFO 2014b). North Atlantic right whales reach a length of ~17 m, with adult females being up to 1 m longer than males. Adults generally weigh between 60,000 and 70,000 kg.

The diet of right whales in the western North Atlantic consists of a variety of organisms, including calanoid copepods and occasionally euphausiids and barnacle larvae; however, evidence suggests that right whales depend heavily on the later oil-rich developmental stages of the copepod *Calanus finmarchicus* (Mayo and Marx 1990; Baumgartner *et al.* 2003). Foraging activity has been observed throughout most of the water column, including at the surface (skim feeding) and at depths of at least 200 m. In the lower Bay of Fundy, right whales have been known to surface with mud on their heads, suggesting feeding activity near the seafloor. Recently, a relatively high incidence of near-bottom diving was reported by Baumgartner *et al.* (2017) for right whales in the Gulf of Maine and southwestern Scotian Shelf area, including the Bay of Fundy. According to their findings, diving events were governed by the vertical distribution of right whale primary prey, *C. finmarchicus*. Due to the high energy requirement associated to the maintenance of basic metabolic functions, North Atlantic right whales seek habitats that provide substantial amounts of food sources. Consequently, the abundance of whales in any given area is subject to the important inter-annual fluctuations characteristic of copepod production. According to a recent study (Plourde *et al.* in prep), the CBT is an area of recurrent high *Calanus* biomass (1982-2012: average biomass in June was relatively high with less inter-annual variability compared to other regions of the sGSL). As a result, the CBT represents a potential feeding area for the North Atlantic right whale. Reported right whale predators include macropredatory sharks (e.g., white shark) and the killer whale (Ford and Reeves 2008; Taylor *et al.* 2012).

Since the end of commercial whaling in the 1930s, the two most important threats to the North Atlantic right whale population have been identified as vessel strikes and entanglements in fishing gear (COSEWIC 2013b; Kraus *et al.* 2016). Human-induced mortalities appear to be higher in females than males, possibly because females tend to spend more time in coastal waters and at the sea surface when lactating and accompanied by a calf. The behaviour of right whales in general makes them particularly vulnerable to vessel strikes, as studies have shown that they do not respond to vessels or to the sounds of approaching vessels. This suggests that right whales are habituated to noises associated to vessel traffic. Given their occurrence in areas of intense commercial fishing activity, both in U.S. and Canadian waters, North Atlantic right whales are constantly exposed to a high risk of entanglement in fishing gear (Johnson *et al.* 2005; Vanderlann *et al.* 2011). Head entanglements are particularly concerning as they can interfere with feeding and lead to starvation. Habitat reduction and degradation are also thought to hinder the population's recovery. The Recovery Strategy (DFO 2014b) identified several potential anthropogenic threats to habitat, including: exposure to contaminants from marine and land-based activities; exposure to excessive noise, as hearing is critical for communication, navigation and predation; vessel presence disturbance, which can disturb social interactions (e.g., nursing) or displace individuals from rich food patches; changes in food supply; and, global climate change. According to the Strategy, there are several existing and potential point and non-point sources of contaminants in Atlantic Canadian waters, including: vessel discharges; aquaculture operations; land run-off; oil and gas activities; and, dredging (through remobilization of contaminants).

Fin Whale

The fin whale (*Balaenoptera physalus*) in Canada was first assessed by COSEWIC in 1987, when it was designated *Special Concern*. In May 2005, the Canadian population was split into two designatable units (DUs), the Atlantic and Pacific populations, at which time Atlantic fin whales remained listed as *Special Concern* (COSEWIC 2005). In July 2006, this population was officially added to Schedule 1 of the *Species at Risk Act* (DFO 2017d). The Atlantic fin whale population was significantly reduced by whaling during much of the 20th century. The reason for designation is related to the uncertainty in current abundance and level of depletion compared to pre-whaling numbers, as well as the numerous threats faced by the population throughout its range (discussed below). The only published estimate of the total population in Atlantic Canadian waters is 1,352 animals, including 890 individuals off the east coast of NL and Labrador, and 462 individuals in the GSL and on the Scotian Shelf (Lawson and Gosselin 2009). These estimates, obtained through aerial surveys, represent minimum numbers as they were not corrected for diving or undetected animals.

Fin whales inhabit all oceans of the world, with greatest numbers occurring in the temperate and polar latitudes (Edwards *et al.* 2015). They have been observed in both coastal shelf waters and on the high seas. Fin whales generally migrate seasonally from low-latitude wintering areas to high-latitude summer feeding grounds (DFO 2017d); however, evidence suggests that not all individuals within a population complete a “full” migration, with some animals remaining at higher latitudes throughout the winter and at lower latitudes during warmer months (Edwards *et al.* 2015). In Atlantic Canada, summer occurrence may be observed in the EGSL, on the Scotian Shelf, in the Bay of Fundy, in the nearshore and offshore waters of Newfoundland, and off Labrador. According to the Management Plan for the Atlantic population of the fin whale in Canada (DFO 2017d), the CBT is part of this species’ distribution range.. Fin whales are rarely reported in the sGSL and details on their occurrence in the vicinity of the CBT remain unavailable. As stated by Lesage *et al.* (2007), this could be due to the low survey effort in this area, both spatially and temporally, as regular sightings by whale-watching tours based in or near Cheticamp NS, indicate that this species is present on a regular basis between May and October along the northwestern coast of Cape Breton Island, and therefore within the CBT area. The summer habitat of fin whales tends to consist of areas where oceanographic conditions support high prey concentrations. An association of fin whale distribution with oceanic fronts, areas known for high biological productivity, and low surface temperatures has been documented (DFO 2017d). In a study conducted in the Bay of Fundy, fin whales occurred primarily in areas where physical conditions favored high densities of principal prey (i.e. shallower areas with high topographic variation) (Woodley and Gaskin 1996). Fin whales have been observed alone or in pairs, but are more often in groups of 6 or 7 animals, with larger, ephemeral aggregations reported in areas of high productivity (Leatherwood *et al.* 1982; COSEWIC 2005). There is no evidence for long-term social bonds between individuals of this species.

Conception and calving occur in the warm waters of lower latitudes during the winter months, with females typically giving birth to a single calf (Mizroch *et al.* 1984; Aguilar and Lockyer 1987). Evidence suggests that the gestation period lasts 11 to 12 months and that there is a 2 to 3 year interval between calvings (DFO 2017d). The strong mother-calf bond terminates upon weaning, when the calf is approximately 6 months of age (Ratnaswamy and Winn 1993). Age at sexual maturity has been reported to vary considerably between populations in the northern hemisphere (Aguilar *et al.* 1988). In females, estimates of age at sexual maturity have ranged from 5 to 12 years, while age estimates for males have varied from 4 to 11 years. In the northern hemisphere, adults attain an average length of 24 m and weigh between 40,000 and

50,000 kg (COSEWIC 2005). Available information suggests that fin whales can live up to at least 100 years (DFO 2017d), with estimates reaching 114 years (Nowak 2003).

Fin whale diet is believed to be as much a function of availability as preference, which allows some flexibility in their feeding strategy. According to available data, fin whales forage on a variety of species, including invertebrates, such as euphausiids (krill), copepods and squid, and small schooling fish, such as Atlantic herring, capelin, and sandlance (DFO 2017d). Potential fin whale predators include large sharks, while successful predatory attacks by killer whales have been well documented (Jefferson *et al.* 1991; Ford and Reeves 2008).

According to the Threat Assessment associated to the Management Plan for fin whales in Atlantic Canada, several factors threaten this population (DFO 2017d). Threats related to noise pollution, such as seismic exploration and navigation, were considered to be of highest concern, while threats given a medium level of concern included: changes in prey availability, quantity and quality; toxic spills; vessel strikes; and, whaling, still occurring in some countries. Threats that should involve close monitoring but were associated to a smaller level of concern included: epizootic diseases; entanglement in fishing gear; marine life observation activities; pollution by contaminants; and, harmful algal blooms. Climate change was not recognized as a threat, but rather a factor that will likely add to the degree of impact of identified threats.

Pinnipeds (seals)

Four species of seals commonly occur in the Gulf of St. Lawrence: grey seals (*Halichoerus grypus*), harbour seals (*Phoca vitulina*), harp seals (*Pagophilus groenlandica*), and hooded seals (*Cystophora cristata*) (Lesage *et al.* 2007). Grey and harp seals are the most abundant pinnipeds in the GSL. The CBT, where all four species of seals have been observed, has been identified as an important part of the core area of distribution for grey, harp and hooded seals during winter months. Grey and harbour seals also occupy this area during the summer months. Grey seals in particular are dependent on this area for use as haul-out sites during the ice-free period, but this is also one of the few places where they are found in the GSL during the ice-covered period, at which time whelping occurs (Lesage *et al.* 2007).

A brief overview of available information on the four species that are most likely to occur in the CBT is provided below, including seasonal distribution, biological characteristics and threats.

Grey Seal

The grey seal (*Halichoerus grypus*) in Canada was designated Not at Risk by COSEWIC in April 1999. According to estimates from population models, the grey seal population in Atlantic Canada continues to increase (DFO 2017e). Total population size (including pups) has increased from approximately 15,000 animals in the 1960s (Hammill *et al.* 2014a) to an estimated 424,300 animals in 2016 (DFO 2017e). In the Gulf, the population has grown more slowly due to higher mortality among young animals associated with breeding on the pack ice, as well as a greater number of removals from the population (Hammill *et al.* 2014a). As mentioned previously, the significant increase in the grey seal population is considered a possible explanation for the extreme increases in natural mortality that is inhibiting the recovery of collapsed fish populations in the NW Atlantic ecosystem.

Grey seals occur on both shores of the North Atlantic Ocean. In the NW Atlantic, they are distributed from the Gulf of Maine to southern Labrador, including the GSL (shores of QC, NB, PEI, NS and NL) (Bowen 2016). Although grey seals in Canadian waters form a single genetic population (DFO 2014c), they are subdivided into three groups for management purposes based on the locations of main breeding colonies: 1) Sable Island (Sable); 2) Gulf of St. Lawrence (Gulf); and, 3) Coastal Nova Scotia (CNS). According to the most recent survey on

total pup production in eastern Canada (2016), most pups are born on Sable Island (85%), while smaller fractions are born in the Gulf and along the coast of Nova Scotia (11 and 4%, respectively) (DFO 2017e). NW Atlantic grey seals breed on islands, isolated beaches or pack-ice from December to February. In the GSL, grey seals whelp on pack ice mainly in the Northumberland Strait and off the west coast of Cape Breton (DFO 2014c), including the CBT (Lesage *et al.* 2007). Pups are nursed for a period of approximately two weeks. Adults mate during the later stages of nursing before returning to sea to forage. After the breeding season, animals normally exit the GSL moving onto the Scotian Shelf during the spring (Benoît *et al.* 2012), although some remain in the area of the CBT throughout the summer (Lesage *et al.* 2007). In Canada, adult females moult in May-June, while moulting in males occurs about a month later. An overlap in the distribution of animals from the different colonies occurs outside of the breeding season (Bowen 2016). Males can weigh up to 350 kg and reach a length of 2.3 m, whereas females are smaller, typically not exceeding 250 kg and 2 m in length (DFO 2014c).

Grey seals consume a wide variety of forage and groundfish species (DFO 2014c). Individuals occurring along the west coast of Cape Breton Island have been observed to prey mostly on white hake, sandlance, Atlantic cod, herring, capelin and flatfish (Hammill *et al.* 2014b). Furthermore, there is growing evidence suggesting that grey seals also prey on harbour porpoises (Leopold *et al.* 2015; Bouveroux *et al.* 2014). Presumably due to their large size, grey seals have few predators in eastern Canada (DFO 2011e). According to available information, potential predators include sharks (e.g., great white shark, blue shark, shortfin mako shark, Greenland shark) and killer whales.

Harbour seal

The harbour seal in Canada (*Phoca vitulina concolor*) was assessed as Not at Risk by COSEWIC in November 2007 (COSEWIC 2007). In Atlantic Canada, trends in harbour seal numbers are largely undocumented. In 2005, the population in the EGLS was estimated at ~4000 to 5000 animals (Robillard *et al.* 2005).

There are five subspecies of harbor seals worldwide, with one being recognized in Canada (Western Atlantic population) as *P.v. concolor*. The harbour seal is a non-migratory coastal species that is widely distributed in the temperate and arctic waters of the northern hemisphere (Lowry 2016). Harbour seals commonly occur in bays, rivers, estuaries and intertidal areas. Haul-out sites include rocks, sand and shingle beaches, sand bars, mud flats, vegetation, sea ice, glacial ice and a variety of man-made structures. Observations suggest that harbour seals are mostly solitary at sea, although they occasionally form small groups. Ephemeral aggregations can form in response to feeding opportunities and concentration of prey. In Atlantic Canada, harbour seals are observed in the coastal waters of QC, NB, PEI, NS, and NL/Labrador (COSEWIC 2007), with the CBT being identified as an area occupied during the summer months. Consequently, harbour seal colonies are found in several areas of the EGSL, where they reside throughout the year (Benoît *et al.* 2012). This species is considered the least abundant of the four species of seals that commonly occur in the GSL. Aggregations in the GSL have been observed during the breeding season in the following areas: along the western shore of Cape Breton; around Prince Edward Island; and, between Miramichi Bay and Baie des Chaleurs (Jacques Whitford Environment Limited 2001). Whelping occurs on land in May and June and pups are nursed for approximately one month. Mating occurs after the nursing period, and is followed by a period of molt (midsummer to early fall) (Lowry 2016). Adult males in eastern Canada attain a length of ~1.5 m while females do not generally exceed ~1.4 m. Males are also typically heavier than females, weighing on average 90 kg versus 70 kg (COSEWIC 2007).

Harbour seals are generalist predators that feed on a wide variety of fishes, cephalopods and crustaceans. Common prey species include sand lance, herring, pollock, flatfish, cod, silver hake, alewife, smelt, mackerel, capelin and squid (COSEWIC 2007; Lowry 2016). Several animal species are known predators of harbour seals, including killer whales and sharks (Greenland, great white and possibly other species) (Jefferson *et al.* 1991; Lowry 2016).

Given their proximity to shore, harbour seals are vulnerable to contamination by various anthropogenic pollutants, including those associated to industrial and agricultural activities (e.g., organochlorines, PCBs, dioxins) (Lowry 2016). Large-scale oil spills, as well as chronic spills and discharges, can lead to mortality of exposed harbour seals. Foraging behaviour and physical condition of seals can be negatively impacted by noise and other disturbances from offshore oil and gas and renewable energy (e.g., windfarms) developments. Finally, entanglement and bycatch are also reported as threats to harbor seals.

Harp Seal

No designation under COSEWIC exists for the harp seal (*Pagophilus groenlandicus*) as this species has never been assessed. However, the northwest Atlantic harp seal population is considered healthy and abundant (DFO 2017f). According to model estimates, the NW Atlantic harp seal population consisted of 7.4 million animals in 2014 (Hammill *et al.* 2014c). The population appears to be relatively stable, showing little change in abundance since 2004, although pup production has become highly variable among years.

The harp seal, considered the most abundant pinniped species in the northern hemisphere, exhibits a widespread distribution in the North Atlantic and the adjacent Arctic Ocean and shelf seas (Kovacs 2015). This species is highly migratory, as individuals travel long distances between Arctic and sub-Arctic regions on an annual basis (DFO 2016f). The NW Atlantic population, which is the largest of three populations, spends its summers in the eastern Canadian Arctic and Greenland. In the fall, most of the seals from this population migrate southward to Atlantic Canada, inhabiting the GSL (including the CBT area or the waters off southern Labrador and northern Newfoundland, where they give birth (whelp) in the winter (late February or March) on medium to thick first year pack-ice. Older seals undergo a period of moulting during the post-breeding months, from early April to early May, resulting in large seal aggregations on sea ice off northeastern Newfoundland and in the northern GSL. Following the moulting process, seals disperse and eventually return to northern latitudes, mostly along the continental shelf. A small number of harp seals may reside in southern waters throughout the summer, while a portion of the population remains in the Arctic throughout the year. Male and female seals are similar in size, with adults averaging 1.6 m in length and 130 kg in weight prior to the breeding season (DFO 2016f).

Harp seals forage heavily in the winter and summer and to a lesser extent in the spring and fall (Kovacs 2015). They prey on both fish and invertebrates throughout their range, although the diet of pups and juveniles consists mostly of invertebrates. In the GSL, harp seals prey on capelin, herring, Atlantic cod, Arctic cod and redfish. Reported natural predators include polar bears, killer whales and Greenland sharks (Jefferson *et al.* 1991; Kovacs 2015).

The annual extent and duration of ice cover in Atlantic Canada have varied considerably over the last four decades. This is particularly true for the GSL, where declining trends in ice cover severity have been observed since 1990, with a few rebounds in 2003, 2014 and 2015. This poses a serious threat to harp seals, given their reliance on stable ice as a platform for resting, moulting, pupping, and early development of their young (Kovacs 2015). With climate change expected to result in a further decline in seasonal ice cover in Atlantic Canada, breeding in the GSL may be noticeably reduced or even absent in future years (Hammill *et al.* 2014c). Another

significant threat to the harp seal is the reduced availability of important prey, such as cod, capelin and herring (Kovacs 2015).

Hooded Seal

The hooded seal (*Cystophora cristata*) in Canada was assessed as Not at Risk by COSEWIC in April 1986. Existing information on historical trends in abundance of the NW Atlantic population is limited. In Canada, the estimated total population in 2005 was 593,500 animals (Lesage *et al.* 2007). According to population models, the NW Atlantic population exhibited a moderate increase in both pup production and population size between the mid-1980s and 2005 (Stenson 2005). Aerial surveys from 2005 suggest that approximately 6,600 pups were born in the Gulf in 2005, compared with approximately 107,000 pups born off the NE coast of Newfoundland and 3,300 pups born in Davis Strait (DFO 2015).

The hooded seal occupies the high latitudes of the North Atlantic, and seasonally extends its range to the northern waters of the Arctic Ocean (Kovacs 2016). It is a large, highly migratory mammal that lives in deep waters and is associated with the outer edge of ice cover during most of the year. Hooded seals in Atlantic Canada are part of one of two populations - the NW Atlantic population. Animals from this population breed in three locations: 1) the Davis Strait; 2) off the coast of northern Newfoundland/southern Labrador; and, 3) the southern GSL, including the CBT. Hooded seals migrate from northern waters to breeding grounds in the EGSL in late fall/early winter (Lesage *et al.* 2007). The breeding season is very short and spans approximately 2.5 weeks through March and early April. Consequently, pups are born on pack ice when the pack is already breaking up. After this period, hooded seals disperse to feed and migrate to moulting areas off southeast Greenland. Individuals moult in July, thereafter migrating northward to foraging grounds in Baffin Bay and Davis Strait. This species is thought to be mainly solitary outside of the breeding and moulting seasons, when it tends to form loose aggregations (Kovacs 2016). Adults exhibit sexual dimorphism, with males being larger than females (average of 2.5 m in length and 300 in weight versus 2.2 m and 160 kg).

Hooded seals feed on a variety of fishes and invertebrates, including Polar and Atlantic cod, Greenland halibut, redfishes, capelin, herring, sand eels, squid and a variety of amphipods (Kovacs 2016). According to available information, animals that prey on hooded seals include polar bears, killer whales and Greenland sharks.

Due to their reliance on pack ice to conduct essential biological functions, such as resting, moulting and pupping, hooded seals have been deemed one of the most sensitive Arctic/subarctic marine mammal species to the impacts of climate change (Kovacs 2016). It is thought that their preference for heavy sea ice conditions during the breeding season will result in the abandonment of their southern-most breeding grounds in the future.

LEATHERBACK SEA TURTLE

The leatherback sea turtle in Canada was first designated as Endangered by COSEWIC in April 1981, a status that was re-examined and confirmed in May 2001. When the Species at Risk Act (SARA) was enacted in 2003, the species was immediately listed under Schedule 1 of the Act. As of May 2012, the leatherback turtle in Canada has been divided into two populations: the Pacific and Atlantic populations. The Atlantic population was designated as Endangered in May 2012 due to a sharp population decline, estimated at over 70% (COSEWIC 2012e).

Leatherback sea turtles are the largest and most widespread marine turtles in the world. Most individuals occurring in Atlantic Canadian waters are large sub-adults or adults that can attain a body mass of 640 kg and reach a curved carapace length (CCL) of 175 cm. The average size of leatherbacks found in these waters is 393 kg with a CCL of 148.1 cm (James *et al.* 2007). Data

from genetic and tag-recapture studies confirm that leatherback turtles migrate annually to Atlantic Canada from feeding/breeding areas and nesting beaches in tropical and subtropical latitudes of the western Atlantic (Goff *et al.* 1994; James *et al.* 2005a; 2005b; 2007; Stewart *et al.* 2013). These extensive migrations have been reported to cover up to 18,000 km round-trip.

Leatherbacks migrate widely throughout the North Atlantic in search of highly-concentrated and seasonally-abundant prey, with a large proportion of individuals exhibiting fidelity to specific foraging areas off eastern Canada (James *et al.* 2005c; Stewart *et al.* 2013). Although many leatherbacks are present in Atlantic Canada by July, peak densities in high-use habitats in the northern range, such as the shelf waters off Cape Breton Island and the southern Gulf of St Lawrence, occur in late summer and early fall (James *et al.* 2005c; 2006a). The southward migration to nesting grounds is observed in the fall, with most turtles departing the temperate northwest Atlantic waters by mid-October (James *et al.* 2007). In Atlantic Canada, leatherback sea turtles have been observed in water depths ranging from 2 to 5033 m, although most turtles have been observed on the continental shelf within the 200 m isobath (James *et al.* 2006a). Foraging in Canadian waters occurs during daylight hours within the top 6 m of the water column. Leatherback turtles seldom dive deeper than 50 m while in northern waters, and spend ~50% of their time (day and evening) at the surface (James *et al.* 2006b). Sightings in Atlantic Canada have been associated to a mean sea surface temperature of 16.6°C, with 19.7% of sightings reported in waters <15°C (James *et al.*, 2006a). A review of satellite tracking data identified three primary areas of important habitat to leatherbacks in Atlantic Canadian waters, one of which (entitled “GSL”) includes the CBT (DFO 2012a). The “GSL” important habitat comprises the southeastern GSL and waters off eastern Cape Breton Island, including Sydney Bight, the Cabot Strait, portions of the Magdalen Shallows and adjacent portions of the Laurentian Channel.

According to available data, the diet of leatherback turtles consists primarily of gelatinous zooplankton, mostly including jellyfish, but also salps and siphonophores. A study conducted on individuals in shelf waters off Cape Breton Island identified Lion’s Mane Jellyfish as the dominant prey (83 to 100%), while Moon Jellyfish were also consumed (Heaslip *et al.* 2012). Reported predators of juvenile, sub-adult and adult leatherbacks along their full geographic range include sharks, barracuda, crocodiles, jaguars and killer whales (COSEWIC 2012e); however, threats associated to predation is minimal for large-sized mature individuals.

The life history strategy of leatherback sea turtles is expected to be similar to that of other long-lived species (i.e., delayed age at maturity, low and variable survival in egg and juvenile stages, and a relatively high and constant annual survival in subadult and adult stages) (COSEWIC 2012e). Studies examining age at maturity have revealed varying results, with estimates ranging from 2 years to 3 decades. Given these findings, generation time is expected to be over 30 years (COSEWIC 2012e). Available data suggests that the sex-ratio is female-biased, with one study reporting a ratio of 1.86:1 for leatherbacks occurring in coastal areas of Nova Scotia (James *et al.* 2007). Females nest at 2- to 4-year intervals, laying clutches of ~80 eggs (reported range is 23 to 166 eggs) several times during a nesting season (3 to 6 months). Leatherback turtle hatchlings are larger than those of other sea turtle species, weighing ~40 g (COSEWIC 2012e). Age composition of populations, growth rates and survivorship across life stages remain unknown.

Several anthropogenic activities threaten the survival of the Atlantic population of leatherback sea turtles throughout their range. Fisheries interactions, particularly those involving fixed fishing gear, have been identified as an important source of injury and mortality for individuals foraging in Atlantic temperate waters (James *et al.* 2005c, DFO 2012b) and have been reported as the main threat to leatherbacks, both globally and in Atlantic Canada. Due to their pelagic nature, individuals are vulnerable to entanglement and incidental capture in fishing gear such as

buoy lines, mooring lines, gill nets, fish traps, and aquaculture gear (e.g., collecting ropes). Evidence suggests that most fisheries in Atlantic Canada pose a threat to leatherback turtles (DFO 2012b; DFO 2013). Other potential threats include: collisions with commercial and recreational vessels; interactions with marine pollution (e.g., ingestion of plastic and contaminants, entanglement in marine debris such as ghost fishing gear and plastic); acoustic disturbance resulting from activities such as commercial shipping, industrial development and natural resource exploration and extraction; and climate change (COSEWIC 2012e; DFO 2012b). With findings suggesting that Canadian waters support one of the highest summer and fall densities of leatherback turtles in the North Atlantic (James *et al.* 2006a), it is likely that mortalities in these northern waters contribute to declines in the overall population.

CONCLUSION

The extensive information provided in this document highlights the physical and biological components of the marine environment of the CBT that have led to its identification as an area of high ecological significance within the Gulf of St. Lawrence. The distinctive features of the physical environment, particularly water depth, water column stratification and the occurrence of upwelling, are favorable to biological productivity, as proven by the various biological functions associated to the trough (e.g., migration, feeding, nursing, reproduction) and the moderate to high biomass of several taxa.

The physical structure and oceanographic processes of the CBT are considered important to primary and secondary production of the area. Analyses have revealed strong phytoplanktonic productivity in the northern portion of the trough and provided evidence for greater diversity in the zooplankton community compared to adjacent areas of the sGSL. Findings have shown high concentrations of krill in the CBT, as well as a recurrent high *Calanus* biomass characterized by less interannual variability than other areas of the sGSL. The CBT provides ideal habitat grounds for a great variety of invertebrate species, and thus it is not surprising that evidence supports the occurrence of high aggregations of various taxa, including crustaceans, molluscs, echinoderms, ascidians and anemones. A high biodiversity of fish is also supported by the marine environment of the trough, with most fish being seasonal residents that occupy the area for specific biological functions (e.g., foraging, spawning, migration). Fishes occupying the trough include species that are designated as Endangered (e.g., Atlantic bluefin tuna, Atlantic cod, white hake, winter skate), Threatened (e.g., Acadian redfish, American plaice) or Special Concern (e.g., smooth and thorny skates, Atlantic wolffish) by COSEWIC. The CBT has been recognized as an important migration corridor (spring and fall) for several fish species (e.g., cod, white hake) and a fundamental summer feeding ground for small pelagic fishes (e.g., adult Atlantic herring, capelin, silver hake) and demersal fishes (witch flounder and white hake). Results from research surveys in the sGSL have revealed significant declines in stock biomass and a progressive shift in distribution of several fish species (e.g., cod, white hake, thorny skate) throughout the years, with individuals moving out of inshore areas and into deeper waters of the CBT and along the slope of the Laurentian Channel. Several species of shark are known to occupy the waters surrounding Cape Breton Island, including the endangered porbeagle and great white sharks. Available data suggests that the CBT is an important migration path for shark, including porbeagle, mako and blue sharks. The CBT supports a diverse megafauna of marine mammals, with some species having few alternate habitats in the GSL (e.g., pilot whales). Observations in the trough have confirmed the occurrence of species listed under SARA, including the fin whale (Special Concern), blue whale (Endangered) and North Atlantic right whale (Endangered). The CBT has been identified as an important part of the core area of distribution for grey, hooded and harp seals during winter months, while grey and harbour seals occupy the area during the summer months. Finally, the CBT falls within one of three areas recognized as important foraging habitat to the leatherback sea turtle in Atlantic Canada. Peak

densities of leatherbacks, a species listed as Endangered under SARA, occur in the CBT area in late summer and early fall.

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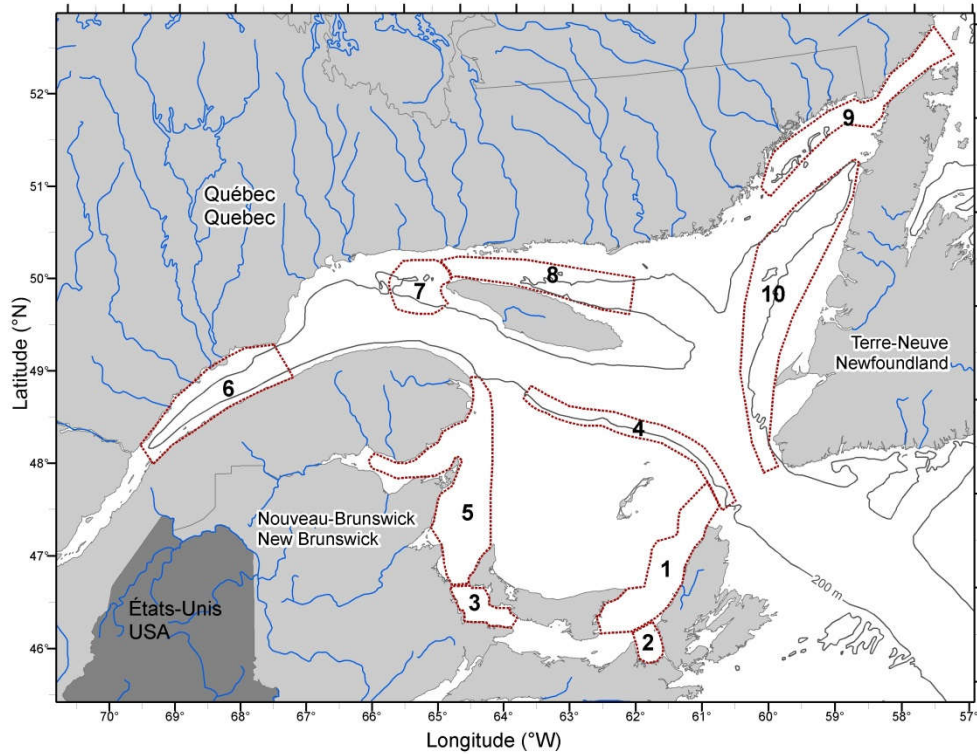
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APPENDIX



Appendix 1. Ecologically and Biologically Significant Areas (EBSA) distribution in the Estuary and Gulf of St. Lawrence: EBSA (1) western Cape Breton, (2) St. George's Bay, (3) Northumberland Strait, (4) the southern fringe of the Laurentian Channel, (5) the south-western coast of the Gulf, (6) the lower estuary, (7) western Anticosti Island, (8) northern Anticosti Island, (9) the Strait of Belle Isle, (10) the west coast of Newfoundland (DFO, 2007).