Scotian Shelf - Bay of Fundy Bioregional

Marine Refuge Management Plan 2024

PART II: Site Profiles

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Cover photo: *Paragorgia arborea* (Bubblegum Coral) & shrimp. Andrew Cogswell, 2009.

CONTENTS

Acronyms

AOI	Area of Interest
AUV	Autonomous Underwater Vehicle
CCGS	Canadian Coast Guard Ship
CSAS	Canadian Science Advisory Secretariat
DFO	Fisheries and Oceans Canada
EBSA	Ecologically and Biologically Significant Area
ECMR	Eastern Canyons Marine Refuge
EEZ	Exclusive Economic Zone
LCCA	Lophelia Coral Conservation Area
MPA	Marine Protected Area
NECMR	Northeast Channel Marine Refuge
NOAA	National Oceanic and Atmospheric Administration
OECM	Other Effective Area-Based Conservation Measure
ROPOS	Remotely Operated Platform for Ocean Science
ROV	Remotely Operated Vehicle
SBA Policy	Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas
SS - BOF	Scotian Shelf - Bay of Fundy
US	United States
WEBMR	Western Emerald Banks Marine Refuge

List of Figures

1. Northeast Channel Marine Refuge

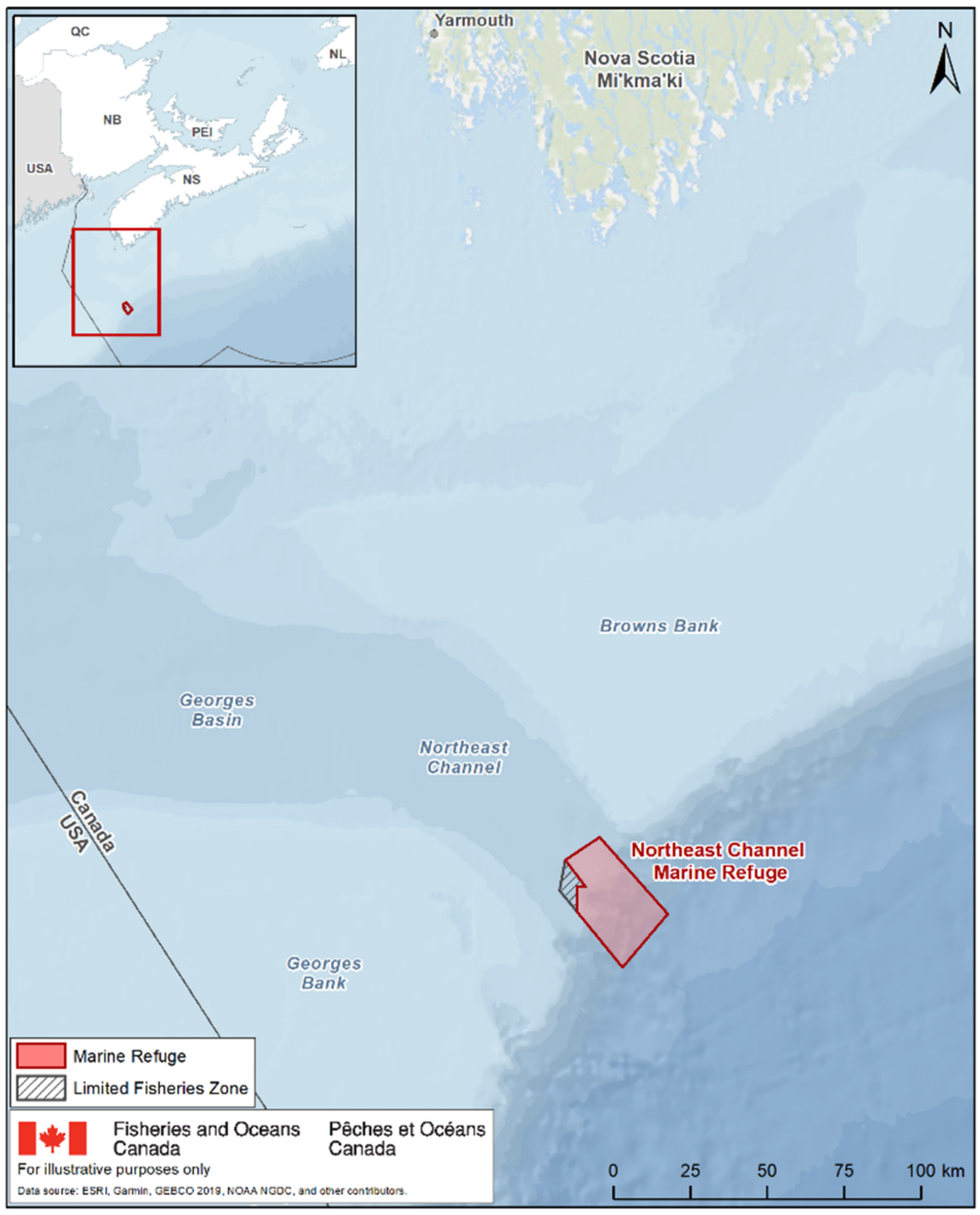


Figure 1. Map of Northeast Channel Marine Refuge.

Description: The Northeast Channel Marine Refuge (NECMR) lies on the outermost portion of the Scotian Shelf in the Gulf of Maine, extending directly south from the tip of Nova Scotia at Cape Sable Island (Figure 1). NECMR lies between Browns Bank and Georges Bank, and was first established as a coral conservation area in 2002 prior to the implementation of the SBA Policy. In 2016, based on CSAS guidance on OECMs, the conservation area was evaluated and recognized as a marine refuge. This marine refuge protects dense concentrations of cold-water corals, primarily octocorals such as bubblegum coral (*Paragorgia arborea*) and seacorn coral (*Primnoa resedaeformis*). These cold-water corals are structure-forming, creating habitats for other species within the ecosystem. Cold-water corals are particularly sensitive to mobile and fixed fishing gears that contact the bottom through both direct (e.g. removal and/or damage) and indirect (e.g. smothering by sedimentation) impacts (DFO, 2010). Due to this sensitivity, bottom-contact fishing is prohibited in NECMR. A Limited Fisheries Zone was established on the western edge of the marine refuge that is closed to all bottom-contact fishing gear except for groundfish longline with an At-Sea Observer.

Fundian Channel-Browns Bank Area of Interest (AOI) is a proposed *Oceans Act* MPA. Announced in 2018, coral conservation is a priority for the site and NECMR is fully included within the site boundaries currently under consultation. If designated, NECMR will be replaced by proposed regulatory measures that protect coral communities from bottom-contact activities throughout the channel feature, including areas currently outside the marine refuge.

Summary Table:

Conservation objectives	1. Protect cold-water corals including significant concentrations of large gorgonian corals (e.g. *Paragorgia arborea* and *Primnoa resedaeformis*). 2. Protect benthic habitats and associated communities.
Legislative authority	*Fisheries Act* closure in license conditions
Date established	2002
Size	Marine Refuge: 391 km^2 Limited Fisheries Zone: 33.7 km^2
Notable species	Cold-water corals such as bubblegum coral (*Paragorgia arborea*), seacorn coral (*Primnoa resedaeformis*), armoured sea fan coral (*Acanthogorgia armata*), bamboo corals *(Keratoisis grayi, Acanella arbuscula), Paramuricea* spp., sea pens (*Balticina finmarchica*, *Kophobelemnon* sp., *Pennatula* spp.), soft corals (*Anthomastus* spp.), and cup coral (*Desmophyllum dianthus*)
Main habitat types	Continental rise, shelf channel, and slope
Restrictions	The marine refuge is closed to all commercial bottom-contact fishing gear including bottom and mid-water gillnet, bottom trawl, bottom handline/jig, Danish or Scottish seine, dredge/dragging, bottom longline, fish traps, and traps/pots. A Limited Fisheries Zone exists on the western edge of the marine refuge (in 5Z) allows for groundfish longline fishing with an At-Sea Observer and remains closed to all other bottom-contact fishing.

Conservation Milestones: The area was initially identified as being significant to corals through reports from harvesters that described the presence and abundance of several coral species in this area (Breeze et al., 1997; DFO, 2006). Visual surveys conducted by DFO Science in 2000 and 2001 confirmed a high density of various cold-water corals (Mortensen et al., 2005). A DFO-industry working group was established to advise on protection measures for this area, including options on boundaries for a closure to bottom-contact fishing gear (Breeze & Fenton, 2007). In the spring of 2002, DFO consulted with industry on a boundary proposal and concerns from various fleets were brought forward, including groundfish longline representatives which noted the historical and active fishing presence in the area. A zoning scheme was put in place to allow for some continued activity by this fleet in a portion of the closure to better

understand the presence of corals and fishery interactions, with a final adjustment being made in 2003 to simplify monitoring and management. This Limited Fisheries Zone is open only to longline gear for groundfish with an At-Sea Observer and is closed to all other bottom-contact fishing activity.

Ecological Components of Interest:

Habitat: The Northeast Channel, also referred to as the Fundian Channel, is a large channel between Georges Bank and Browns Bank that extends into the deeper slope area as a depositional fan feature (Stortini, 2015). In the southern part of the channel feature, the substrate is mixed including relief areas of exposed bedrock, boulders, and cobbles providing suitable habitat for aggregations of cold-water corals (Stortini, 2015). A persistent clockwise gyre over Browns Bank, upwelling at the continental shelf, and strong tidal currents result in constant flow in and out of the channel promoting the mixing of important nutrients for filter-feeding organisms (DFO, 2020; Kostylev et al., 2001).

Species of conservation focus: Twelve species of cold-water corals have been identified within the protected area from depths of 190 m to 2000 m (Bennecke & Metaxas, 2017; Cogswell et al., 2009; Mortensen et al., 2005). Cold-water corals are considered ecologically significant species as they add structural complexity to the sea-floor, providing important habitat for many species. The Northeast Channel contains aggregations of large gorgonian corals including bubblegum coral (*Paragorgia arborea*) and seacorn coral (*Primnoa resedaeformis*) and is thought to contain the densest concentration of seacorn coral in the Maritimes, and possibly Atlantic Canada (King et al., 2016). Anthipatharia spp. (black/thorny corals), which are extremely rare and listed as threatened under the International Union for Conservation of Nature, have also been found in the deeper waters of the channel.

Bubblegum coral *(Paragrogia arborea).* DFO, 2007.

Other species: Other species found within NECMR include a variety of fish and invertebrates such as echinoderms and crustaceans, which are often found living on coral colonies. Commercially important groundfish species found within NECMR include Atlantic cod, haddock, cusk and Atlantic halibut.

Past Research: Initial visual data surveys from DFO Science in 2000, 2001, 2004, and 2005 confirmed the presence of large aggregations of cold-water corals in the area. For example, 45 Campod (a towed camera system) transects and 7 transects using the remotely operated vehicle (ROV) ROPOS (Remotely Operated Platform for Ocean Science) were conducted in 2004 (Mortensen et al., 2005). The 2005 mission recorded the state of seacorn coral and bubblegum coral both within and outside the western boundary of NECMR. DFO, Dalhousie University, and the National Oceanic and Atmospheric Administration (NOAA) conducted several ROV (using ROPOS) transects throughout the channel and into deeper waters in 2006, 2010, 2014, and 2019 to analyze the existing coral populations (Bennecke & Metaxas, 2015; Cogswell et al., 2009; Wang et al., 2022). Research vessel trawl survey data supplemented with other available data has been used to identify significant benthic areas and to create presence probability distribution models for corals within and around the marine refuge to aid in the identification of coral hotspots (Kenchington et al., 2016; Wang et al., 2022) (Figure 2).

Ongoing Research: Cooperation between DFO and Dalhousie University allows for continued exploration of this area through Contribution Agreements. These missions aim to determine cold-water coral population recovery, areas of density, and recruitment development. The broader scope of the project centres on the understanding of factors that shape the distribution of deep-water corals in the Gulf of Maine and adjacent continental slope. In 2024, another collaborative mission between DFO, Dalhousie University, and NOAA conducted several ROV (using ROPOS) transects in Canadian waters including within NECMR. Two areas were targeted, including previously surveyed coral communities to measure changes in coral density, size, and presence which contributes to monitoring efforts plus previously unsurveyed portions across the eastern boundary.

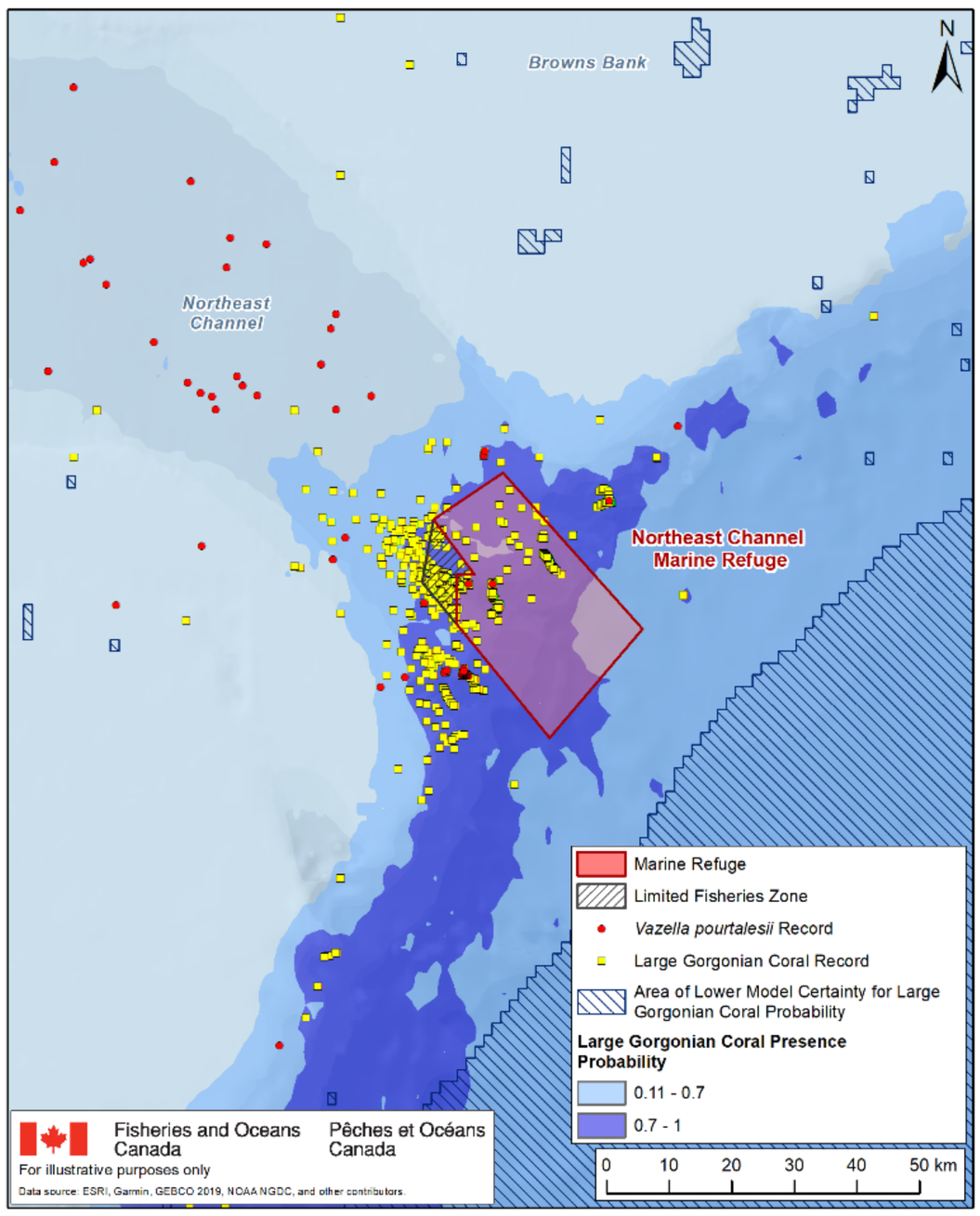
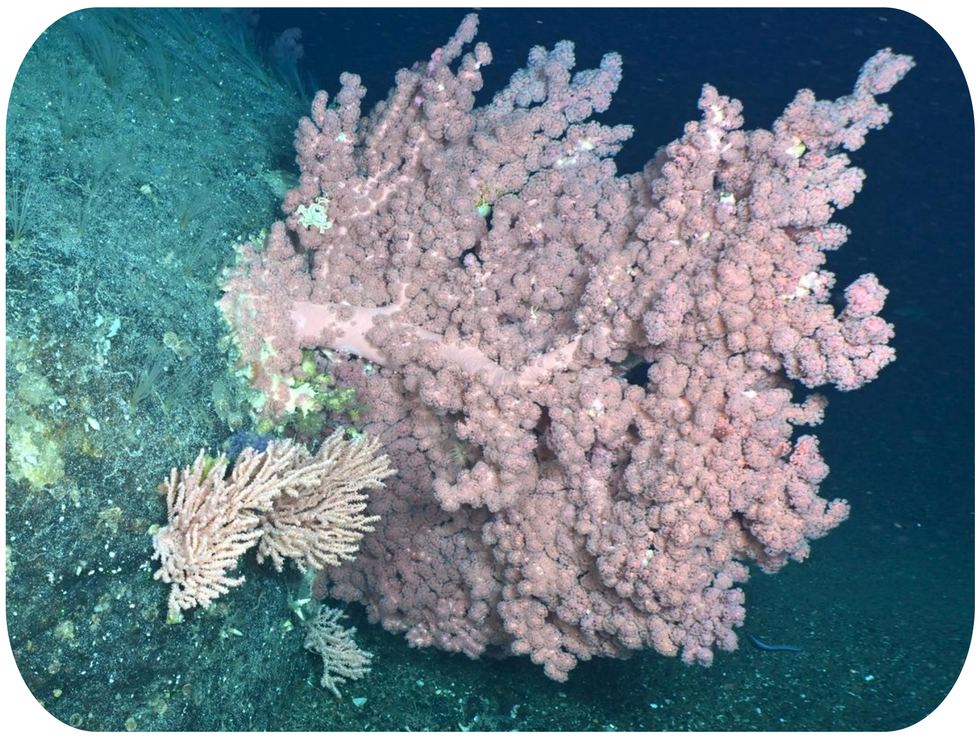


Figure 2. Large gorgonian coral records and presence probability model.



Bubblegum coral *(Paragorgia arborea).* Anna Metaxas, Dalhousie University/ Martha Nizinski, NOAA/ CSSF, 2024.

Climate Change: As a consequence of climate change, NECMR is expected to experience shifting environmental conditions, primarily warming bottom and surface temperatures at a faster rate than other areas within the SS-BOF bioregion (Brickman et al., 2021). Environmental changes such as increasing ocean temperatures, may cause poleward and vertical distribution shifts of cold-water corals, like bubblegum coral and seacorn coral (Poloczanska et al., 2016). There are several interrelated variables influencing suitable habitat for cold-water corals resulting in different predicted outcomes in climate change scenarios. For example, based on one site-level climate change modelling scenario, the probability of occurrence and the extent of suitable habitat for bubblegum coral is expected to increase within NECMR (Wang et al., 2022). However, these corals may be exposed to novel environmental conditions by 2046-2065 as bottom temperatures within the NECMR are projected to increase outside of the known thermal range for bubblegum coral (3°C - 7°C) (Wang et al., 2022). Therefore, despite the predicted increase in suitable habitat based on certain variables, it is unknown if the bubblegum coral within NECMR will be able to adapt to the increased bottom temperatures (Wang et al., 2022). Through continued monitoring, research, and the adaptive management of the NECMR, the early detection of climate change impacts is possible, resulting in increased opportunity for the persistence and sustainability of bubblegum coral.

Conservation Network: NECMR contributes to various regional priorities and targets established through the SS-BOF bioregional conservation network (King et al., 2021) including the representation of important oceanographic and geomorphic features such as the Gulf of Maine, shelf channel, and continental slope. Additionally, this site contributes to other bioregional conservation network targets such as the protection of biogenic habitat including small and large gorgonian coral aggregations, and the protection of habitat for depleted species including cusk. NECMR has also been recognized to have hydrographic connectivity with other conservation areas in the SS-BOF bioregion including Corsair and Georges Canyons Marine Refuge.

Site-Specific Priorities:

- Potential expansion of coral protection measures as part of the Fundian Channel Browns Bank AOI and potential designation as an *Oceans Act* MPA. If not put in place, a revised marine refuge boundary would be required to address coral protection needs.
- Monitoring and surveillance of commercial fishing activity adjacent to the marine refuge.

Coordinates for Northeast Channel Marine Refuge:

42° 04′ N	65° 44′ W
42° 07′ N	65° 38′ W
41° 57′ N	65° 26′ W
41° 50′ N	65° 34′ W
41° 57′ 18″ N	65° 42′ W
42° 00′ 30″ N	65° 42′ W
42° 00′ 30″ N	65° 40′ 30″ W

Limited Fisheries Zone:

42° 04′ N	65° 44′ W
42° 00′ N	65° 45′ W
41° 57′ 18″ N	65° 42′ W
42° 00′ 30″ N	65° 42′ W
42° 00′ 30″ N	65° 40′ 30″ W

2. Emerald Basin and Sambro Bank Marine Refuge

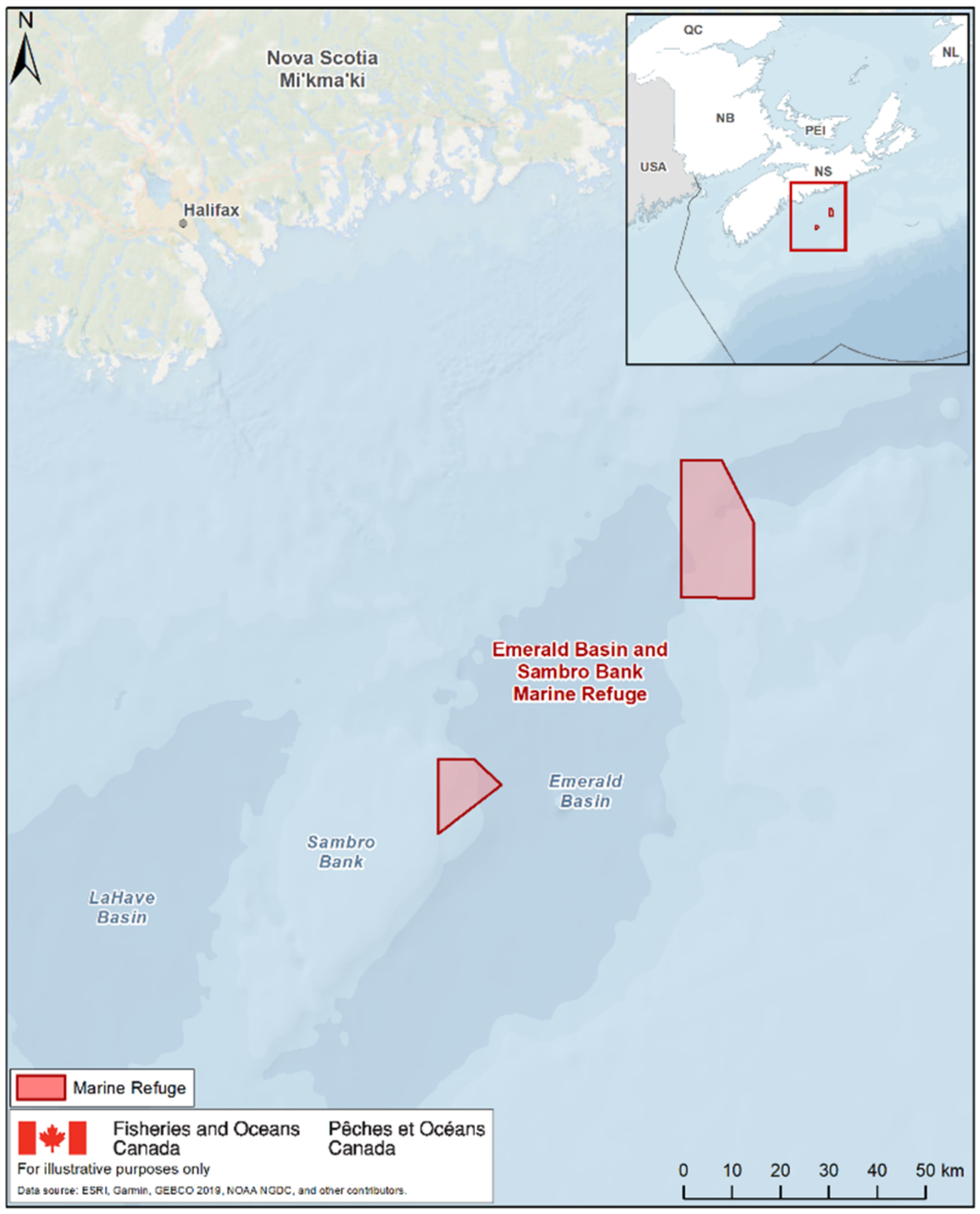


Figure 3. Map of Emerald Basin and Sambro Bank Marine Refuge.

Description: The Emerald Basin and Sambro Bank Marine Refuge includes two distinct areas located adjacent to Emerald Basin on the central Scotian Shelf (Figure 3). Established as the first site in Canada using the SBA Policy, this site was first designated as a conservation area in 2013 under the *Fisheries Act,* restricting bottom-contact fishing. In 2016, based on CSAS guidance on OECMs, the conservation area was evaluated and recognized as a marine refuge.

This marine refuge protects globally significant aggregations of the glass sponge *Vazella pourtalesii,* commonly known as the Russian hat sponge. *Vazella pourtalesii* has been found to create extensive benthic habitat that locally enhances biodiversity (Hawkes et al., 2019). Cold-water sponges are particularly sensitive to mobile and fixed fishing gears that contact the bottom through both direct (e.g. removal and/or damage) and indirect (e.g. smothering by sedimentation) impacts (DFO, 2010). Due to this sensitivity, bottom-contact fishing is prohibited in Emerald Basin and Sambro Bank Marine Refuge.

Conservation Milestones: *Vazella* was first discovered by scientists in 2001 (Fuller et al.,2008), but interactions and knowledge within the fishing industry has existed for decades (Honeyman, 1889). In 2006, the significance of *Vazella* was noted through the Region's ecologically and biologically significant areas (EBSA) identification process. In 2010, the Groundfish Enterprise Allocation Council, put in place a voluntary closure for trawling in a portion of the known *Vazella* sponge grounds. A 2010 CSAS National Advisory Process on sponges, corals, and hydrothermal vents suggested increased in situ research into potential sponge sites along the Scotian Shelf (DFO, 2010). A research effort was undertaken in 2011 to validate predicted *Vazella* distribution sites. Findings from the cruise were a key component of the successful application of the SBA Policy to the *Vazella* sponge grounds on the Scotian Shelf, leading to a conser-

vation area being put in place in 2013 (Beazley et al., 2017a; Beazley et al., 2018). To assist DFO with the boundary design, targeted consultations with a multi-fleet industry working group and license holders were undertaken.

In 2016, Emerald Basin and Sambro Bank became a case study for the EU Horizon 2020 Project, SponGES: Deep-sea Sponge Grounds Ecosystems of the North Atlantic: an integrated approach towards their preservation and sustainable exploitation, with the coordination office in Norway. The collaborative research that followed has made this area the best biologically and ecologically characterized sponge species and habitat worldwide.

Summary Table:

Conservation objectives	1. Protect globally unique concentration of *Vazella pourtalesii*, a structure-forming species of glass sponge. 2. Protect benthic habitats and associated communities.
Legislative authority	*Fisheries Act* closure in license conditions
Date established	2013
Size	Marine Refuge: 259 km^2 (Sambro Bank: 62 km^2 Emerald Bank: 197 km^2)
Notable species	Russian hat glass sponges (*Vazella pourtalesii*)
Main habitat types	Shelf bank, shelf basin, and shelf flat
Restrictions	The marine refuge is closed to all commercial bottom-contact fishing gear including bottom gillnet, bottom trawl, bottom handline/jig, Danish or Scottish seine, dredge/dragging, bottom longline, fish traps, traps/pots, and midwater gillnet.

Ecological Components of Interest:

Habitat: Sambro Bank and Emerald Basin are both located within the Scotian Shelf in an area due south of Halifax. Emerald Basin is a large basin feature that is connected to the surrounding shelf and slope environments of the Scotian Shelf. The waters of both sites include inundations of warmer, more saline water that is high in nutrients from the slope. Emerald Basin is made up of two components and is overlain by Scotian Drift, a hard substrate occurring in patches over soft sediment up to boulder-sized substrate.

Species of conservation focus: Globally unique concentrations of the glass (i.e., Hexactinellid) sponge *Vazella pourtalesii* have been found within Emerald Basin and Sambro Bank Marine Refuge. *Vazella w*ithin the marine refuge have been identified from depths of 75 m to 275 m growing to a maximum height of 110 cm (Fuller, 2011; Hawkes et al., 2019). *Vazella* are considered to be ecologically significant due to both their rarity and their contributions to the health of benthic ecosystems through habitat creation, water filtration, and the linking of benthic and pelagic environments(DFO , 2010; Hawkes et al.,2019). Their importance to biogeochemical cycling is observed through the hotspots of carbon processing that these sponges facilitate in addition to their role to the silicon cycle (Maldonado et al., 2021).

Other species: Emerald Basin and Sambro Bank are important habitat for various other fish and invertebrates species including northern shortfin squid, various species of zooplankton, tuna, swordfish and some shark species (King et al., 2016). Hawkes et al. (2019) recorded 77 different invertebrate species associated with the sponges. The marine refuge has also been found to be important habitat for species of commercial importance such as white hake, silver hake, and Acadian redfish (Grinyó et al., 2023; King et al., 2016).

Past Research: An initial transect with the remotely operated vehicle ROPOS in 2001 and a Campod transect in 2002 confirmed the presence of *Vazella* within the marine refuge (Fuller, 2011). In 2011, DFO conducted additional Campod transects in Emerald Basin, including several within the marine refuge. The collaborations with the SponGES

Russian hat sponge *(Vazella pourtalesii).* DFO, 2014.

project brought the ROV, ROPOS to the region in 2017, which was deployed from CCGS Martha L. Black. It confirmed large *Vazella* aggregations within the marine refuge and enabled novel physiological experiments on the sponges to be conducted (e.g. Bart et al., 2020; Wurz et al., 2021). The probability of *Vazella* occurrence was modelled across its distribution using a suite of environmental variables to aid in the identification of *Vazella* habitat and to evaluate presence in unsampled areas both in the present (Beazley et al., 2018) (Figure 4), and under future conditions (Beazley et al., 2021a).

Ongoing Research: Three benthic landers equipped with camera systems and passive acoustic receivers were deployed in September 2021 in areas of differential aggregation sites within Sambro Bank (Kenchington et al., 2021). The benthic landers were retrieved in May 2022 and the data is currently being examined in order to better understand ecosystem activities and characteristics of these sponge sites including occurrence and behavior of Acadian redfish (*Sebastes fasciatus*) (Grinyó et al., 2023). One benthic lander was redeployed in August 2022. In June 2022 collaborative efforts between NRCan and DFO sent an autonomous underwater vehicle (AUV) into Sambro Bank to collect high resolution bathymetry data and to test if an AUV could be used as a monitoring tool for sponge concentrations within the marine refuge (King et al., 2022).

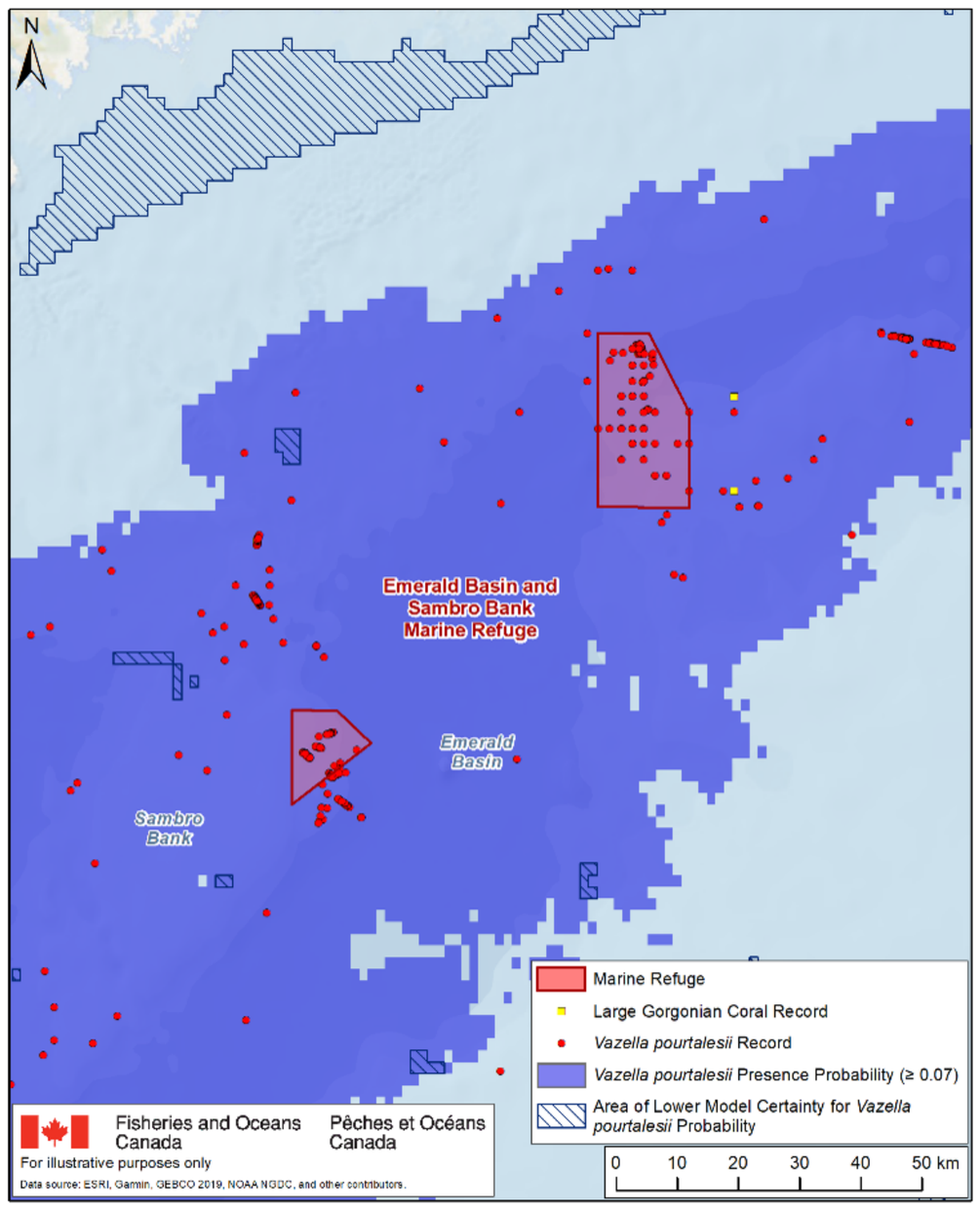


Figure 4. *Vazella pourtalesii* records and presence proabability model.

Climate Change: Projected climate change models show that Emerald Basin and Sambro Bank Marine Refuge is expected to experience rapidly warming surface and bottom temperatures as a result of climate change (Beazley et al., 2021a). The *Vazella* population within Emerald Basin and Sambro Bank Marine Refuge has persisted through varying environmental conditions since 1889, demonstrating that the species may be resilient to climatic variability (Beazley et al., 2018). Despite *Vazella's* ability to persist through some variable environmental change, the thermal thresholds of *Vazella* remain unknown and it is therefore unclear as to how long the species will be able to persist as temperatures continue to rise as a result of climate change (Beazley et al., 2021a). Overall, projected climate change scenarios show that suitable habitat for *Vazella* within the marine refuge is expected to increase in the future (Beazley et al.,

2021a). Continued monitoring and research in the Emerald Basin and Sambro Bank Marine Refuge is critical to inform adaptive management strategies of *Vazella* and other conservation benefits.

Conservation Network: Emerald Basin and Sambro Bank Marine Refuge contributes to various regional priorities and targets established through the SS-BOF bioregional conservation network (King et al., 2021) including the representation of important oceanographic and geomorphic features such as the LaHave and Emerald Basins, shelf basin, and shelf flat. Additionally, this site contributes to other bioregional conservation network targets such as the protection of biogenic habitat including sponge (*Vazella pourtalesii)* aggregations and the protection of an area with high fish species richness. Through hydrodynamic connectivity models developed specifically for *Vazella* (Wang et al., 2021) connectivity has been found between Emerald Basin and Sambro Bank Marine Refuge and NECMR.

Site-Specific Priorities:

- Research changes of *Vazella* populations prior to and following closures, including areas with significant fishing activity adjacent to the sites' boundaries (i.e. Sambro).
- Revisit protection needs for *Vazella* populations including evaluation of boundaries of the marine refuge.

Russian hat sponges (*Vazella pourtalesii*). DFO, 2018.

Coordinates for Emerald Basin and Sambro Bank Marine Refuge

Sambro Bank:

43° 56′ 00″ N	63° 07′ 00″ W
43° 56′ 00″ N	63° 03′ 00″ W
43° 54′ 00″ N	63° 00′ 00″ W
43° 50′ 00″ N	63° 07′ 00″ W

Emerald Basin:

44° 20′ 00″ N	62° 40′ 00″ W
44° 20′ 00″ N	62° 35′ 30″ W
44° 15′ 00″ N	62° 32′ 00″ W
44° 09′ 00″ N	62° 32′ 00″ W
44° 09′ 00″ N	62° 40′ 00″ W

3. Corsair and Georges Canyons Marine Refuge

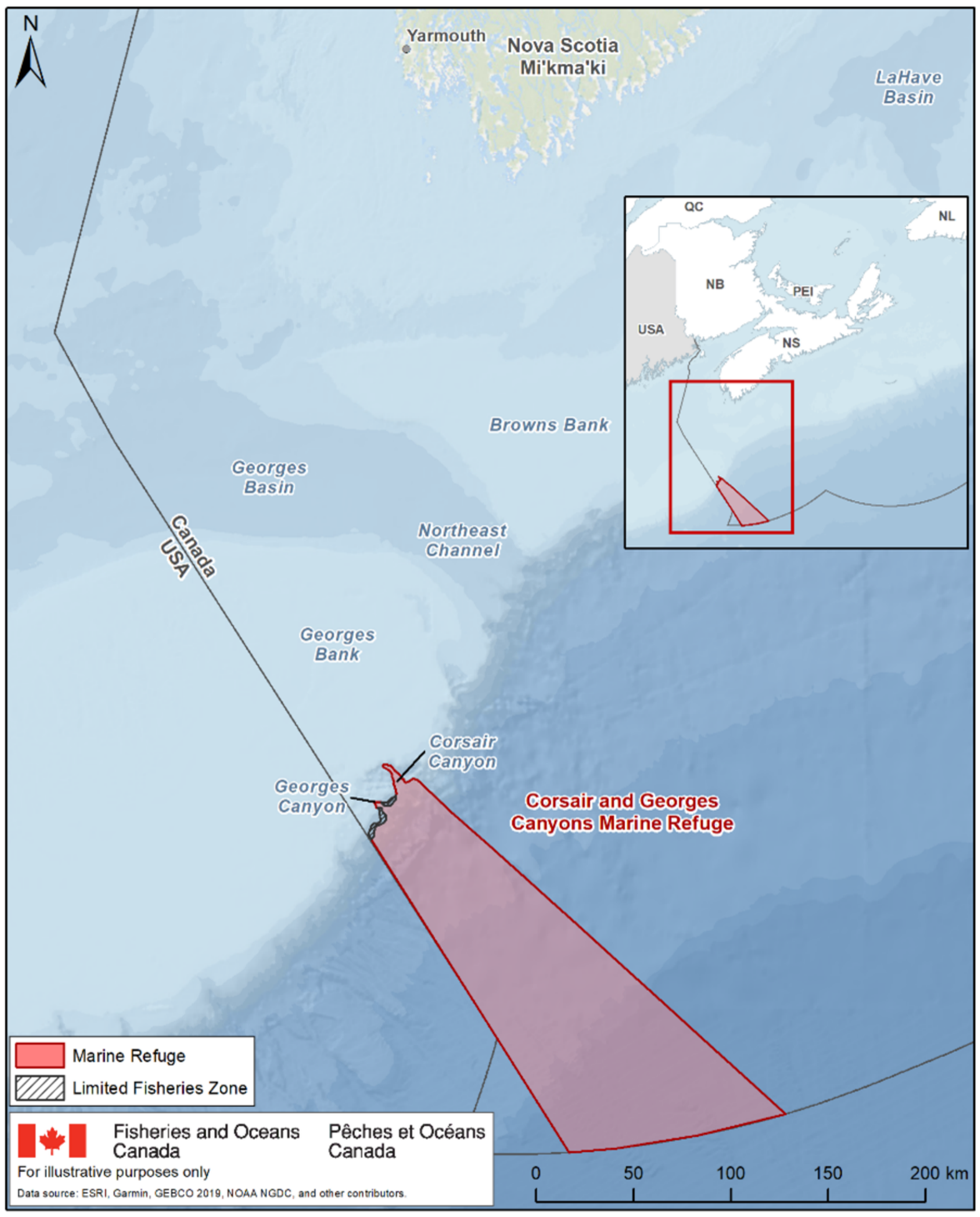


Figure 5. Map of Corsair and Georges Canyons Marine Refuge.

Description: The Corsair and Georges Canyons Marine Refuge lies adjacent to the United States (US) border on the southern edge of Georges Bank extending to the limit of the Canadian EEZ (Figure 5). Established in 2016 under the *Fisheries Act*, this marine refuge protects two deep (over 2000 m) steep-sided canyons that host dense concentrations of large gorgonian (mainly bubblegum coral (*Paragorgia arborea*)) and other corals that act as important habitat to other invertebrates and various species of fish. Corsair and Georges Canyons are ecologically linked to the extensive chain of canyons that extend up the eastern seaboard of North America, many of which have also achieved conservation status under various US laws. Cold-water corals and sponges are particularly sensitive to mobile and fixed fishing gears that contact the bottom through both direct (e.g. removal and/or damage) and indirect (e.g. smothering by sedimentation) impacts (DFO, 2010). Due to this sensitivity, bottom-contact fishing is prohibited in Corsair and Georges Canyons Marine Refuge. In 2016, based on CSAS guidance on OECMs, the conservation area was evaluated and recognized as a marine refuge.

Conservation Milestones: From 2013-2015 in the United States there was a focus on exploration and science in the series of canyons along the shelf edge, a chain of features that includes Georges and Corsair Canyons in Canadian waters. A survey in 2014 conducted by Dalhousie University and NOAA in collaboration with DFO Science ran two transects – one inside Corsair Canyon and one deeper. The survey discovered high densities of gorgonian corals, such as bubblegum coral (*Paragorgia arborea*), and a variety of other coral species (DFO, 2018a). This survey offered the first confirmed insight into the special features of this area and led to dedicated discussions with the

commercial fishing industry and other interested rights holders and stakeholders (Jordan Basin Marine Refuge was included in these consultations). Several boundary proposals for a closure were explored, including the expansion of the canyon closure to the deeper waters out to the EEZ. This approach is similar in design to canyon conservation measures in the United States, and is consistent with the "frontier areas" definition under the SBA Policy. A frontier area is defined as an area without a history of fishing in Canadian waters, which is interpreted to mean waters deeper than 2000 m.

Summary Table:

Conservation objectives	1. Protect cold-water corals including significant concentrations of large gorgonian corals (e.g. *Paragorgia arborea* and *Primnoa resedaeformis*). 2. Protect deep-water habitats (continental slope, continental rise and abyssal plain) and associated benthic communities.
Legislative authority	*Fisheries Act* closure in license conditions
Date established	2016
Size	Marine Refuge: 8,797 km^2 Limited Fisheries Zone: 31.2 km^2
Notable species	Cold-water coral species including bubblegum coral (*Paragorgia arborea*), seacorn coral (*Primnoa resedaeformis),* bamboo corals *(Acanella arbuscula*, *Keratoisis grayi)*, other gorgonians such as *Paramuricea* spp.*, Chrysogorgia* sp., *Anthothela grandiflora*, the cup coral, *Flabellum* sp.*,* sea pens (Pennatuloidea), *Anthomastus* spp., *Clavularia* sp., and Stolonifera (SO.) spp.
Main habitat types	Abyssal plain, continental rise, shelf bank, shelf flat, and slope
Restrictions	The marine refuge is closed to all commercial bottom-contact fishing gear including bottom gillnet, bottom trawl, bottom handline/jig, Danish or Scottish seine, dredge/dragging, bottom longline, fish traps, traps/pots, and midwater gillnet. Two Limited Fishing Zones adjacent to Georges Canyon remain open for Red Crab, a trap fishery.

Ecological Components of Interest:

Habitat: Corsair and Georges Canyons are two glacially formed, large, steep sided, deep (over 2000 m) submarine canyons that cut into the seabed (Stortini, 2015). The canyon walls are composed of ridges and gullies containing outcroppings of boulders providing suitable habitat for large gorgonian coral species. The canyon floors are composed of mostly soft sediment including sand and mud.

Octopus (*Octopodoidea sp*.). DFO, 2014.

Species of conservation focus: Various species of cold-water coral have been identified within Corsair and Georges Canyons Marine Refuge from depths of 330 m to 2100 m. The marine refuge has been found to contain significant aggregations of large habitat forming gorgonian corals such as bubblegum coral (*Paragorgia arborea*) and seacorn coral (*Primnoa resedaeformis*). Other identified coral species include bamboo corals (*Acanella arbuscula*, *Keratoisis grayi)*, *Paramuricea* spp., *Chrysogorgia* sp., *Anthothela grandiflora*, the cup coral, *Flabellum* sp., sea pens (Pennatuloidea), *Anthomastus* spp., *Clavularia* sp., and Stolonifera (SO.) spp.

Other species: Commercially important species such as Atlantic halibut, lobster, cusk and other groundfish are present in the site. Numerous invertebrates including echinoderms, anemones, squids, and octopuses are also observed in the marine refuge. Cetacean species including Cuvier's beaked whale, True's beaked whale, and Sowerby's beaked whale (listed as Special Concern under the *Species at Risk Act*) have been regularly acoustically detected within the marine refuge.

Past Research: In 2017, two ROPOS dives were conducted in Georges Canyon; this corroborated statements from the red crab fishery that labelled portion of Georges Canyon as 'Mud Cove", having a muddy bottom with few gorgonian corals observed. In 2019, ROV transects were conducted within and around the marine refuge, focused on Corsair Canyon, discovering dense aggregations of corals, including some outside the eastern boundary. Additional research in the area suggests that connectivity among the *Paragorgia aborea* and *Primnoa resedaeformis* populations in northwest Atlantic originates from Georges Canyon and Heezen Canyon to the south (US waters) (Metaxas et al., 2019). Research vessel trawl survey data supplemented with other available data has been used to identify significant benthic areas and to create presence probability distribution models for corals within and around

the marine refuge to aid in the identification of coral hotspots (Kenchington et al.,2016; Wang et al., 2022) (Figure 6).

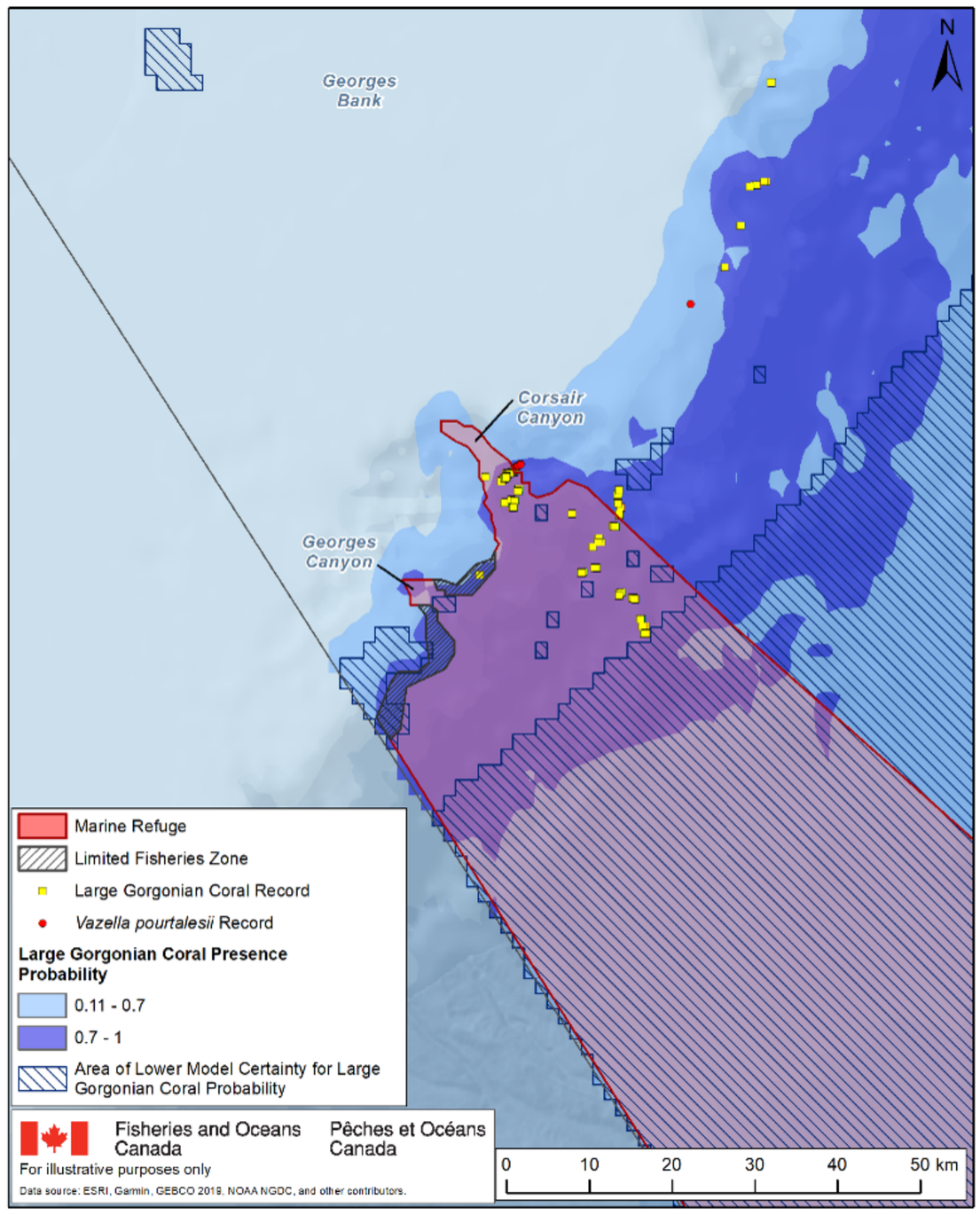


Figure 6. Large gorgonian coral records and presence.

Ongoing Research: Cooperation between DFO and Dalhousie University allows for continued exploration of this area through Contribution Agreements. These missions aim to determine cold-water coral population recovery, aggregation density and recruitment development. The broader scope of the project centres on the understanding of factors that shape the distribution of deep-water corals in the Gulf of Maine and adjacent continental slope. Passive acoustic monitoring with a stationary, bottom-mounted with a stationary, bottom-mounted recorder has been conducted in Corsair Canyon since 2020, providing information on the presence and habitat use of cetacean species. In recordings analyzed from September 2020 to August 2021, beaked whale echolocation clicks were detected and identified as Sowerby's beaked whales, Cuvier's beaked whales, and probable True's beaked whales. All three species were regularly detected, indicating that they commonly forage in this area throughout the year (J. Stanistreet, unpublished data). In addition, calls produced by North Atlantic right whales were detected on a single day in March 2021. Analysis is underway for the daily presence of other baleen whale species including blue, fin, sei, and humpback whales (H. Moors-Murphy, pers. comm.). In 2024, another collaborative mission between DFO, Dalhousie University,and NOAA conducted several ROV (using ROPOS) transects in Canadian waters including within Corsair and Georges Canyons Marine Refuge. A previously unexplored area of Corsair Canyon was visited, documenting an area with dense concentrations of bubblegum coral.

Climate Change: Corsair and Georges Canyons Marine Refuge is expected to undergo changing environmental conditions due to climate change (Murillo et al., 2022). Under projected environmental conditions, existing aggregations of bubblegum coral within the Corsair and Georges Canyons may experience both novel environmental conditions and a decrease of suitable habitat by 2046-2065 (Wang et al., 2022). As a

result, it is unknown if the bubblegum coral within Corsair and Georges Canyons Marine Refuge will be able to adapt to shifting environmental conditions (Wang et al., 2022). The importance of this site for cold-water coral species is significant, particularly because this site has been found to provide larval connectivity for bubblegum coral across the various conservation areas within the SS-BOF bioregion (Wang et al., 2022). Connectivity between conservation areas within the SS-BOF bioregion and across the Gulf of Maine is critical for the retention and expansion of the distributional range for cold-water corals as environmental conditions continue to change as a result of climate change (Metaxas et al., 2019; Wang et al., 2022). Monitoring the impacts of changing environmental conditions on coral species and larval connectivity across the bioregion will be critical to inform the adaptive management of Corsair and Georges Canyons Marine Refuge.

Conservation Network: Corsair and Georges Canyons Marine Refuge contributes to various regional priorities and targets established through the SS-BOF bioregional conservation network (King et al., 2021) including the representation of important oceanographic and geomorphic features such as continental rise, continental slope, and abyssal plain. Additionally, this site contributes to other bioregional conservation network targets such as the protection of biogenic habitat including sea pen fields, small gorgonian coral, and large gorgonian coral aggregations.

Site-Specific Priorities:

- Continued Canada/US collaboration to ensure complete understanding of canyon environments along the shelf break/Georges Bank.
- Renewal of the Georges Bank oil and gas exploration moratorium beyond 2032.
- Research and exploration of frontier habitat (depth > 2000 m).
- Following 2024 survey, examine current boundary configurations in light of all research findings since establishment.

Desmophyllum pertusum. Anna Metaxas, Dalhousie University/ Martha Nizinski, NOAA/ CSSF, 2024.

Coordinates for Corsair and Georges Canyons Marine Refuge

41° 9' 59.366" N	66° 17' 41.547" W
41° 11' 45.000" N	66° 16' 45.000" W
41° 12' 15.000" N	66° 16' 15.000" W
41° 12' 15.000" N	66° 15' 0.000" W
41° 12' 45.000" N	66° 14' 15.000" W
41° 14' 0.000" N	66° 14' 30.000" W
41° 15' 0.000" N	66° 14' 30.000" W
41° 15' 30.000" N	66° 15' 0.000" W
41° 15' 30.000" N	66° 15' 30.000" W
41° 16' 0.000" N	66° 15' 30.000" W
41° 16' 45.000" N	66° 16' 0.000" W
41° 16' 45.000" N	66° 14' 0.000" W
41° 16' 45.000" N	66° 13' 30.000" W
41° 16' 30.000" N	66° 12' 30.000" W
41° 17' 30.000" N	66° 11' 15.000" W
41° 17' 45.000" N	66° 10' 15.000" W
41° 18' 7.500" N	66° 10' 0.000" W
41° 18' 30.000" N	66° 9' 45.000" W
41° 18' 45.000" N	66° 10' 0.000" W
41° 19' 15.000" N	66° 10' 0.000" W
41° 19' 45.000" N	66° 10' 15.000" W
41° 20' 0.000" N	66° 10' 15.000" W
41° 20' 30.000" N	66° 10' 45.000" W
41° 20' 45.000" N	66° 10' 30.000" W
41° 21' 15.000" N	66° 10' 45.000" W
41° 21' 30.000" N	66° 10' 45.000" W
41° 21' 45.000" N	66° 11' 0.000" W
41° 22' 30.000" N	66° 11' 0.000" W
41° 23' 15.000" N	66° 11' 45.000" W
41° 23' 30.000" N	66° 12' 30.000" W
41° 24' 0.000" N	66° 13' 30.000" W
41° 24' 30.000" N	66° 13' 30.000" W
41° 24' 30.000" N	66° 12' 30.000" W
41° 24' 15.000" N	66° 12' 0.000" W
41° 24' 15.000" N	66° 11' 30.000" W
41° 24' 0.000" N	66° 11' 0.000" W
41° 23' 15.000" N	66° 10' 15.000" W
41° 22' 30.000" N	66° 9' 0.000" W
41° 22' 0.000" N	66° 8' 45.000" W
41° 22' 0.000" N	66° 8' 15.000" W
41° 21' 30.000" N	66° 8' 15.000" W
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41° 21' 0.000" N	66° 7' 45.000" W
41° 20' 45.000" N	66° 7' 15.000" W
41° 21' 0.000" N	66° 6' 15.000" W
41° 21' 37.500" N	66° 5' 15.000" W
41° 21' 15.000" N	66° 4' 0.000" W
40° 11' 9.213" N	64° 22' 2.502" W
40° 3' 1.741" N	65° 22' 0.138" W
41° 8' 55.473" N	66° 16' 49.357" W
41° 9' 26.775" N	66° 16' 9.740" W
41° 11' 30.000" N	66° 15' 45.000" W
41° 12' 22.500" N	66° 13' 15.000" W
41° 13' 7.500" N	66° 12' 37.500" W
41° 13' 45.000" N	66° 12' 37.500" W
41° 14' 45.000" N	66° 13' 45.000" W
41° 15' 15.000" N	66° 13' 45.000" W
41° 15' 30.000" N	66° 14' 15.000" W
41° 16' 15.000" N	66° 13' 45.000" W
41° 16' 15.000" N	66° 13' 15.000" W
41° 16' 0.000" N	66° 13' 15.000" W
41° 16' 0.000" N	66° 11' 30.000" W
41° 17' 15.000" N	66° 10' 0.000" W

Limited Fisheries Zones:

41° 9' 59.366" N	66° 17' 41.547" W
41° 11' 45.000" N	66° 16' 45.000" W
41° 12' 15.000" N	66° 16' 15.000" W
41° 12' 15.000" N	66° 15' 0.000" W
41° 12' 45.000" N	66° 14' 15.000" W
41° 14' 0.000" N	66° 14' 30.000" W
41° 15' 0.000" N	66° 14' 30.000" W
41° 15' 30.000" N	66° 15' 0.000" W
41° 15' 30.000" N	66° 14' 15.000" W
41° 15' 15.000" N	66° 13' 45.000" W
41° 14' 45.000" N	66° 13' 45.000" W
41° 13' 45.000" N	66° 12' 37.500" W
41° 13' 7.500" N	66° 12' 37.500" W
41° 12' 22.500" N	66° 13' 15.000" W
41° 11' 30.000" N	66° 15' 45.000" W
41° 9' 26.775" N	66° 16' 9.740" W
41° 8' 55.473" N	66° 16' 49.357" W

41° 16' 45.000" N	66° 14' 0.000" W
41° 16' 45.000" N	66° 13' 30.000" W
41° 16' 30.000" N	66° 12' 30.000" W
41° 17' 30.000" N	66° 11' 15.000" W
41° 17' 45.000" N	66° 10' 15.000" W
41° 17' 15.000" N	66° 10' 0.000" W
41° 16' 0.000" N	66° 11' 30.000" W
41° 16' 0.000" N	66° 13' 15.000" W
41° 16' 15.000" N	66° 13' 15.000" W
41° 16' 15.000" N	66° 13' 45.000" W

4. Jordan Basin Marine Refuge

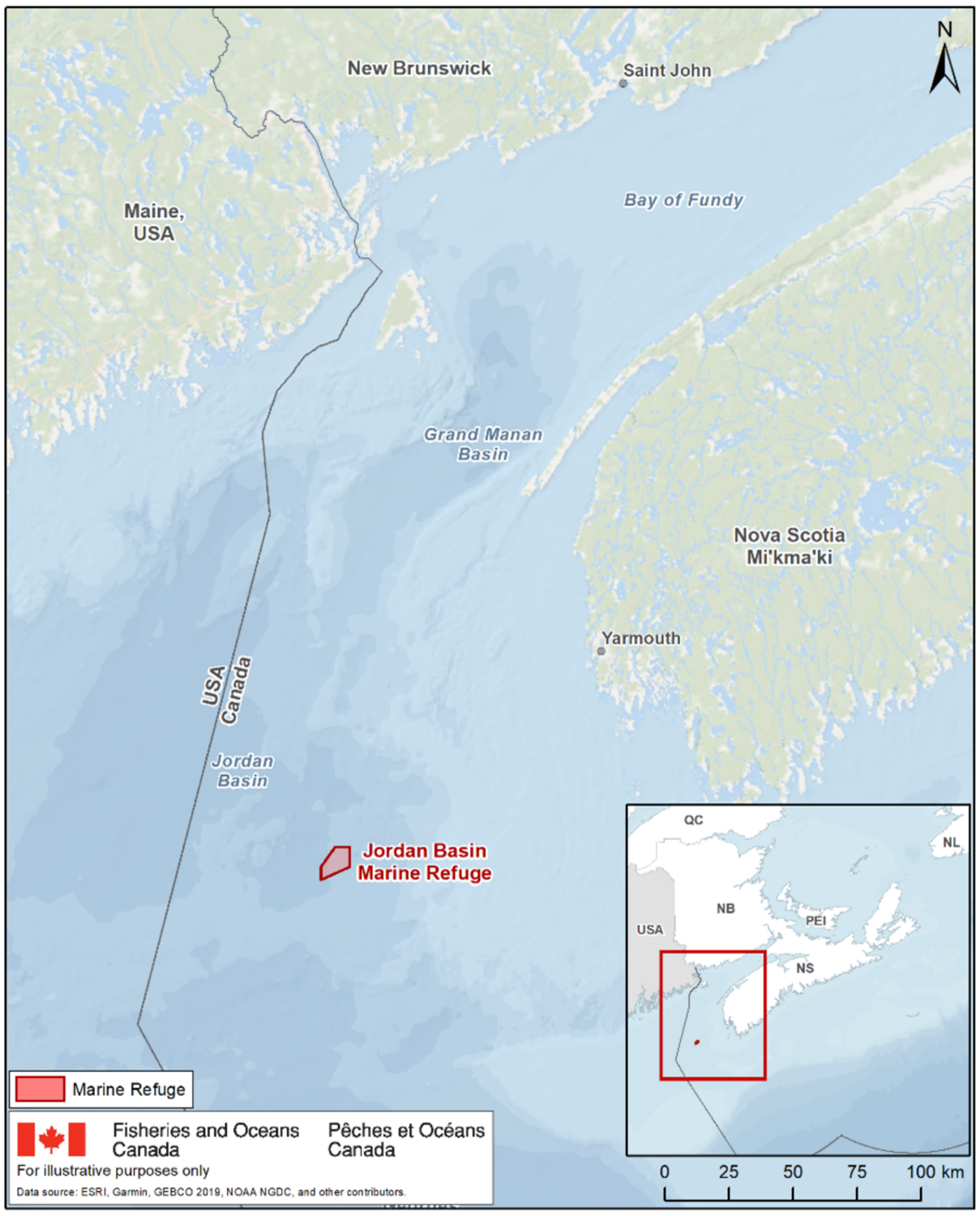


Figure 7. Map of Jordan Basin Marine Refuge.

Description: The Jordan Basin Marine Refuge lies offshore of Yarmouth in the Gulf of Maine (Figure 7). In 2005, DFO conducted several camera transects in the area that identified deep-sea features of conservation interest, initially centred on a bedrock pinnacle feature called the "Rock Garden". Several other surveys were conducted, confirming the biodiversity value of the area. As a result, a *Fisheries Act* closure under the SBA Policy was implemented in 2016. The area contains two large bedrock outcrop features that provide habitat for large concentrations of seacorn coral (*Primnoa resedaeformis*), *Paramuricea* sp., and other benthic invertebrates resulting in high overall biodiversity within the basin feature. Cold-water corals and sponges are particularly sensitive to mobile and fixed fishing gears that contact the bottom through both direct (e.g. removal and/or damage) and indirect (e.g. smothering by sedimentation) impacts (DFO, 2010). Due to this sensitivity, bottom-contact fishing is prohibited in Jordan Basin Marine Refuge. In 2016, based on CSAS guidance on OECMs, the conservation area was evaluated and recognized as a marine refuge.

Conservation Milestones: In June 2014, a research cruise led by NOAA, Dalhousie University, and DFO conducted a ROV survey in several sites within the Gulf of Maine. Within Canada, two areas that were targeted revealed significant cold-water coral concentrations; Corsair and Georges Canyons and Jordan Basin. The importance of two large bedrock outcrop features were confirmed and a fisheries closure was advanced under the SBA Policy following a consultation process (DFO, 2018a). The consultation process began in 2015 and included dedicated discussions with fishing industry representatives, license holders, and other interested rights holders and stakeholders (Corsair and Georges Canyons Marine Refuge was included in these consultations).

Summary Table:

Conservation objectives	1. Protect cold-water corals (e.g., *Primnoa resedaeformis, Paramuricea sp*. and *Desmophyllum pertusum*) including the diverse bedrock pinnacle feature known as the Rock Garden. 2. Protect benthic habitats and associated communities.
Legislative authority	*Fisheries Act* closure in license conditions
Date established	2016
Size	Marine Refuge: 49km^2
Notable species	Cold-water corals with particularly high abundance of seacorn coral (*Primnoa resedaeformis*) and *Paramuricea* sp.
Main habitat types	Shelf flat
Restrictions	The marine refuge is closed to all commercial bottom-contact fishing gear including bottom gillnet, bottom trawl, bottom handline/jig, Danish or Scottish seine, dredge/dragging, bottom longline, fish traps, traps/pots, and midwater gillnet.

Ecological Components of Interest:

Habitat: The Jordan Basin Marine Refuge is a broad complex feature capturing two prominent bedrock features, including a large outcrop called the “Rock Garden”. The substrate within this marine refuge is soft sediment with pebbles, cobbles, small boulders, shell hash, and bedrock ridges (Breeze and Horsman, 2005).

Sea anemone (Actiniaria) species. DFO, 2014.

Species of conservation focus: Jordan Basin Marine Refuge has been found to have large dense fields of cold-water corals primarily seacorn coral (*Primnoa resedaeformis)* and *Paramuricea* sp. *Primnoa resedaeformis* has been recognized as a structure-forming species that provides important habitat for other species and is associated with a high fish and invertebrate diversity (DFO, 2010). Originally described as the “Rock Garden” the northern bedrock feature in the closure is covered in anemones, sponges, sea stars, crustaceans, and other epifauna.

Other Species: Within Jordan Basin there are numerous species of groundfish, including those of commercial importance such as Atlantic cod, haddock, white hake, redfish and pollock.

Past Research: Since 2005, a DFO-led survey using Campod, a towed camera system, identified numerous underwater features of interest within Jordan Basin. These surveys identified two prominent bedrock ridges that contained high densities of coral species as well as sensitive invertebrate communities. In 2006, 2010, 2014, 2017, and 2019, additional benthic surveys were conducted within Jordan Basin. These additional surveys allowed for further exploration of the area as well as measuring coral colony size and abundance. Research vessel trawl survey data supplemented with other available data has been used to identify significant benthic areas and to create presence probability distribution models for corals within and around the marine refuge to aid in the identification of coral hotspots (Kenchington et al., 2016; Wang et al., 2022) (Figure 8).

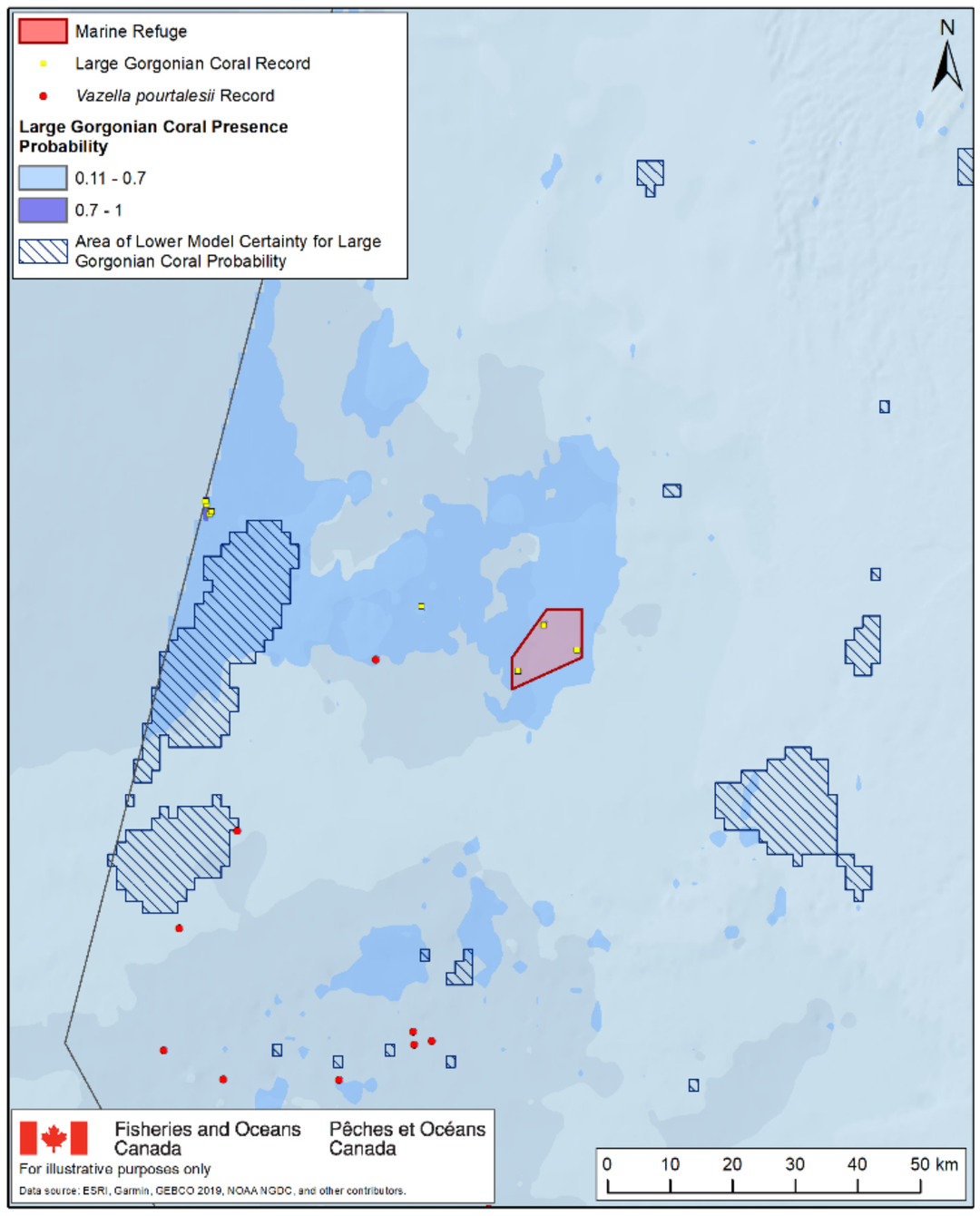


Figure 8. Large gorgonian coral records and presence probability model.

Ongoing Research: Cooperation between DFO and Dalhousie University allows for continued exploration of this area through Contribution Agreements. These missions aim to determine cold-water coral population recovery, aggregation density, and recruitment development. The broader scope of the project centres on the understanding of factors that shape the distribution of deep-water corals in the Gulf of Maine.

Climate Change: As a consequence of climate change, Jordan Basin Marine Refuge is expected to experience shifting environmental conditions, primarily warming bottom and surface temperatures at a relatively rapid rate when compared to other areas of the SS-BOF bioregion (Murillo et al., 2022). The impacts of shifting environmental conditions within Jordan Basin Marine Refuge is largely unknown due to the absence of climate change modelling for species of conservation importance such as seacorn coral. However, due to the relative shallow depths and southern location, the possible climate change induced poleward and vertical distribution shift of cold-water corals may have a considerable impact on biodiversity and conservation benefits provided by Jordan Basin Marine Refuge (Poloczanska et al., 2016). Climate change modelling for species of conservation importance such as seacorn coral*, Paramuricea* sp. or *Desmophyllum pertusum* (formally known as *Lophelia pertusa*) will be integral to the continued management of Jordan Basin Marine Refuge to ensure conservation objectives and biodiversity outcomes are achieved. Additionally, transboundary collaborations should be considered to increase conservation of cold-water coral aggregations as potential connectivity across the entire Gulf of Maine and Jordan Basin is high (Metaxas et al., 2019).

Conservation Network: Jordan Basin Marine Refuge contributes to various regional priorities and targets established through the SS-BOF bioregional conservation network (King et al., 2021) including the representation of important oceanographic

and geomorphic features such as the Gulf of Maine and continental shelf flat. Additionally, this site contributes to other bioregional conservation network targets such as the protection of an area with high species richness of small invertebrates. Hydrodynamic connectivity models show downstream links between Jordan Basin Marine Refuge and other conservation areas within the SS-BOF bioregion including both NECMR and Corsair and Georges Canyons Marine Refuge for the large gorgonian corals and *Vazella* sponges (Wang et al., 2021; Wang et al., 2022).

Site-Specific Priorities:

- Focus research effort on bedrock features similar to the "Rock Garden" in and adjacent to the marine refuge. Information gathered could result in the identification of additional coral concentrations and lead to the adjustment of the boundaries of the marine refuge or identification of additional locations for protection.

Coordinates for Jordan Basin Marine Refuge

43°20′30″ N	67°0′0″ W
43°17′30″ N	67°0′0″ W
43°15′30″ N	67°6′0″ W
43°17′30″ N	67°6′0″ W
43°20′30″ N	67°3′0″ W

5. Western and Emerald Banks Marine Refuge

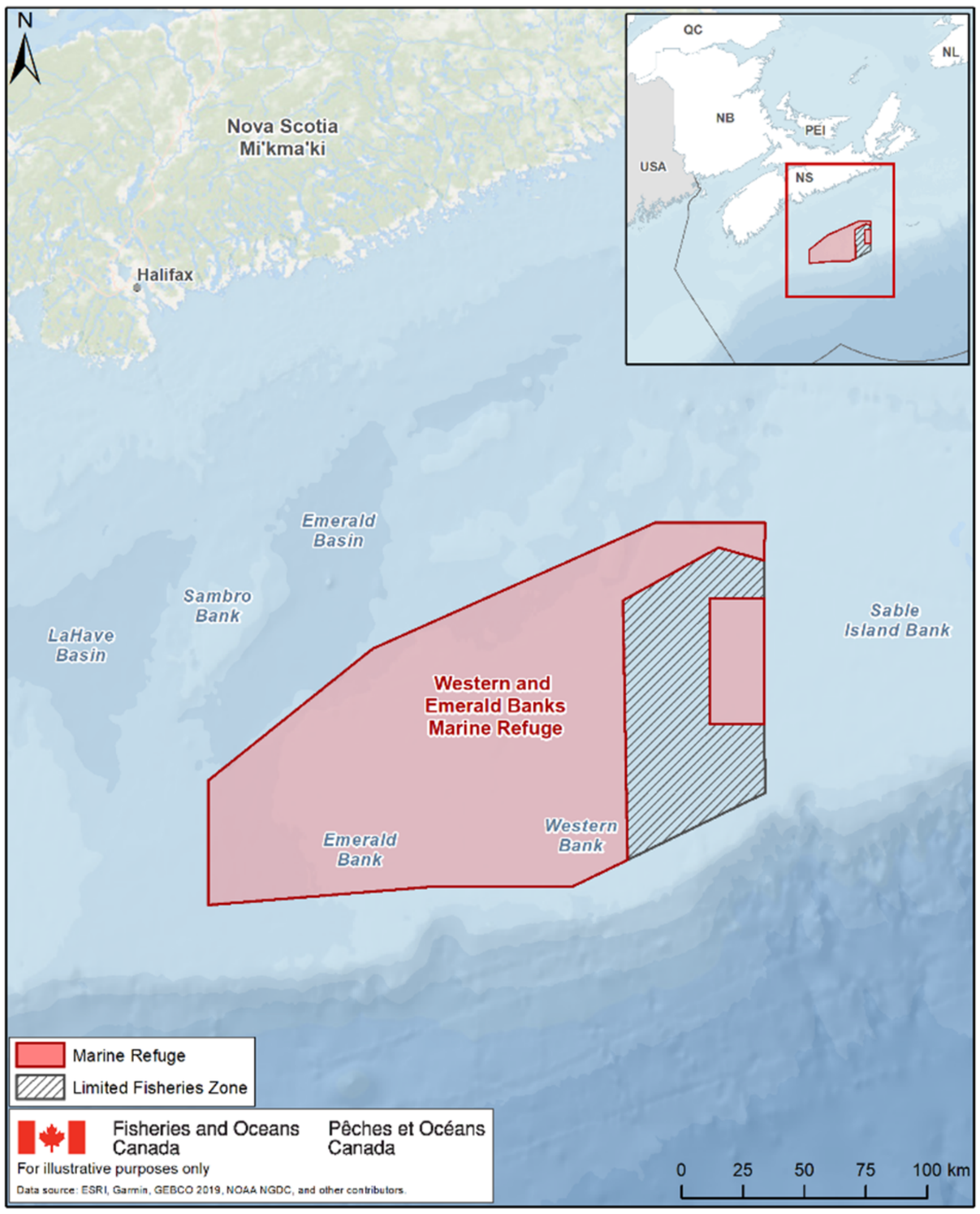


Figure 9. Map of Western and Emerald Banks Marine Refuge.

Description: The Western and Emerald Banks Marine Refuge (WEBMR) often referred to as the "Haddock Box" lies offshore of Halifax, Nova Scotia in the eastern Scotian Shelf (Figure 9). Historically this area was an important commercial groundfish fishing area, however, due to high catches of juvenile haddock DFO put in place conservation measures in 1987 (prohibiting mobile gear) and 1993 (prohibiting fixed gear) restricting those fisheries (DFO, 2018b).

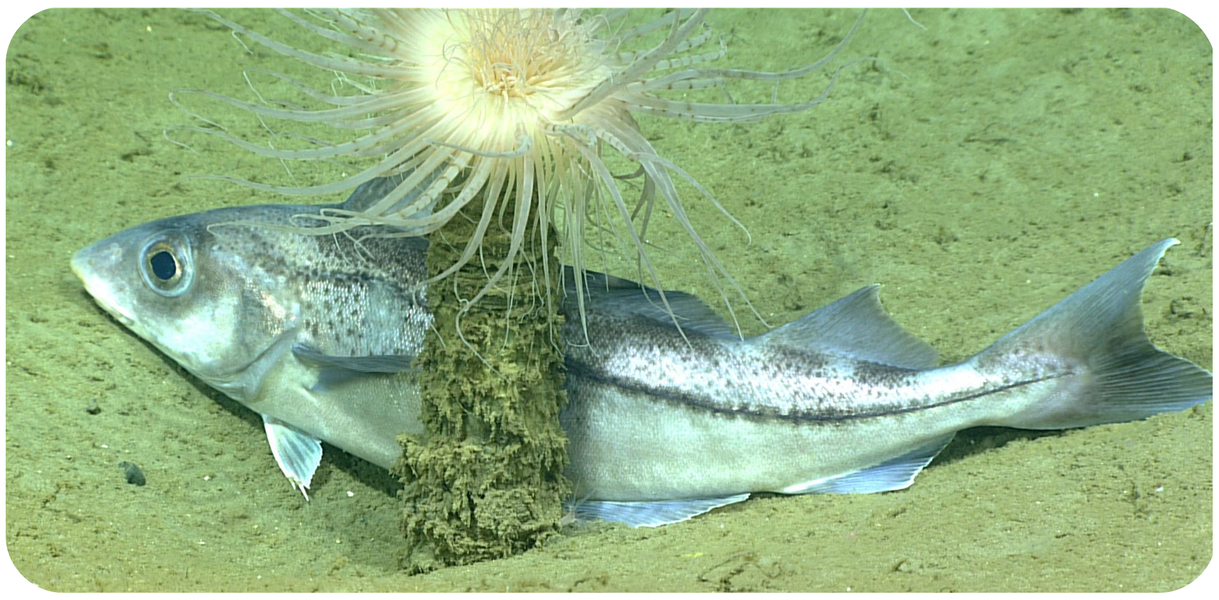
In 2017, based on CSAS guidance on OECMs, the site was evaluated and recognized as a marine refuge. As a result, the marine refuge is closed to all bottom-contact fishing gear. As part of this evaluation, a separate Limited Fishing Zone was delineated based on an active scallop fishery (scallop rakes/dredges). Although the Limited Fisheries Zone has low overall fishing effort it was not included as part of Marine Conservation Target contributions for WEBMR. WEBMR includes the majority of the Emerald-Western-Sable Island Bank Complex EBSA and has been recognized as important habitat for a variety of regionally significant species and as an area of high species diversity (King et al., 2016).

Conservation Milestones: In 1986, the Scotia-Fundy Groundfish Advisory Committee recommended closing this area to groundfish fishing activity due to its role as important nursery habitat for juvenile haddock (Frank et al., 2000). In response, this area was designated as a fisheries closure under the *Fisheries Act* prohibiting mobile gear groundfish fishing activity in 1987. The intent of this closure was to protect juvenile haddock and allow for continued stock rebuilding. In 1993, the prohibition of fishing within the closure was extended to include all groundfish gear types (fixed and mobile gear) and has remained in effect until the present (Frank et al., 2000). In 2016,

the Emerald-Western-Sable Island Bank Complex was delineated as an EBSA due to importance as habitat for several benthic fish, high levels of year-round larval fish diversity, importance as a juvenile fish nursery area, and high concentrations of eggs and larvae of several species (King et al., 2016). The revised EBSA encompasses a large portion of WEBMR.

Summary Table:

Conservation objectives	1. Protect continental shelf habitats and associated benthic and demersal communities. 2. Support productivity objectives for groundfish species of Aboriginal, commercial, and/or recreational importance, particularly North Atlantic Fisheries Organization Division 4VW haddock. 3. Protect benthic habitats that support juvenile and adult haddock and other groundfish species.
Legislative authority	*Fisheries Act* closure in license conditions
Date established	2017 (originally established in 1987, revised in 2017)
Size	Marine Refuge: 10,234 km^2 Limited Fisheries Zone: 2,548 km^2
Notable species	Structure-forming benthic biogenic habitats including sea pen (Pennatuloidea) fields and horse mussel (*Modiolus modiolus*) reefs, benthic bioturbating habitat including sand dollar (*Echinarachnius parma*) beds Haddock, Atlantic cod, American plaice, winter skate
Main habitat types	Shelf bank, shelf basin, and shelf flat
Restrictions	The marine refuge is closed to all bottom-contact fishing gear known to interact with groundfish including bottom gillnet, bottom trawl, bottom handline/jig, Danish or Scottish seine, dredge/dragging, bottom longline, fish traps, traps/pots, and midwater gillnet.



Haddock (*Melanogrammus aeglefinus).* Image courtesy of the NOAA Office of Ocean Exploration and Research, Deep Connections 2019

Ecological Components of Interest:

Habitat: WEBMR is an area of large bank habitat encompassing all of Emerald Bank and most of Western Bank as well as a shelf trough known as the 'Western Gully'. This site spans a complex array of sediments and bedforms including post-glacial sand and gravel, glacial and post-glacial marine mud, glacial diamict (homogenous mixture of mud, sand, gravel, and cobble clasts), and glacial sublittoral sand (Philibert et al., 2022) resulting in relatively high habitat heterogeneity. Additionally, the area has a unique feature in which a partial gyre encircles the Western – Sable Island banks area in the winter and summer months. This partial gyre feature serves as a retentive mechanism resulting in increased retention levels of pelagic larvae and their food (Shackell & Frank, 2000). Larger banks typically host higher diversity of species and habitat (Frank & Shackell, 2001). The combination of a large bank area, high habitat heterogeneity, and a large partial gyre has resulted in WEBMR being an area of high representativity with relatively high species richness and abundance.

Species of conservation focus: WEBMR has been found to be an area of high benthic diversity containing multiple species recognized to contribute to key ecosystem functions. Those have been identified as benthic ecologically or biologically significant areas (Kenchington, 2014). Specifically, structure-forming benthic biogenic species such as sea pen fields and horse mussel reefs and benthic bioturbating species such as sand dollar beds have been identified within WEBMR (Beazley et al., 2017b; Kenchington et al., 2016). Additionally, WEBMR has been identified as important spawning and nursery habitat for the Scotian Shelf haddock stock, as well as many other fish species (Shackell & Frank, 2000).

Other species: Other ecologically and biologically important species such as Russian hat sponges (*Vazella pourtalesii*) have been recorded within WEBMR. Western and Emerald Banks are also noted as important habitats for depleted species that have been assessed as at-risk by the Committee on the Status of Endangered Wildlife in Canada such as Atlantic cod, American plaice and winter skate (King et al., 2016; Shackell et al., 2021). Furthermore, the area known as the Western Gully within WEBMR may be of importance to various cetacean species including humpback whales, blue whales, sei whales, minke whales, sperm whales, and common dolphins (King et al., 2016).

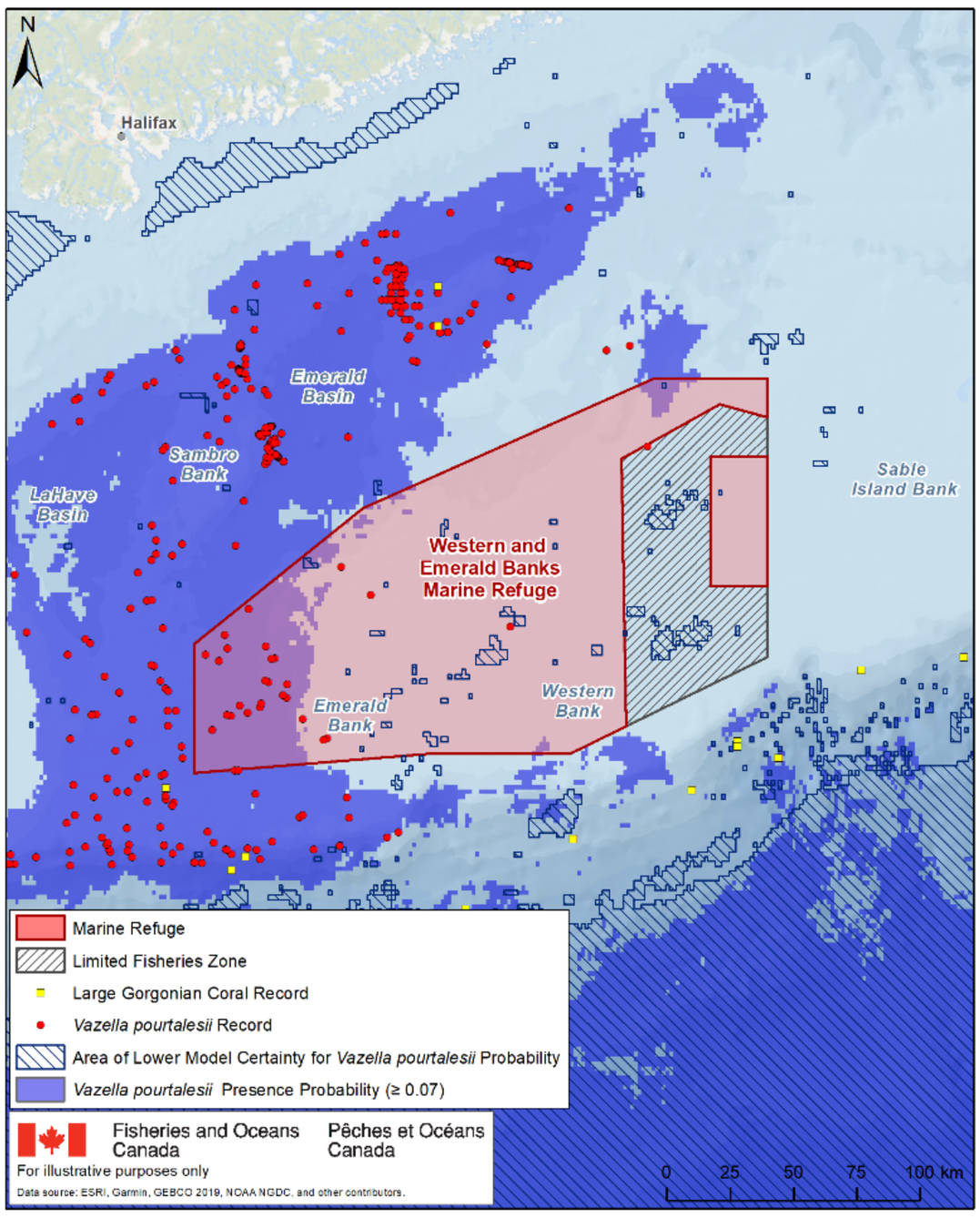


Figure 10. *Vazella pourtalesii* records and presence probability model.

Past Research: Research related to WEBMR has been collected through a variety of methods since its original designation as a fisheries closure in 1987. For example, in 2003 and 2005, benthos sampling of four sites within the marine refuge was conducted contributing to the identification and classification benthic macrofauna species assemblages and habitat composition of the closed area (Rincón & Kenchington, 2016). Additionally, research vessel trawl survey data supplemented with other available data has been used to create presence probability distribution models for ecologically or biologically significant benthic species such as *Vazella pourtalesii* found within and around the marine refuge to aid in the identification of significant benthic areas (Beazley et al., 2017b; Kenchington et al., 2016) (Figure 10). Region-wide survey programs such as the multispecies research trawl survey (1970 to present), the Industry/DFO Halibut Longline Survey (1998 to present) and the 4VsW Sentinel Monitoring Program (1995-2012 in WEBMR) have been used to evaluate long-term trends in the haddock stock and the overall effectiveness of the WEBMR closure. Reviews of the effectiveness of the area have considered it likely that the closure provides, at a minimum, localized benefits to groundfish stocks other than haddock (O'Boyle, 2011), such as American plaice and winter flounder (Frank et al., 2000). However, a full recovery of the groundfish community since 1992 collapse has not been observed (Shackell et al., 2021).

Ongoing Research: WEBMR lacks a site-specific monitoring program with research and monitoring of the site being conducted through region wide groundfish survey programs. A survey using Campod in WEBMR is planned for the future to further classify benthic habitat and ecology within site.

Climate Change: Future climate projections show considerable bottom and surface temperature warming within WEBMR by 2046-2065 (Beazley et al., 2021a). The impact of shifting environmental conditions on species of conservation importance such as

Atlantic haddock within WEBMR is largely unknown due to the absence of climate change modelling for the area. However, climate change models project that the distribution of the Gulf of Maine Atlantic haddock stock will shift northward into the Scotian Shelf in search of colder temperatures (Kleisner et al., 2017). Additionally, under projected environmental conditions suitable habitat for *Vazella pourtalesii* is predicted to shift including a moderate increase within WEBMR by 2046-2065 (Beazley et al., 2021a). Other important structure-forming benthic species reside within WEBMR such as sea pens and horse mussels; it will be important to continue monitoring and research within WEBMR to identify potential climate change impacts to these species. As WEBMR is projected to experience changes in environmental conditions as a result of climate change, additional modelling of species of conservation importance including Atlantic haddock and structure-forming benthic species will be critical for the continued adaptive management of WEBMR to ensure conservation objectives and biodiversity outcomes are achieved.

Conservation Network: WEBMR contributes to various regional priorities and targets established through the SS-BOF bioregional conservation network (King et al., 2021) including the representation of important oceanographic and geomorphic features such as the LaHave and Emerald Basins, Western and Sable Banks, shelf bank, shelf basin, and shelf flat. Additionally, this site is an area of high regional representativity contributing to various bioregional conservation network biodiversity hotspot targets including the protection of areas with high ichthyoplankton, fish, and invertebrate species richness. WEBMR also contributes to the protection of habitat for depleted species including Atlantic cod, ocean pout, and white hake.

Site-Specific Priorities:

- Implement a site-specific monitoring program aimed to characterize benthic habitat and the effectiveness of the site as a conservation measure to meet multiple biodiversity conservation objectives, including at the bioregional network scale.
- Enhance the characterization of the benthic habitat within the marine refuge based on recent species distribution models.
- Evaluate the boundaries of the marine refuge, with particular attention on the eastern boundary given the features identified in the EBSA profile.

Coordinates for Western and Emerald Banks Marine Refuge

43°21'00"N	63°20'00"W
43°01'00"N	63°20'00"W
43°04'00"N	62°30'00"W
43°04'00"N	62°00'00"W
43°19'00"N	61°18'00"W
44°02'00"N	61°18'00"W
44°02'00"N	61°42'00"W
43°42'00"N	62°44'00"W
43°45'59"N	61°18'00"W
43°50'00"N	61°18'00"W
43°50'00"N	61°30'00"W
43°30'00"N	61°30'00"W
43°30'00"N	61°18'00"W
43°08'18"N	61°48'00"W
43°49'37"N	61°49'00"W
43°58'01"N	61°28'00"W

Limited Fisheries Zone:

43°08'18"N	61°48'00"W
43°19'00"N	61°18'00"W
43°30'00"N	61°18'00"W
43°30'00"N	61°30'00"W
43°50'00"N	61°30'00"W
43°50'00"N	61°18'00"W
43°45'59"N	61°18'00"W
43°58'01"N	61°28'00"W
43°49'37"N	61°49'00"W

6. Eastern Canyons Marine Refuge

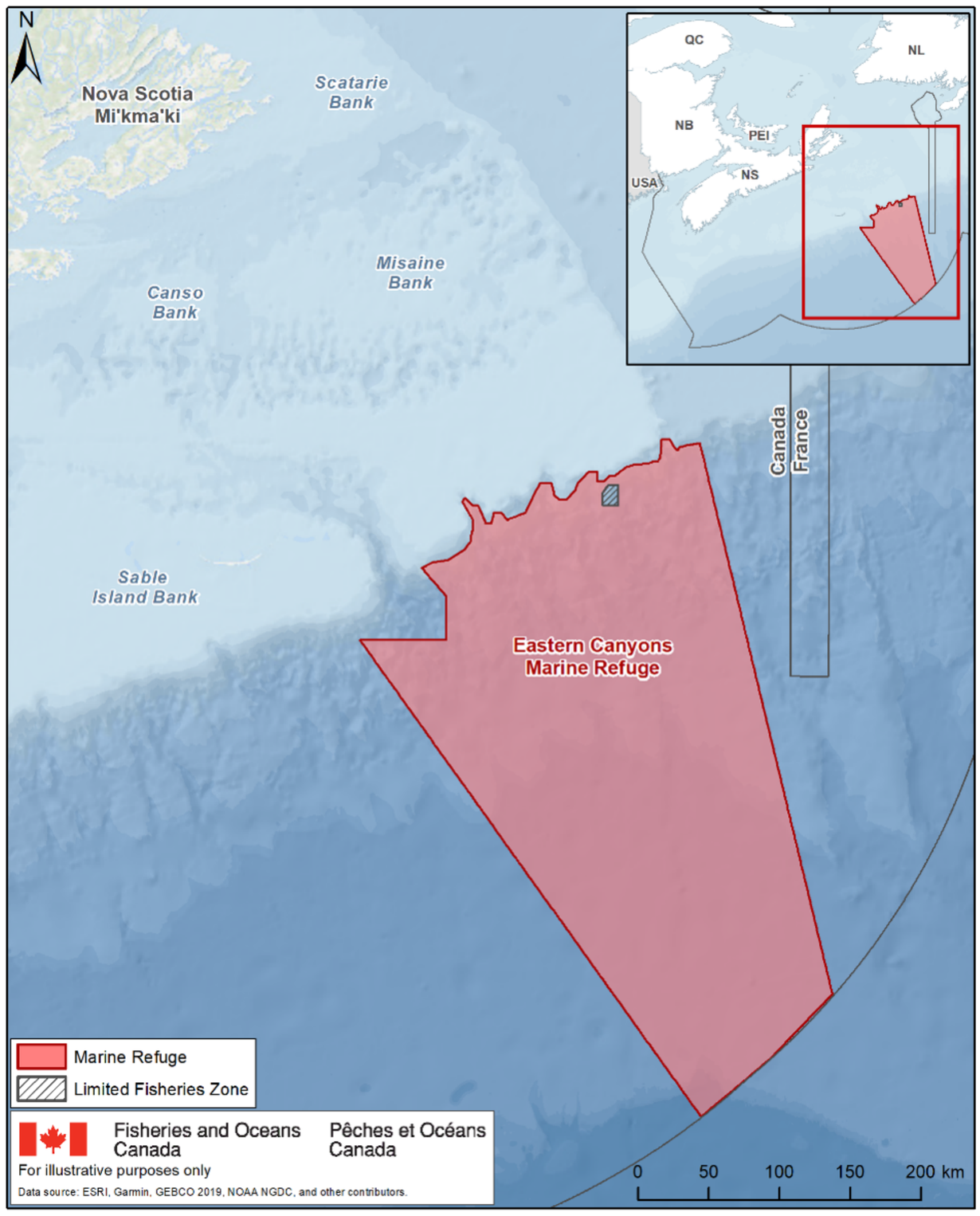


Figure 11. Map of Eastern Canyons Marine Refuge.

Description: The Eastern Canyons Marine Refuge (ECMR) is located offshore of Nova Scotia, to the east of Sable Island, at the break of the continental shelf (Figure 11). The marine refuge includes the continental slope, and extends eastward from the boundary of the Gully MPA to the Laurentian Channel and then south to the Canadian EEZ. ECMR is comprised of two underwater canyons, Shortland Canyon and Haldimand Canyon, and a substantial portion of the continental slope and abyssal plain in the eastern portion of the bioregion. Much of this deep-water is considered frontier area as there is no history of bottom-contact fishing activity, and little to no information on benthic features or the impacts of fishing on those features.

Eastern Canyons was announced as a proposed marine refuge in 2018 to protect extensive and fragile gorgonian coral concentrations and habitat, and minimize future impacts on the deep-water frontier area. Following a consultation process in 2021-2022, the final marine refuge was established using variation orders under the *Fisheries Act* in June 2022 and encompassed the pre-existing Lophelia Coral Conservation Area (LCCA), which had been in place since 2004. The *Desmophyllum pertusum* (formally known as *Lophelia pertusa)* reef is the only known cold-water coral reef in eastern Canada.

Conservation Milestones: LCCA was established in June 2004 after DFO scientists observed aggregations of reef building corals, *Desmophyllum pertusum* (formally known as *Lophelia pertusa)* in the previous year (Breeze & Fenton, 2007). DFO regularly conducted multi-species trawl surveys in the Eastern Canyons area between 2002 and 2016 which noted the presence of coral species. Additional data on coral presence was collected from multiple research missions using camera and video systems, with a survey in 2018 providing a systematic survey of the area (Beazley et al., 2016). Models

have been created to predict the distribution of corals in the area (Beazley et al., 2016; Wang et al., 2022). As a result, beginning in 2020, DFO engaged the Province of Nova Scotia, Indigenous organizations and local First Nations communities, fishing industry, stakeholders, and environmental non-government organizations on the design of ECMR. This collaborative process was guided by available science and knowledge of commercial (including commercial communal) bottom-contact fisheries operating within the area, with the aim of minimizing impacts of site establishment on active fisheries while upholding the conservation goals for the area (DFO, 2022a).

Summary Table:

Conservation objectives	1. Protect cold-water corals including significant concentrations of large gorgonian corals (e.g. *Paragorgia arborea* and *Primnoa resedaeformis*) and *Desmophyllum pertusum* (formally known as *Lophelia pertusa)*. 2. Protect deep-water habitats (continental slope, continental rise and abyssal plain) and associated benthic communities.
Legislative authority	*Fisheries Act* closure in license conditions
Date established	2022
Size	Marine Refuge: 43,976 km ^{2} Limited FisheriesZone: 76.4 km ^{2}
Notable species	Cold-water coral species including the reef-building *Desmophyllum pertusum* (formally known as *Lophelia pertusa),* bubblegum coral (*Paragorgia arborea*), seacorn coral (*Primnoa resedaeformis*), bamboo corals (A*canella arbuscula*, *Keratoisis grayi*), *Acanthogorgia armata,* sea pens (A*nthoptilum grandiflorum*, *Balticina finmarchica*, *Pennatula* spp), and soft corals (*Anthomastus* spp., *Nephtheidae* spp.)
Main habitat types	Abyssal plain, continental rise, shelf bank, shelf channel, slope, and slope channel
Restrictions	The marine refuge is closed to all commercial bottom-contact fisheries including bottom gillnet, bottom trawl, bottom handline/jig, Danish or Scottish seine, dredge/dragging, bottom longline, fish traps, traps/pots, and midwater gillnet. A Limited Fishing Zone on the western edge of the marine refuge permits groundfish longline fishing with an at-sea observer while remaining closed to all other bottom-contact fisheries.

Ecological Components of Interest:

Habitat: ECMR protects a mosaic of benthic habitats. The Shortland and Haldimand Canyons are a mix of sand and mud with a varied distribution of boulders, rocks, and ledges. ECMR primarily protects deep-water frontier habitat, as 91% of the refuge is beyond 2000 m in depth. There exists little information on the benthic features, ecology, or fishing impacts within the deep-water frontier habitat; however, modelling suggests that this area could include cold-water coral habitat. The marine refuge includes depths from 100 m to over 5000 m.

Species of conservation focus: ECMR is home to the only known cold-water coral (*Desmophyllum pertusum*) reef in eastern Canada. The area also hosts large aggregations of gorgonian corals, including bubblegum coral (*Paragorgia arborea*), seacorn coral (*Primnoa resedaeformis*), and bamboo corals (A*canella arbuscula*, *Keratoisis grayi*). Gorgonian corals are slow-growing and some species can live for hundreds of years (Sherwood & Edinger, 2009). These corals provide important biogenic habitat, refuge, and nurseries for other species. Other species of cold-water corals identified within ECMR include *Acanthogorgia armata* and the soft corals *Anthomastus* spp. *and Nephtheidae* spp*.* (Cogswell et al., 2009).

Soft coral (*Anthomastus grandiflorus*). DFO, 2008.

Other species: Sea pens, tube-dwelling anemones, and large sponges have all been found in ECMR. These sessile species provide structure and habitat for other species and play important roles in the transfer of nutrients across trophic levels. Commercially important groundfish species such as Atlantic halibut and redfish are found within the ECMR. Cetacean species including the northern bottlenose whale, Scotian Shelf population (listed as Endangered under the *Species at Risk Act*), and Sowerby's beaked whale (listed as Special Concern under the *Species at Risk Act*) are regularly observed within the marine refuge (DFO, 2016; DFO, 2017). Northern bottlenose whales have been recorded moving along the contours of the Scotian Shelf between Shortland Canyon, Haldimand Canyon, and the Gully MPA. As a result, under the *Species at Risk Act*, portions of ECMR have been designated as both critical habitat and important habitat for the Scotian Shelf population of northern bottlenose whales (DFO, 2022b).

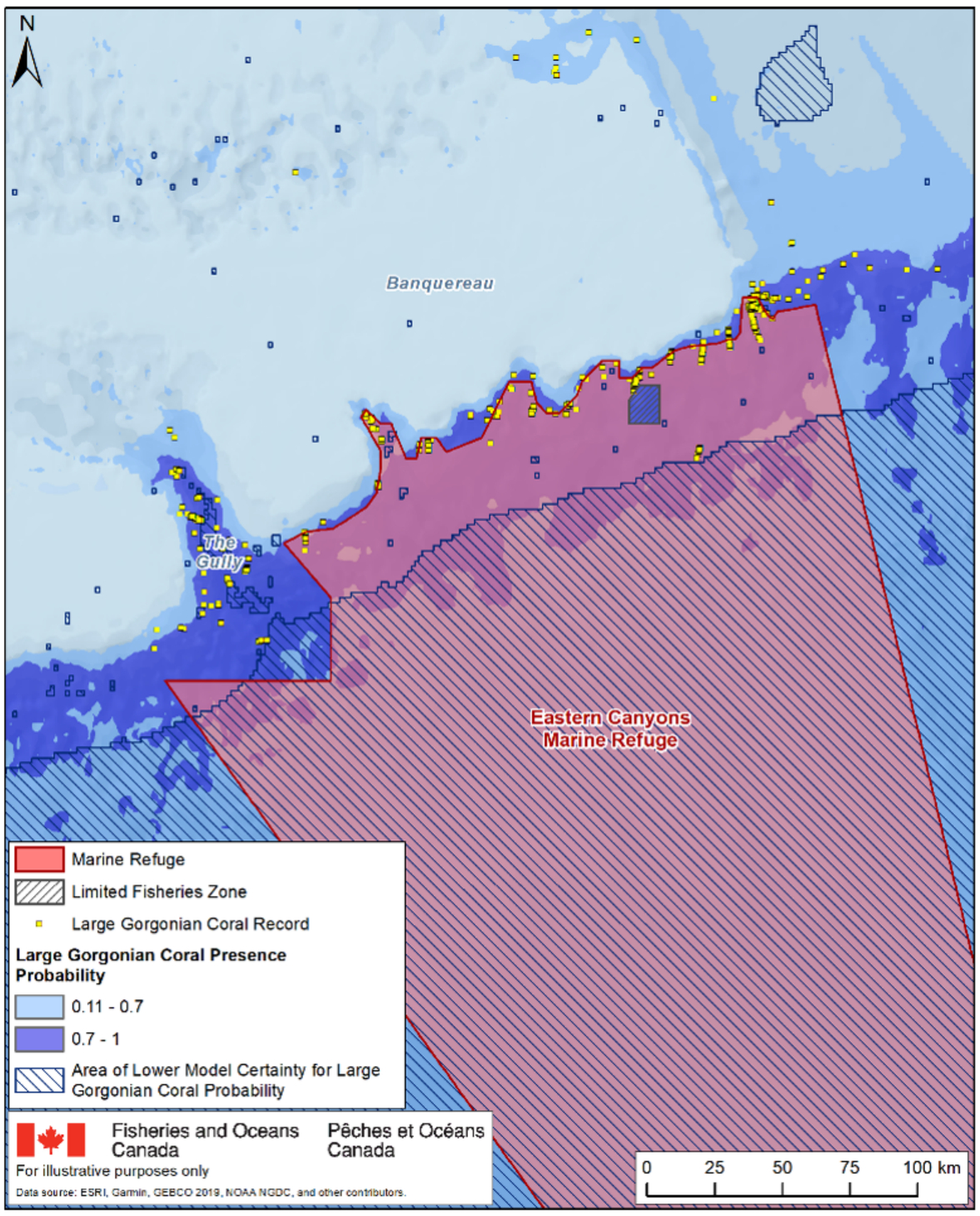


Figure 12. Large gorgonian coral records and presence probability model.

Past Research: Information concerning the Eastern Canyons area has been collected through a variety of methods over two decades. In 1997, prior to the designation of LCCA, marine harvester knowledge identified the presence of deep-sea corals along the Scotian Slope as well as within the Gully. DFO conducted imaging surveys in 1997 which observed live *Desmophyllum pertusum* fragments near the Stone Fence, which is now included in ECMR. This survey was followed up with a Campod survey of Stone Fence in 2003 which led to the designation of LCCA in 2004 (Buhl-Mortensen et al., 2017). Additional surveys were conducted in 2008, 2009, and 2015 and used to assess the effectiveness of the closure (Beazley et al., 2021b). Invertebrate diversity and abundance within the closure was observed to increase over time and be higher when compared to areas outside of the closure, suggesting that biodiversity benefits have accrued through the management actions. Between 2003-2017 the Fishery At-Sea Observer Program and the region-wide multispecies research trawl survey program reported the presence of corals in the Eastern Canyons area. Research vessel trawl survey data supplemented with other available data has been used to create presence probability distribution models for corals within and around the marine refuge to aid in the identification of coral hotspots and significant benthic areas (Kenchington et al., 2016; Wang et al., 2022) (Figure 12). Finally, Campod video and images were collected in a 2018 survey to validate coral distribution models based on previously collected data (Beazley et al., 2019). Vessel-based visual and acoustic surveys were conducted to study the distribution of northern bottlenose whales in multiple years between 2001 and 2022.

Ongoing Research: ROV surveys were conducted in the Gully MPA and ECMR in August 2022, as a collaborative research effort between Dalhousie University and DFO. The research cruise surveyed specific sites along transects to record video data and collect live coral samples. Sites were selected based on specific research objectives,

including how gradients in depth, substrate, and other factors influence coral and sponge habitats and their functioning, and evaluate life history strategies and potential vulnerabilities.

Climate Change: ECMR is projected to experience a lesser degree of change in environmental conditions compared to other sites within the SS-BOF bioregion (Murillo et al., 2022). Within ECMR, the amount of suitable habitat and the probability of occurrence of cold-water corals, specifically bubblegum coral, is expected to increase as the population distributions of cold-water corals may shift poleward and deeper as climate change continues (Poloczanska et al., 2016). Additionally, climate change models predict that the environmental conditions within ECMR will remain within the current recorded range for bubblegum coral representing potential climate refugia for the cold-water coral species (Wang et al., 2022). However, current climate projection models only have estimates up until 2046-2065, therefore, it is unclear whether this site will remain a climate refugia for cold-water coral species past 2065 as temperatures continue to rise. Moreover, ECMR is a vital seed source for cold-water corals including *Desmophyllum pertusum*; coral seed source sites are important for the dispersal of cold-water corals throughout the SS-BOF bioregion (Wang et al., 2022). Monitoring ECMR as a potential climate refugia site may allow for the identification of indicators and thresholds that can be used to find other potential climate refugia sites within the SS-BOF bioregion.

Conservation Network: ECMR contributes to various regional priorities and targets established through the SS-BOF bioregional conservation network (King et al., 2021) including the representation of important oceanographic and geomorphic features such as the Western and Sable Banks, abyssal plan, continental rise, and continental slope. Additionally, this site contributes to other bioregional conservation network targets such as the protection of biogenic habitat including sea pen fields, small and large gorgonian coral aggregations, and the protection of habitat for depleted species including redfish, roughhead grenadier, roundnose grenadier, smooth skate, thorny skate, and white hake. Hydrodynamic connectivity models show connectivity paths from the ECMR to the Gully MPA (Wang et al., 2022).

Site-Specific Priorities:

- Engagement with commercial fishing industry operating adjacent to ECMR through a review of gear drift surveillance, enforcement, and communication.
- Through research and exploration increase understanding of deep-water habitats and potential impacts of human activities.
- Review the Limited Fisheries Zone, and evaluate presence of corals through review of At-Sea Observer results and optical surveys.

Coordinates for Eastern Canyons Marine Refuge:

43° 54' 51.339" N	58° 44' 20.541" W
43° 56' 30" N	58° 40' 0" W
43° 57' 0" N	58° 34' 30" W
44° 0' 0" N	58° 28' 0" W
44° 2' 0" N	58° 26' 0" W
44° 6' 0" N	58° 25' 0" W
44° 8' 0" N	58° 25' 0" W
44° 13' 0" N	58° 29' 0" W
44° 14' 0" N	58° 28' 0" W
44° 12' 0" N	58° 25' 0" W
44° 12' 0" N	58° 23' 0" W
44° 7' 0" N	58° 20' 0" W
44° 7' 0" N	58° 18' 0" W
44° 10' 0" N	58° 17' 0" W
44° 10' 0" N	58° 14' 0" W
44° 8' 0" N	58° 12' 0" W
44° 10' 0" N	58° 5' 0" W
44° 18' 0" N	57° 59' 30" W
44° 18' 0" N	57° 55' 0" W
44° 15' 0" N	57° 54' 0" W
44° 13' 30" N	57° 52' 0" W
44° 13' 30" N	57° 49' 30" W
44° 16' 0" N	57° 46' 0" W
44° 18' 0" N	57° 45' 0" W
44° 21' 0" N	57° 41' 0" W
44° 21' 0" N	57° 37' 30" W
44° 18' 30" N	57° 37' 30" W
44° 18' 30" N	57° 35' 0" W
44° 20' 0" N	57° 33' 0" W
44° 20' 0" N	57° 31' 0" W
44° 22' 30" N	57° 26' 30" W
44° 23' 0" N	57° 24' 0" W
44° 23' 30" N	57° 18' 0" W
44° 24' 0" N	57° 16' 0" W
44° 24' 0" N	57° 14' 30" W
44° 25' 0" N	57° 13' 30" W
44° 30' 0" N	57° 13' 0" W
44° 30' 0" N	57° 10' 0" W
44° 27' 30" N	57° 8' 0" W
44° 27' 0" N	57° 7' 0" W
44° 28' 0" N	57° 6' 0" W
44° 29' 0" N	56° 58' 30" W
41° 56' 0" N	56° 8' 0" W
41° 38' 0" N	56° 31' 0" W
41° 21' 0" N	56° 58' 0" W
43° 35' 0" N	59° 8' 0" W
43° 35' 0" N	58° 35' 0" W
43° 47' 0" N	58° 35' 0" W
43° 54' 51.339" N	58° 44' 20.541" W

Limited Fishing Zone:

44° 17' 30" N	57° 33' 30" W
44° 17' 30" N	57° 29' 30" W
44° 12' 0" N	57° 29' 30" W
44° 12' 0" N	57° 35' 30" W
44° 15' 30" N	57° 35' 30" W
44° 17' 30" N	57° 33' 30" W

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