

# Ecological Overview of the Proposed South Coast Fjords National Marine Conservation Area

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## ABSTRACT

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In support of an ecological overview for the proposed South Coast Fjords National Marine Conservation Area (NMCA), the Department of Fisheries and Oceans Canada (DFO) Newfoundland and Labrador (NL) Region hosted a workshop on available information in September 2024. Subject matter experts from DFO NL Science and Aquatic Ecosystems Branches were invited to present existing information across 12 topics: bathymetry; oceanographic conditions; estuarine and coastal features; anadromous and catadromous fishes; marine fishes; pinnipeds, cetaceans, and sea turtles; invertebrates; corals and sponges; aquatic invasive species; special areas; aquaculture science, and resource utilization and anthropogenic influences.

This technical report describes the information presented at the workshop, which aimed to address four Terms of Reference relating to key biophysical and ecological features of the study area; areas of overlap between activities/stressors and species/habitats of interest, including at-risk species; key uncertainties and knowledge gaps; and recommendations.

Although relatively data poor compared to other areas in NL Region, the information contained in this technical report demonstrates that the South Coast Fjords study area contains multiple biophysical and ecological features, species, and processes of interest. This technical report is a useful baseline summary of existing DFO NL Region information in the area and can be used to support the NMCA feasibility assessment as well as other planning and decision-making processes.

## RÉSUMÉ

Pretty, C., Bartlett, J., Ratsimandresy, A.W., Maillet, G., Bélanger, D., Cyr, F., Pepin, P., Gibb, O., King, C., Warren, M., Sargent, P.S., Gregory, R.S., Kelly, N.I., Bradbury, I., Burke, C., Duffy, S.J., Keefe, D., Adamack, A.T., Mello, L.G.S., Munro, H., Hamilton, C.D., Lang, S.L.C., Lawson, J.W., Charmley, K., Neves, B.M., Hayes, V.E., McKenzie, C.H., Bungay, A., Piersiak, M., Meade, J., and Gullage, M. 2025. Ecological Overview of the Proposed South Coast Fjords National Marine Conservation Area. Can. Tech. Rep. Fish. Aquat. Sci. 3663: xiv + 163 p. <https://doi.org/10.60825/9114-cj80>

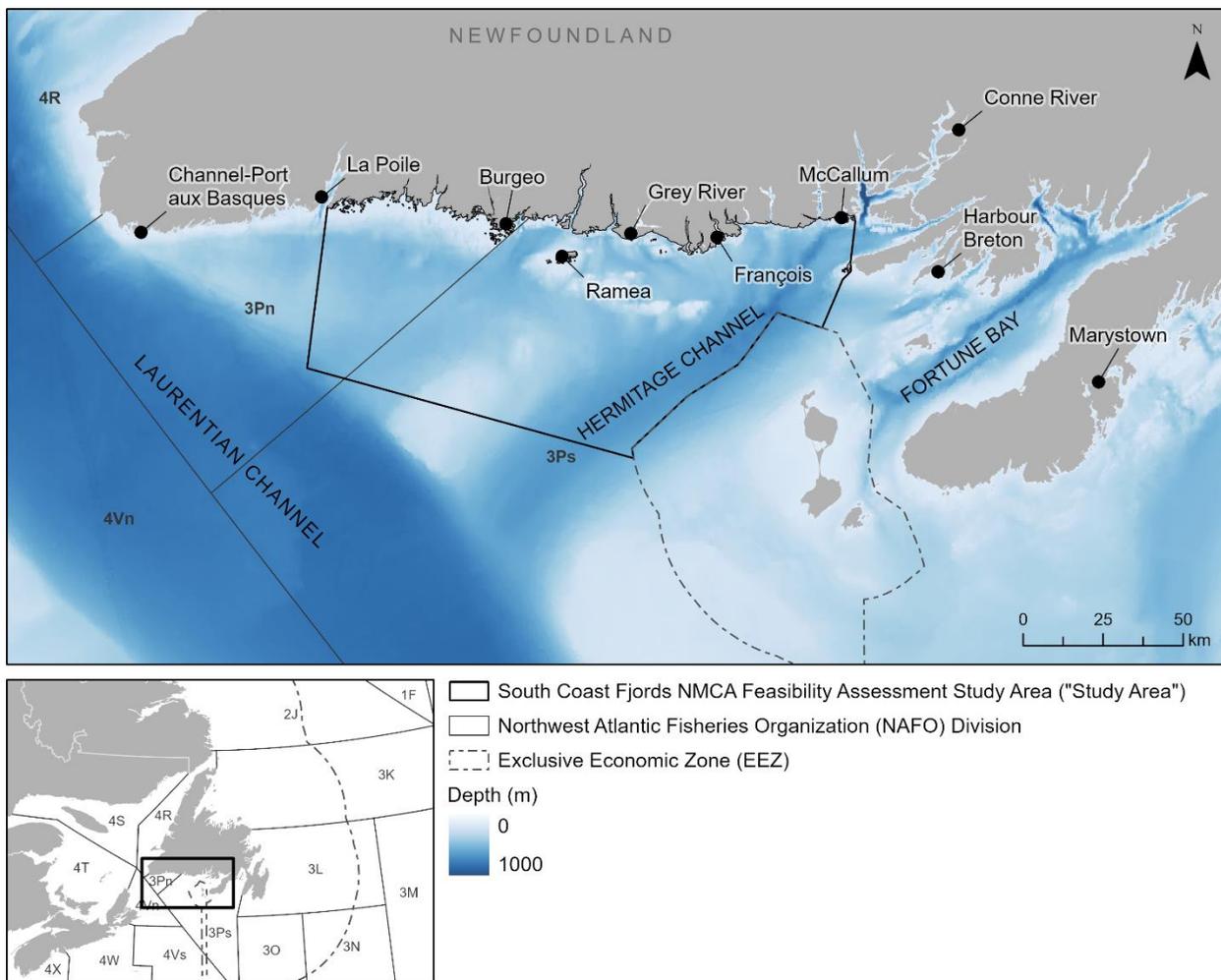
Dans le cadre d'un aperçu écologique du projet d'aire marine nationale de conservation (AMNC) des fjords de la côte sud, la région de Terre-Neuve-et-Labrador (T.-N.-L.) du ministère des Pêches et des Océans du Canada (MPO) a organisé un atelier sur l'information disponible en septembre 2024. Les spécialistes des directions des sciences et des écosystèmes aquatiques de la région de T.-N.-L. du MPO ont été invités à présenter l'information existante sur 12 sujets : la bathymétrie; les conditions océanographiques; les caractéristiques estuariennes et côtières; les poissons anadromes et catadromes; les poissons marins; les pinnipèdes, les cétacés et les tortues de mer; les invertébrés; les coraux et les éponges; les espèces aquatiques envahissantes; les zones particulières; la science de l'aquaculture; ainsi que l'utilisation des ressources et les influences anthropiques.

Ce rapport technique décrit les informations présentées lors de l'atelier, dont l'objectif était de répondre à quatre cadres de référence liés aux principales caractéristiques biophysiques et écologiques de la zone d'étude; aux zones de chevauchement entre les activités/facteurs de stress et les espèces/habitats d'intérêt, y compris les espèces en péril; aux principales incertitudes et lacunes dans les connaissances; et aux recommandations.

Même si cette zone est relativement pauvre en données par rapport à d'autres zones de la région de Terre-Neuve-et-Labrador, l'information contenue dans ce rapport technique démontre que la zone d'étude des fjords de la côte sud contient de nombreuses caractéristiques biophysiques et écologiques, espèces et processus d'intérêt. Ce rapport technique présente un résumé de base utile des informations existantes de la région de Terre-Neuve-et-Labrador du MPO dans la zone et peut être utilisé pour appuyer l'évaluation de faisabilité de l'AMNC ainsi que d'autres processus de planification et de prise de décision.

## INTRODUCTION

In June 2023, the Government of Canada signed a Memorandum of Understanding with the Government of Newfoundland and Labrador, Miawpukek First Nation, Qalipu First Nation, and the Town of Burgeo to assess the feasibility of establishing a national marine conservation area (NMCA) on the south coast of Newfoundland. The feasibility assessment for the proposed South Coast Fjords NMCA has a study area of approximately 9,112 km<sup>2</sup> (Figure 1.0; Parks Canada 2024). As the lead agency for the NMCA, Parks Canada is undertaking community, stakeholder, and rightsholder group engagement sessions, as well as gathering information towards ecological and socio-economic reviews of the study area. As part of their ecological overview, Parks Canada requested that the Department of Fisheries and Oceans Canada (DFO) Newfoundland and Labrador (NL) Region host a workshop on available information in the study area.



*Figure 1.0: The South Coast Fjords NMCA feasibility assessment study area (black outline) is located on the south coast of Newfoundland between the communities of La Poile and McCallum, extending into the offshore. The study area overlaps with the Northwest Atlantic Fisheries Organization (NAFO) Subdivisions (Subdiv.) 3Ps and 3Pn (grey lines). The Laurentian Channel, Hermitage Channel, and Fortune Bay are also labelled.*

A hybrid workshop was held at the Northwest Atlantic Fisheries Centre in St. John's, NL, on September 24-25, 2024. Subject matter experts from DFO NL Science and Aquatic Ecosystems Branches were invited to present existing information across 12 topics chosen by Parks Canada and largely consistent with similar biophysical and ecological overviews undertaken in NL Region:

1. Bathymetry;
2. Oceanographic Conditions;
3. Estuarine and Coastal Features;
4. Anadromous and Catadromous Fishes;
5. Marine Fishes;
6. Pinnipeds, Cetaceans and Sea Turtles;
7. Invertebrates;
8. Corals and Sponges;
9. Aquatic Invasive Species;
10. Special Areas;
11. Aquaculture Science; and
12. Resource Utilization and Anthropogenic Influences.

In total, 65 people representing DFO, Parks Canada, Government of Newfoundland and Labrador, academia, industry, Indigenous groups, local communities, and non-governmental organizations attended some portion of the workshop.

The workshop aimed to address four Terms of Reference:

1. Identify, describe, and map, where possible, key biophysical and ecological features of the study area, including:
  - a. Predominant and unique physical and biological oceanographic characteristics;
  - b. Predominant, unique, and sensitive habitat features (marine, estuarine and coastal); and
  - c. Distribution and abundance of species of interest (including at risk species), and the abiotic and biotic factors influencing their distribution.
2. Identify known areas of overlap between potential activities and stressors and species and habitats of interest, with consideration of sensitivity of species and habitats if possible.
  - a. OPTIONAL: Climate change considerations for species/habitats more vulnerable to climate change.
3. Identify key uncertainties and knowledge gaps as they pertain to the current understanding of the existing environment and the species of interest, and recommended measures to address these data gaps where possible.
4. Recommend key features or areas of ecological significance that warrant protection.

This technical report describes the information presented at the workshop.

## **ASSESSMENT OF THE SOUTH COAST FJORDS STUDY AREA**

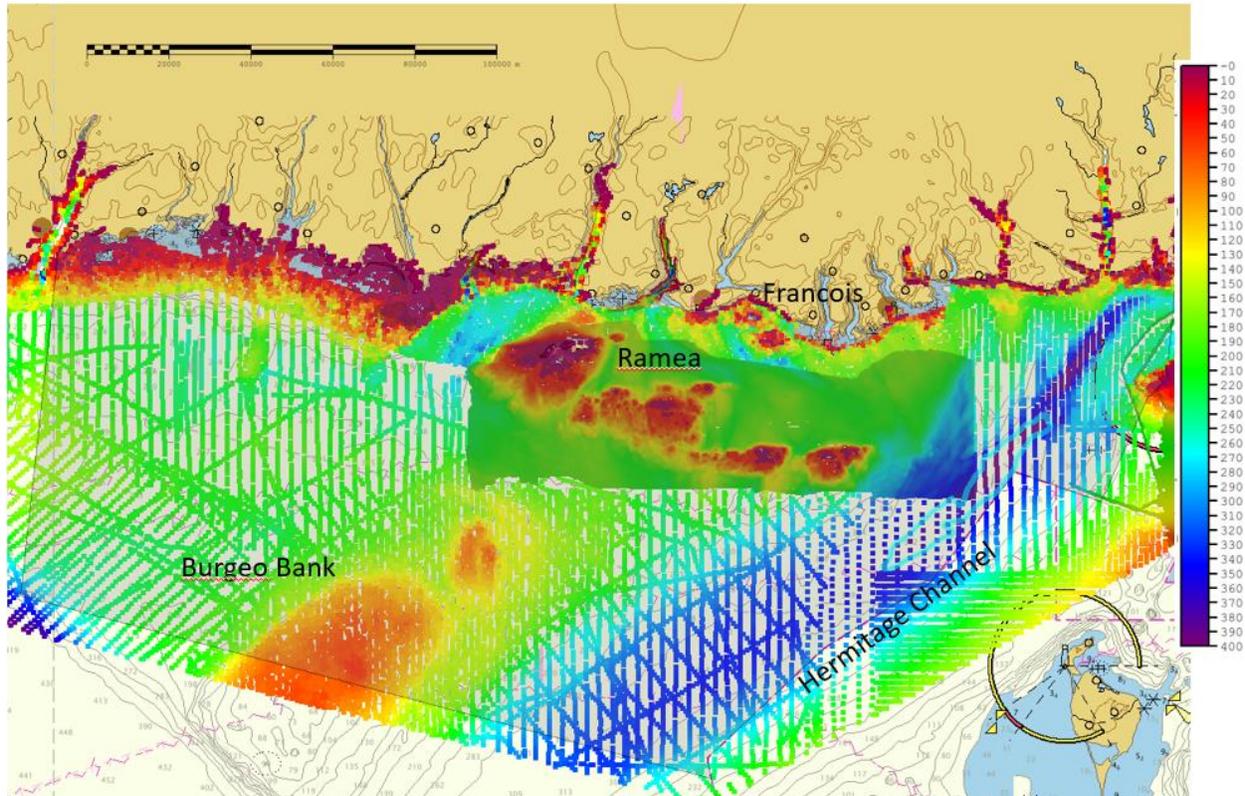
The four workshop Terms of Reference (TOR) are addressed under the headings of Available Information (TOR #1), Sensitive Species and Habitats (TOR #2), and Data Gaps and Recommendations (TOR #3 and #4) for each of the 12 topics of interest in the chapters below.

## 1. BATHYMETRY

*Author: Jason Bartlett*

### Available Information

The existing bathymetry information within the South Coast Fjords study area (Figure 1.1) is available from a mix of technologies (acoustic, airborne laser) spanning collection dates from the 1950s through to 2017.



*Figure 1.1: Complete bathymetry inventory of study area, including singlebeam, multibeam, and airborne laser (Lidar) data. The colour scale represents bathymetric depths from 0 m (red) to 400 m (blue).*

The predominant coverage is from sparse singlebeam soundings collected between the 1950s and early 1990s. This coverage (Figure 1.2) allows for the definition of the general seafloor contours and the identification of macro seafloor features but offers little for other scientific studies.

Denser multibeam bathymetry does exist in select areas (Figure 1.3), spanning collection dates from the late 1990s to 2017. The earlier multibeam data was collected using the earliest commercial multibeam systems and its quality is much poorer than what would be obtained today. While offering a denser dataset for seafloor definition, there are no value added information contained in these datasets. Existing modern multibeam data contains the full suite of information such as gridded seafloor representations and reflectivity, which provide 3D representations of the seafloor topography as well as indications of the seafloor sediment composition.

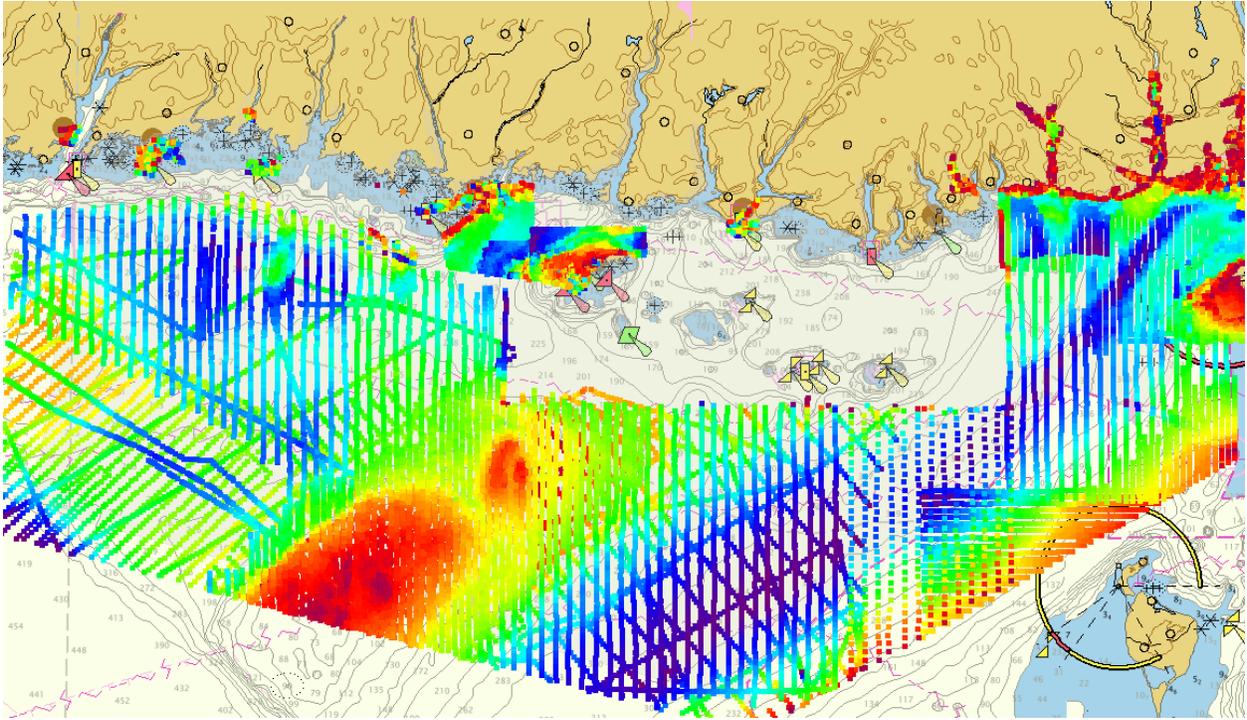


Figure 1.2: Inventory of singlebeam data collected in and around the study area from the 1950s to the early 1990s.

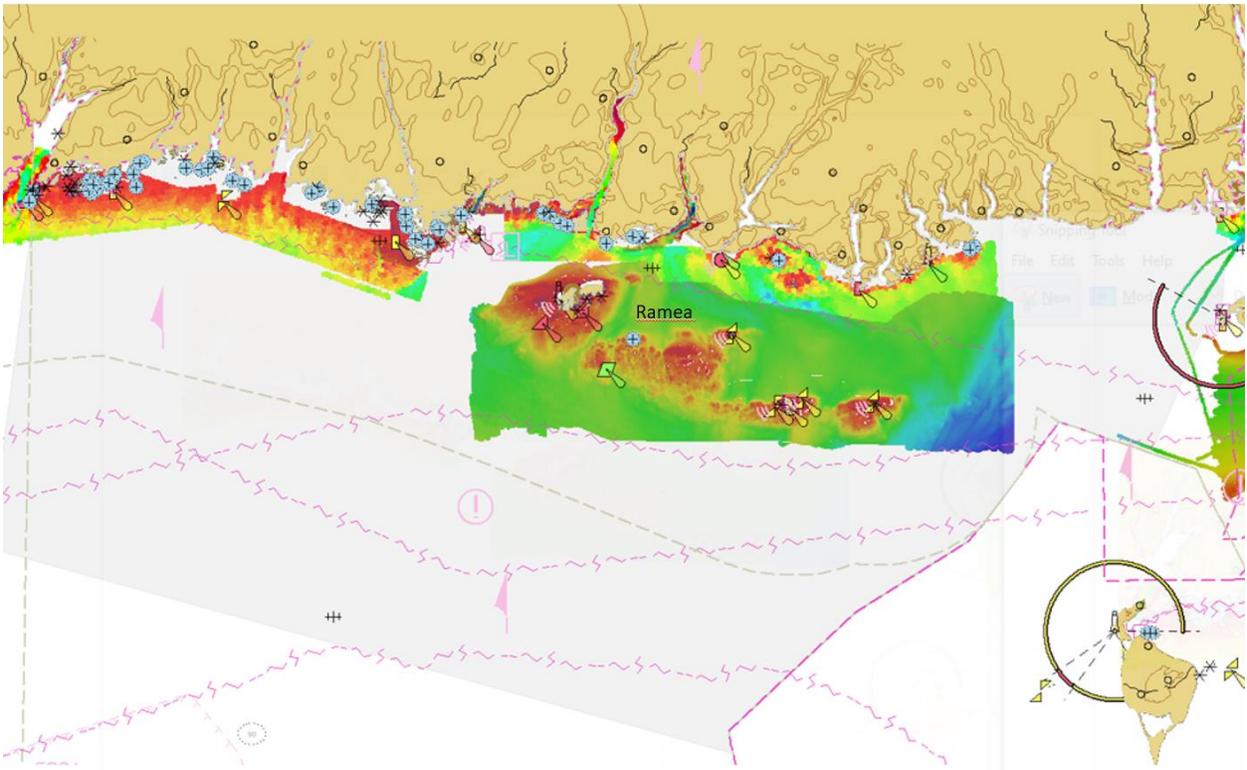


Figure 1.3: Inventory of multibeam data collected in and around the study area from the late 1990s to 2017.

An airborne laser (Lidar) dataset was collected in 2017 along the coastline between Burgeo and Grand Buit (Figure 1.4). It is modern and accurate, however only offers a lower resolution dataset. This is primarily used for nearshore and intertidal zone mapping. It does contain high resolution air photos and could potentially have the optical reflectivity recovered as well as offer some rough determination of water clarity conditions.

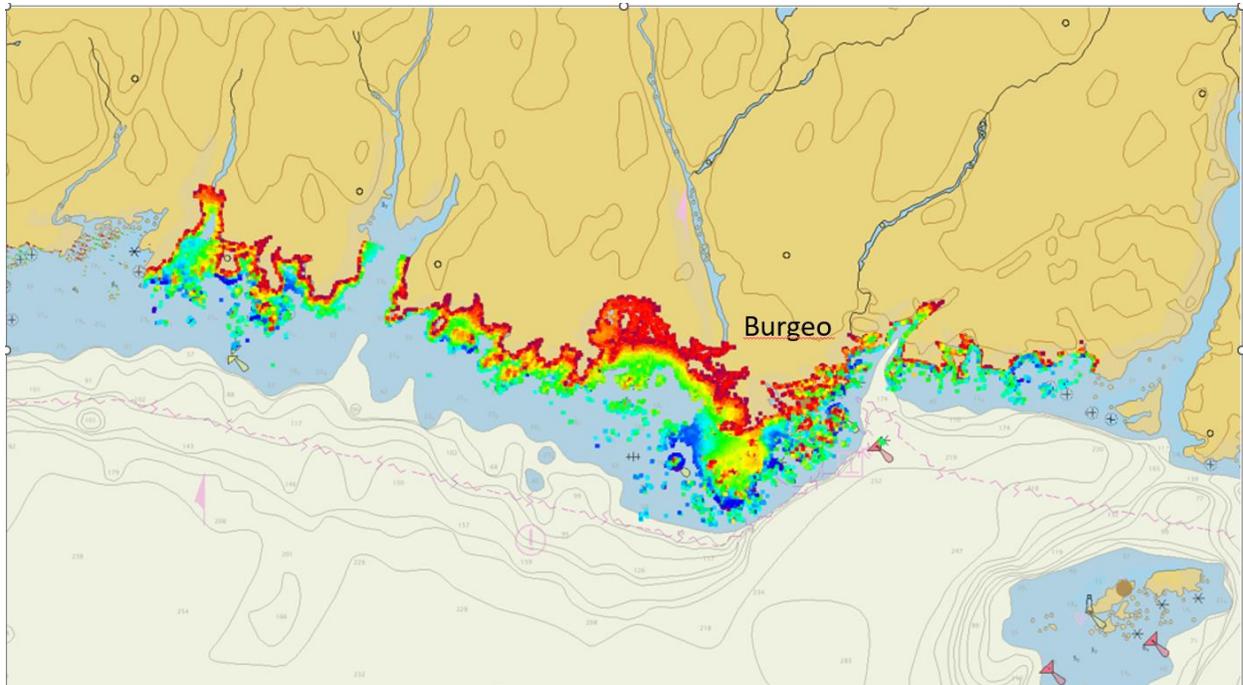


Figure 1.4: Inventory of airborne laser (Lidar) data collected along the coastline between Burgeo and Grand Buit (not pictured) in 2017.

### Bathymetric Zones of Interest

There are six macro-bathymetric zones of interest within the study area; five that show large topographic diversity and one which encompasses the remainder of the area. The five diverse areas are outlined in Figure 1.5. The zones of interest can be defined as follows:

1. Burgeo Bank – large, bathymetrically non-complex, shoal rising to minimum depths of approximately 50 m. The area is approximately 50 km on the long axis and 25 km on the short axis;
2. Hermitage Channel – deep channel (400+ m) that is connected to the Laurentian Channel;
3. Ramea/Harbour Island – large outcropping in otherwise deep water, depth range approximately 0–250 m;
4. Coastal/Nearshore zone – two distinct areas in this zone:
  - a. A broader, bathymetrically complex seafloor, stretching out approximately 5 km from the shoreline, to a depth of approximately 100 m;
  - b. Very narrow zone approximately 1 km from the shoreline, complex but quickly transitions into the deeper zone to a depth of approximately 100 m;
5. Fjords – maintains standard Fjord topography, steep slopes and deep in the middle;
6. Area remainder – gentle sloping or flat, ranging between 200 and 250 m depth.

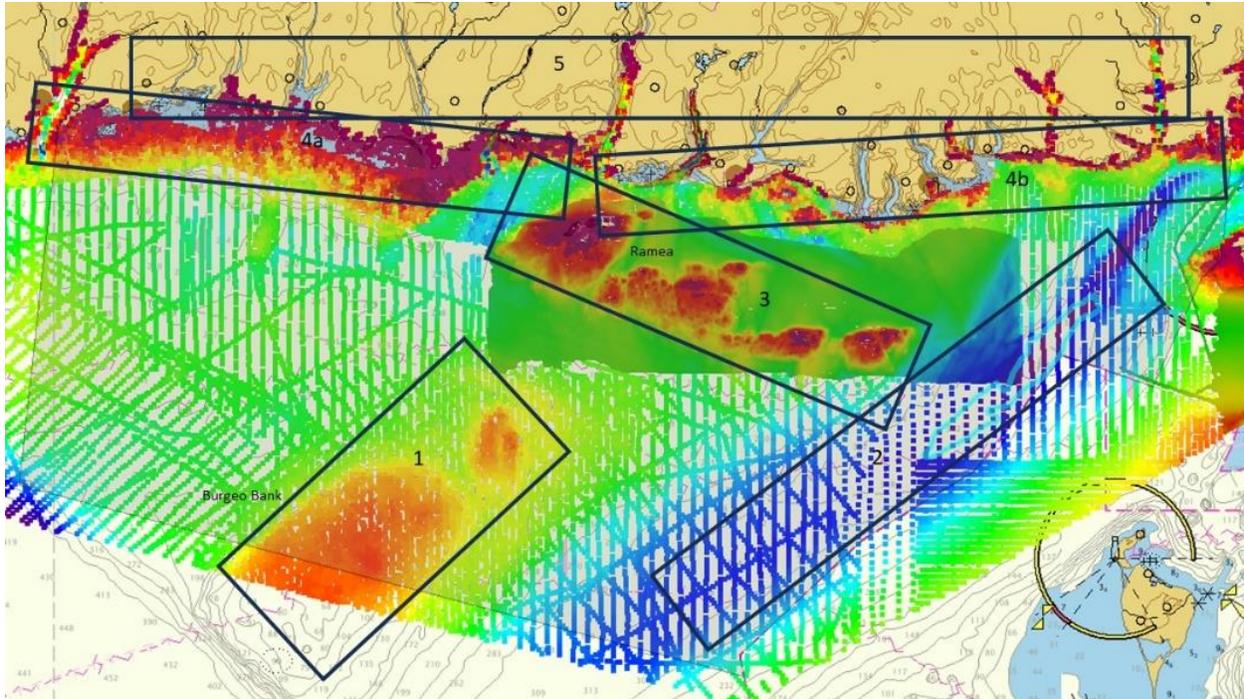


Figure 1.5: Bathymetric zones of interest within the study area include: 1) Burgeo Bank, 2) Hermitage Channel, 3) Ramea/Harbour Island, 4) Coastal/Nearshore Zone, 5) Fjords, and the area remainder.

### Data Gaps and Recommendations

From a strict bathymetry perspective, the gaps in data lie where we do not have full bottom coverage. Figure 1.6 graphically shows the gap analysis of the study area highlighting that it is predominantly of minimal coverage. Another gap that is directly related to the bathymetry is the coastal tidal structure, which has not been adequately studied.

Recommendations:

- Replace the singlebeam with denser and more modern technology (e.g., multibeam).
- Obtain an accurate measure of the tidal dynamics so the bathymetry influences on the nearshore and intertidal zones can be understood.
- Explore alternate technologies for data collection such as Satellite Derived Bathymetry and autonomous vehicles to address the complexities of bathymetry collection in the shallow nearshore zones.



Figure 1.6: Colour-coded gap analysis from the Canadian Hydrographic Service (CHS) Priority Planning Tool. The blue map background indicates no coverage.

## 2. OCEANOGRAPHIC CONDITIONS

Authors: Andry W. Ratsimandresy, Gary Maillet, David Bélanger, Frédéric Cyr, Pierre Pepin, and Olivia Gibb

### Available Information

The report on physical and biological oceanography of the South Coast Fjords study area draws extensively on information obtained by DFO in coastal oceanographic studies conducted to develop Bay Management Areas (BMAs) on the south coast of Newfoundland to support optimal fish health management for aquaculture (Ratsimandresy et al. 2020), the [Coastal Environmental Baseline Program](#) (Placentia Bay, NL Region; CEBP), and the [Atlantic Zone Monitoring Program](#) (AZMP). The latter was implemented in 1998 with the aim of increasing DFO's capacity to understand, describe, and forecast the state of the marine ecosystem and to quantify the changes in the ocean's physical, chemical, and biological properties based on a series of standard ocean sections monitored seasonally across the northwest Atlantic Ocean (Therriault et al. 1998, Bernier et al. 2018).

### General Oceanographic Conditions on the South Coast of Newfoundland

Few oceanographic surveys have been conducted within the study area and in many cases, we rely on seasonal studies conducted nearby to infer the general conditions and trends over the Newfoundland south coast. In the sections below, we provide available information on general oceanographic conditions, the light environment, and chemical (e.g., nutrient conditions) and biological (e.g., phytoplankton and zooplankton dynamics) indices to describe the baseline conditions of the marine ecosystem. We also utilize remote sensing data where available to infer near-surface oceanographic conditions directly within the South Coast Fjords study area.

The south coast of Newfoundland is dominated by large-scale oceanic circulation via the inshore branch of the Labrador Current (LC) which transports colder-lower salinity waters south-eastwardly along the Labrador Shelf, impacting the water properties of the eastern and southern shelf areas (Figure 2.1). Wind forcing, bathymetry, and advective transport of these respective water masses can influence the physical oceanographic dynamics across this area (Donnet et al. 2018, Ratsimandresy et al. 2020).

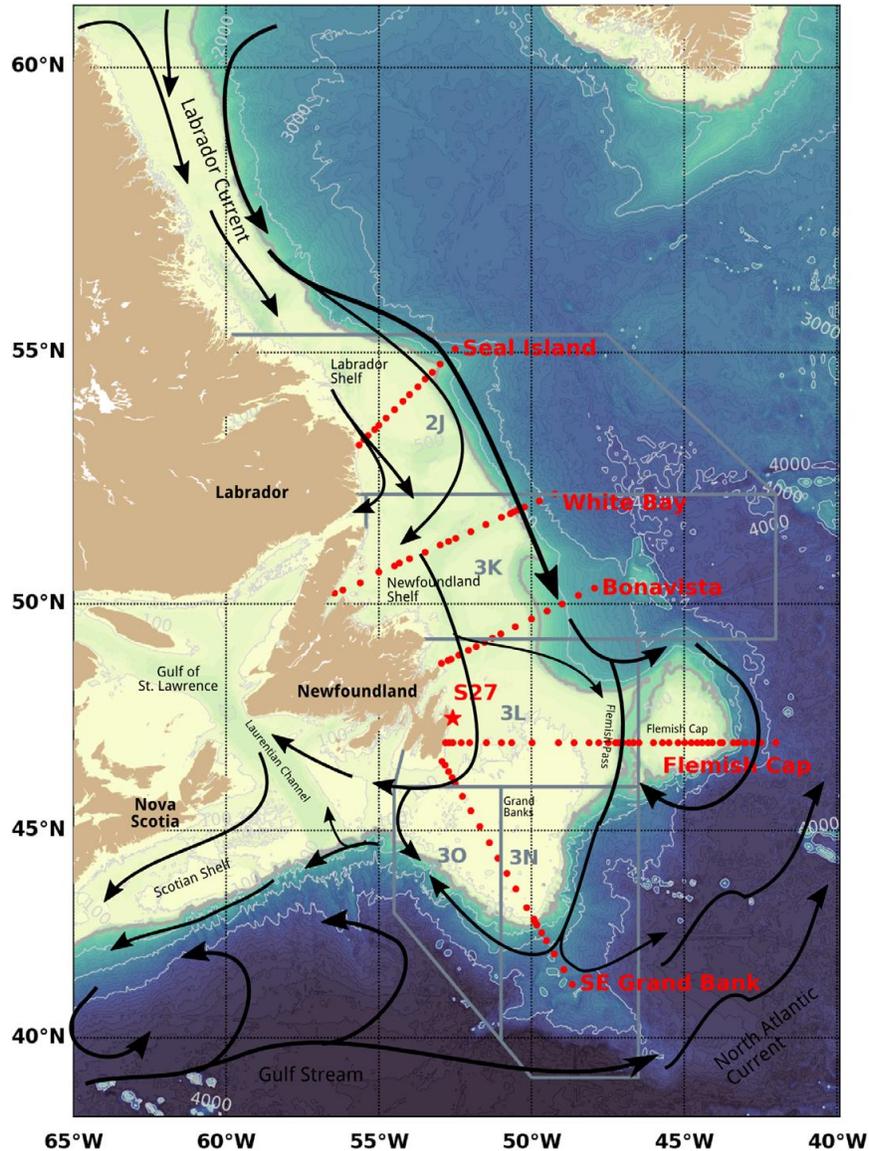


Figure 2.1: Main surface currents from the northwest Atlantic contributing to water masses on the south coast of Newfoundland (black arrows). The Labrador Current transports water southward from polar regions and contributes to the cold-lower saline water mass while inputs from the North Atlantic Current contribute warmer-more saline conditions. Red points indicate biophysical stations conducted by AZMP. Figure obtained from Cyr et al. (2024b).

Use of satellite altimetry permits time series measurements of the LC transport index to infer the quantity of water moving southward from Subarctic areas over the Labrador and northeastern Newfoundland Slope (Han et al. 2008). The inshore branch of the LC flowing southward through the Avalon Channel and around the Avalon Peninsula contributes oceanographic characteristics

to the Newfoundland south coast by transporting cooler-lower salinity waters to the area. The time series generally indicates above average transport indices from 2016 to 2023, transitioning from generally below normal inputs during 2004–2015 (top panel of Figure 2.2). The LC index has remained positive for 7 of the past 8 years on the Labrador and northeastern Newfoundland Slope, contributing larger proportions of subpolar waters to the physical and biological environments off Atlantic Canada (Cyr et al. 2024b). The pattern further south on the Scotian Slope (bottom panel of Figure 2.2) tends to show the opposite trend. The rates of flow are larger by an order of magnitude in the north compared to southern areas where measurements are obtained.

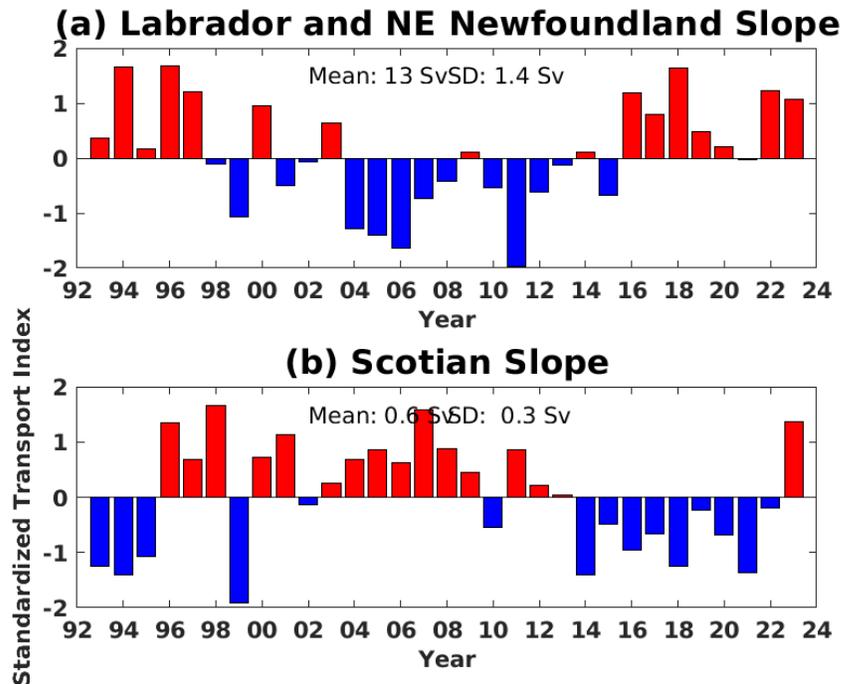
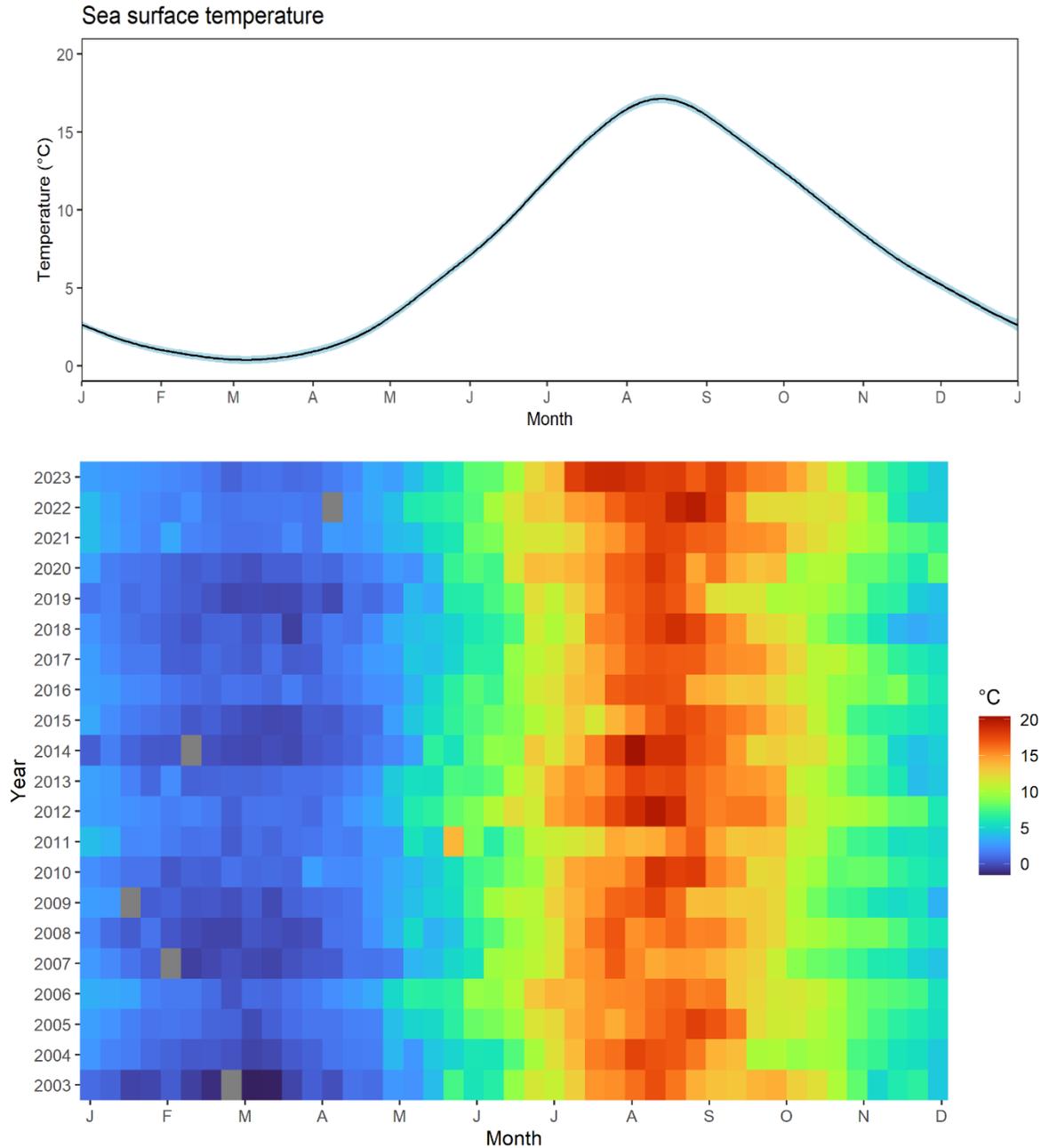


Figure 2.2: Standardized LC transport index during 1993–2023 for a) Labrador and northeastern Newfoundland Slope and b) Scotian Slope. The climatology was established during the reference period 1993–2020. Ocean transport units are Sverdrup (Sv;  $1 \text{ Sv} = 1 \times 10^6 \text{ m}^3 \text{ s}^{-1}$ ). Figure obtained from DFO (2023b).

Sea surface temperature (SST) climatology in the South Coast Fjords study area was acquired from satellite imagery available from 2003 through to 2023 (Clay et al. 2021). We used 8-day composite imagery to account for gaps in the imagery due to cloud cover and satellite image availability. The 20-year seasonal climatology of SST indicates values above subzero conditions throughout the winter months (Figure 2.3). Rapid warming occurs during May through August with peak SST occurring in mid-August. Thereafter, a gradual decline in temperatures occurs throughout the fall (Figure 2.3). Interannual variation in the 8-day composite satellite SST imagery, extracted from Clay et al. (2021), indicates cool temperatures ( $< 5^\circ\text{C}$ ) throughout January through April (Figure 2.3). Surface warming begins gradually in mid-March followed by rapid warming in June with peak SST conditions observed throughout August and September months approaching seasonal maxima of  $20^\circ\text{C}$  in certain years.



*Figure 2.3: Average 20-year (2003–2023) seasonal climatology of SST and  $\pm$  95% confidence interval (shaded blue area) obtained from MODIS-Aqua R2022.0 (top panel). Interannual SST from 2003 to 2023 within the study area (bottom panel).*

Annual mean SST minima and maxima have generally trended upward during the 20-year time series (Figure 2.4). The average rate of change during the series indicates an increase of  $0.07^{\circ}\text{C}$  per year. In recent years (2021–2023), no observations of sub-zero mean temperatures occurred within the study area in contrast to previous years when winter conditions approached near zero or sub-zero levels (Figure 2.4).

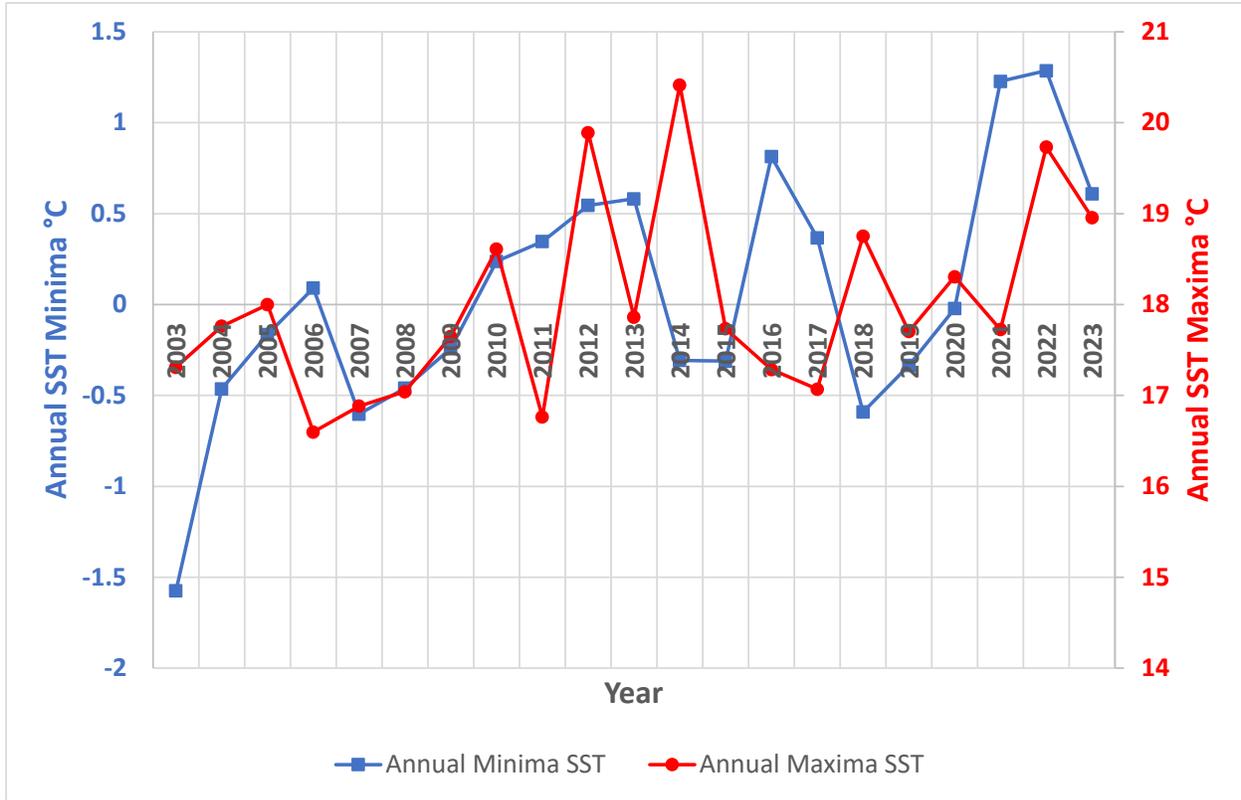


Figure 2.4: Annual mean minima and maxima SST during 2003–2023 time series in the South Coast Fjords study area.

An SST composite index (Figure 2.5) from northern Labrador to the Scotian Shelf indicates a general warming trend throughout the northwest Atlantic since the late 1990s (Cyr et al. 2024b). SST has remained mostly positive in the northwest Atlantic since 1998 through to 2014 when the composite index declined to normal-below normal in 2015–2019. In recent years (2020–2021), the composite index is again above normal. In the heavy ice years throughout the mid-1980s and early 1990s, the composite index remained well below normal. Temperature at the seafloor (Figure 2.6) throughout NL including the south coast (NAFO Subdiv. 3Ps), derived mainly from multispecies surveys, were generally below normal throughout the 1980s to the mid-1990s, transitioning to above average levels during the latter two decades and recent years across both spring and fall seasons (Cyr et al. 2024b).

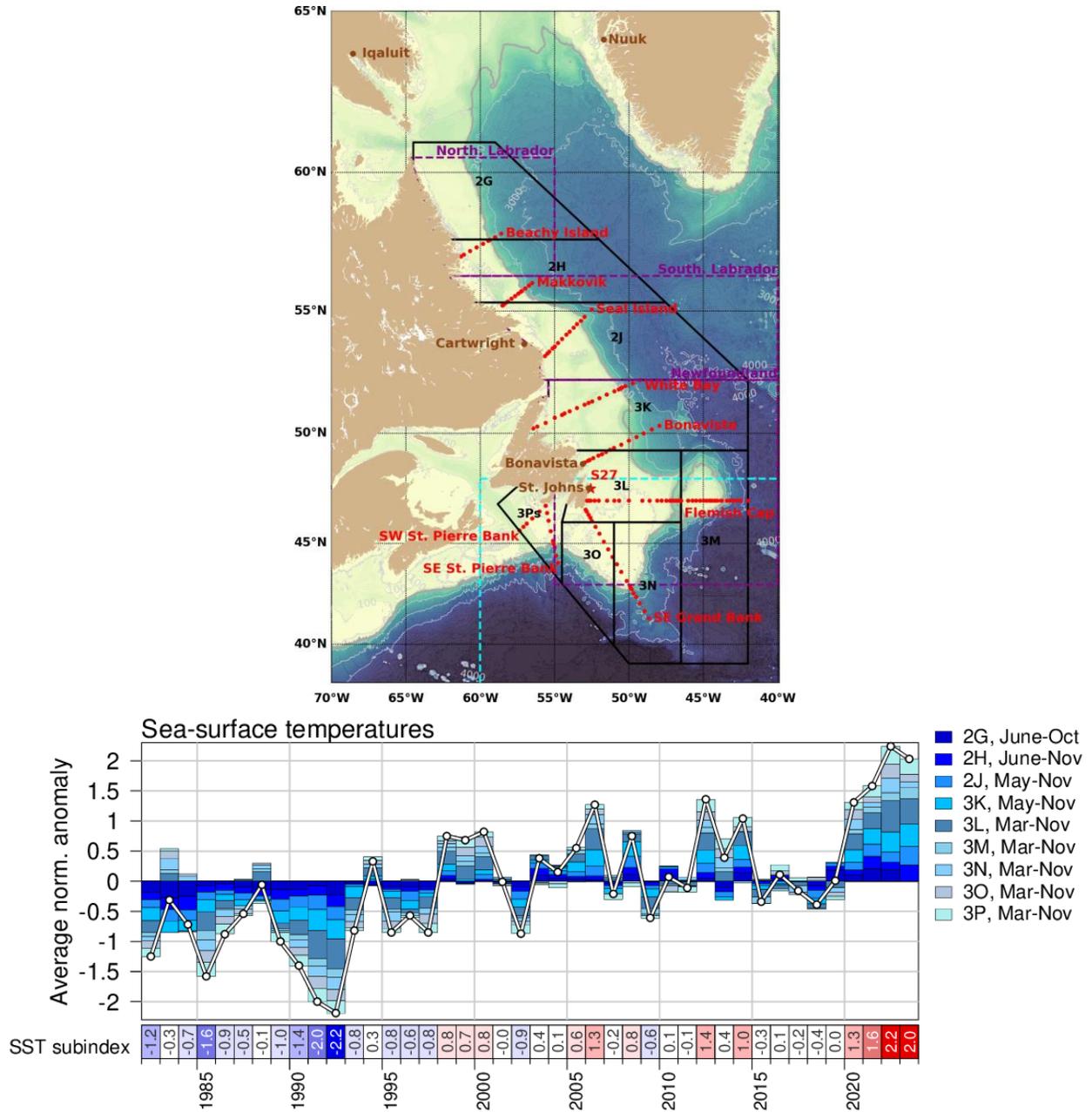


Figure 2.5: Map showing the NAFO Div. 2GHJ3KLMNOPs (NAFO Subareas 2 and 3) delineated by black boxes (top panel). SST composite index in NAFO Subareas 2 and 3 since 1982 (bottom panel). The boxes in various ranges of blue colour within the time series illustrate the contributions from NAFO Divisions and months used in the average normalized anomaly SST index. NAFO Subdiv. 3Ps partially encompasses the South Coast Fjords study area. Figures obtained from Cyr et al. (2024b).

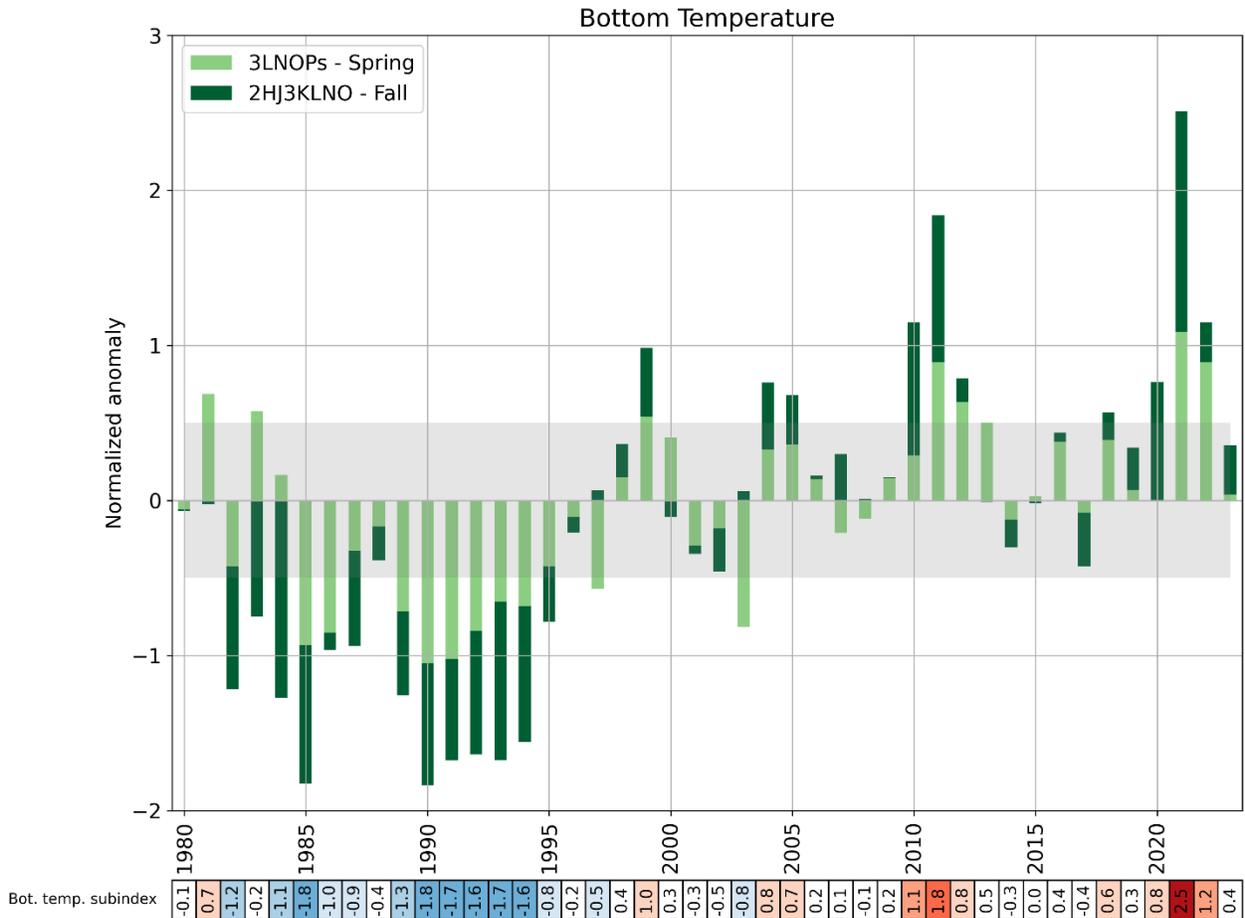


Figure 2.6: Standardized anomalies of averaged bottom temperature in NAFO Div. 3LNOPs (spring) and 2HJ3KLNO (fall). Deviations of  $\pm 0.5$  units (grey-colored band) are within normal levels. The summed indices for both seasons are shown by the color-coded scorecard at the bottom of the figure. NAFO Subdiv. 3Ps partially encompasses the South Coast Fjords study area. Figure obtained from Cyr et al. (2024b).

Ocean climate indices can be used to infer the general environmental conditions over a broad area, providing useful ecosystem indicators. An ocean climate index that incorporates meteorological and oceanographic indices provides an integrated time series of the overall large-scale physical forcing on the marine environment including the Newfoundland south coast (Cyr and Galbraith 2021). The time series extends back to the warm and saline conditions of the 1950s and 1960s throughout the northwest Atlantic culminating with a record-high in 1966 (Figure 2.7). The start of large-scale cooling events were observed throughout the 1970s through to the early 1990s with a record low observed in 1991. In recent decades (2000s and 2010s), ocean climate conditions have fluctuated between short-term warm-saline and colder-fresher conditions (Cyr et al. 2024b). The NL climate index has remained in a positive phase (e.g., warm and fresh conditions) since 2020 with the warmest year on record in 2021 (Figure 2.7).

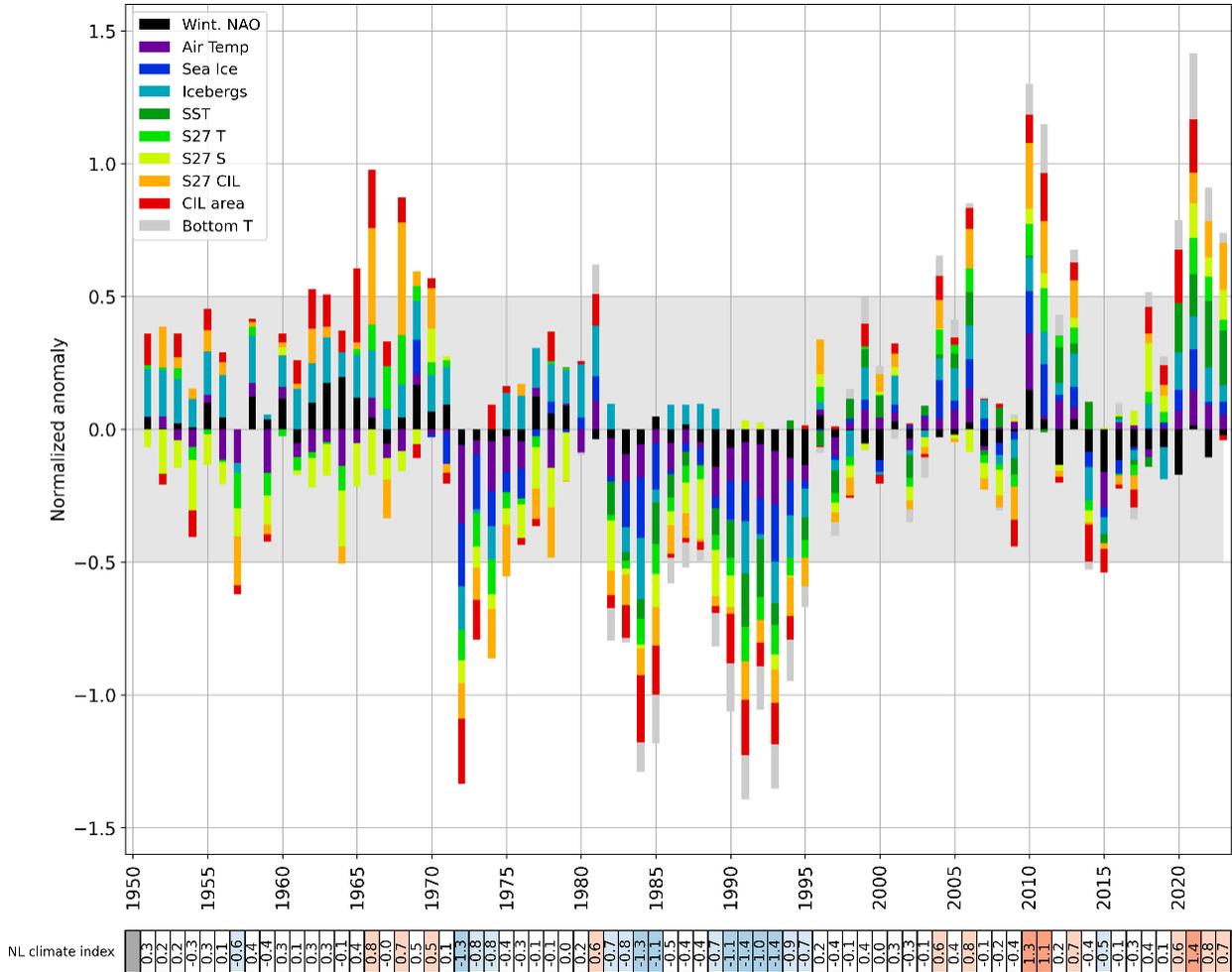


Figure 2.7: NL climate indices include a variety of meteorological and oceanographic variables to describe the overall conditions across a broad region. Some of the climate indices include NAFO Subdiv. 3Ps, which partially encompasses the South Coast Fjords study area. Figure obtained from Cyr et al. (2024b).

Temperature and salinity data extracted from the Canadian Atlantic Shelf Temperature-Salinity (CASTS) database (Coyne et al. 2023, Figure 2.8) for the south coast of Newfoundland and plotted to illustrate monthly profiles for temperature (Figure 2.9) and salinity (Figure 2.10) show the South Coast Fjords study area structure as similar to the surrounding areas. This data set spans the period of 1915 to 2023 with some years and some months having more measurements than others. A cold near-homogenous winter water column is present in the upper 150 m; stratification starts in early spring to reach its peak in August and breaks down again in the fall before being completely mixed again during winter (Cyr et al. 2024b, Donnet et al. 2022). In general, water in the upper layer in the study area can be warmer than that on the western side and cooler compared to the eastern side (by  $\sim 1\text{-}2^\circ\text{C}$ ). At depth (below  $\sim 100\text{ m}$ ) water temperature in the western and the southern areas can be slightly warmer than in the study area. Salinity structure in the study area is also similar to the surrounding regions but with narrower range below the upper layer. This is likely due to differences in the input of water into the region either of Labrador or Atlantic origin. Near the surface, the study area has limited freshwater run-off compared to that in Bay d'Espoir or head of Belle Bay (both located east of the study area).

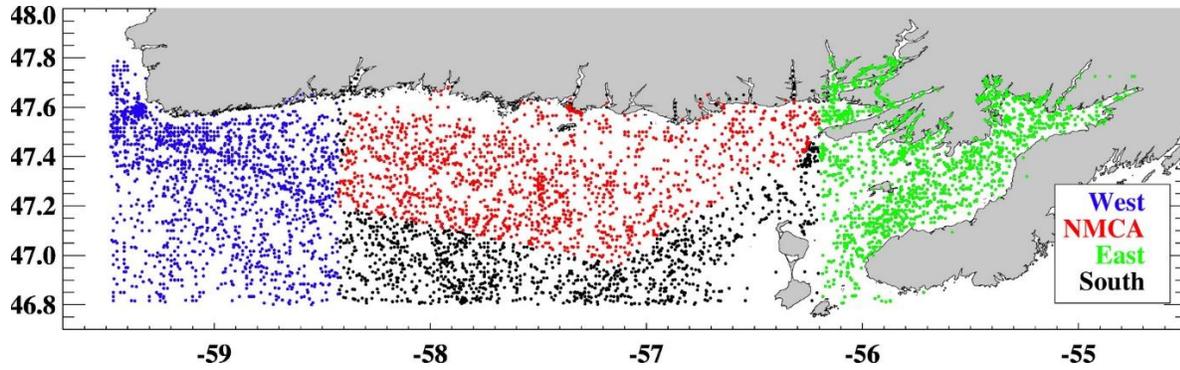


Figure 2.8: Location of the stations on the south coast of Newfoundland where temperature and/or salinity measurements were carried out. The data were split into four sub-areas based on location relative to the South Coast Fjords study area (NMCA, in red). Data span the period of 1915 to 2023.

Similar to the surrounding waters, the deeper part of the South Coast Fjords study area (depth below ~120 m) is fed by the Labrador Current Water (LCW), a water mass of cold ( $< 2^{\circ}\text{C}$ ) and relatively fresh (salinity 32–33) water, in the summer and by the Modified Slope Water (MSW) of Atlantic origin, a water mass of relatively warm ( $> 4^{\circ}\text{C}$ ) and higher salinity (~34.5) water in the winter (McLellan 1957, Lauzier and Trites 1958, de Young and Hay 1987, Hay and de Young 1989, White and Hay 1994, Donnet et al. 2022). Further analysis is necessary to better understand the total contribution of the different water masses.

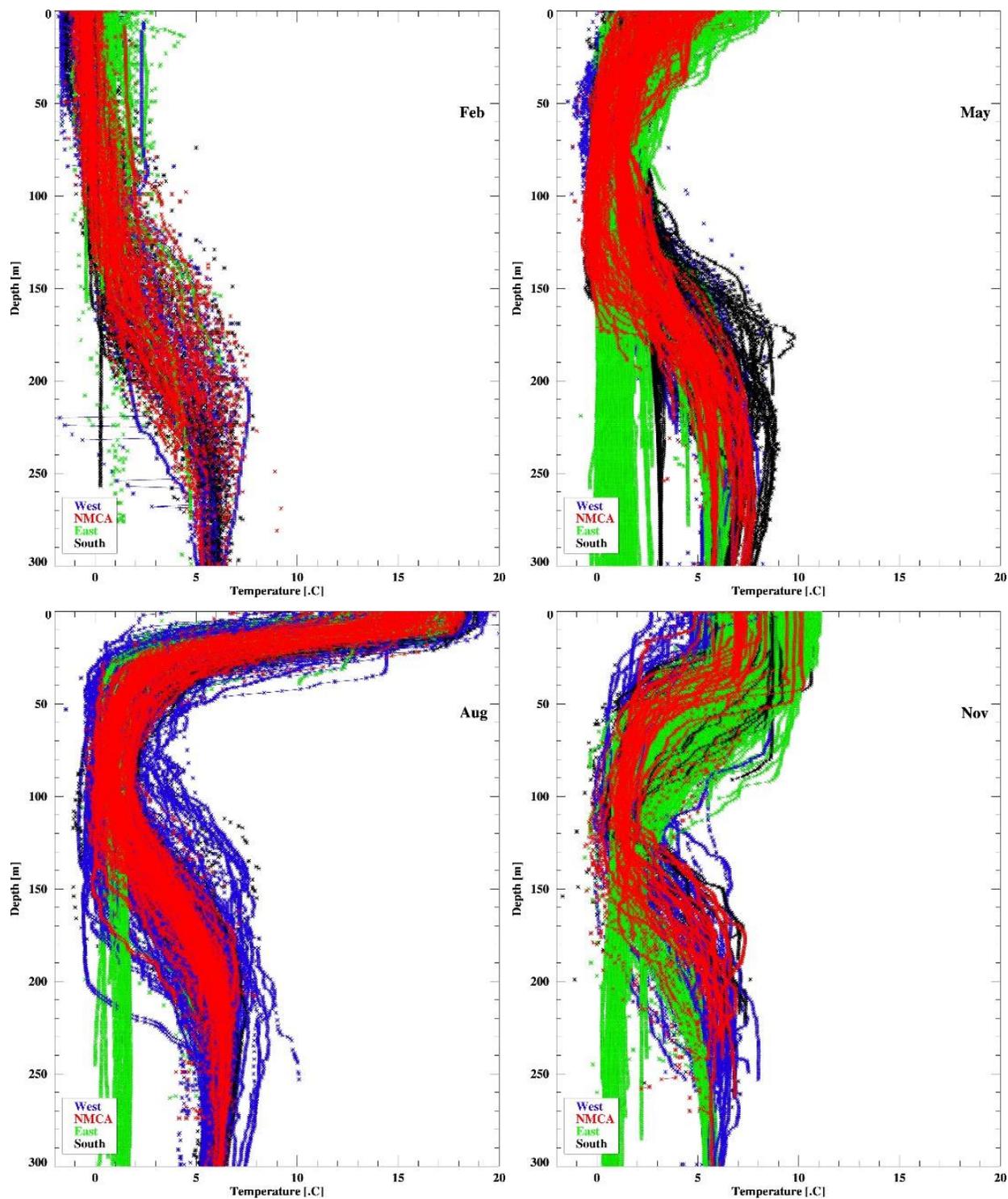


Figure 2.9: Profiles of temperature on the south coast of Newfoundland showing monthly conditions, representing different seasons of the year, for four sub-areas (see Figure 2.8 for a map of the sub-areas): red for the South Coast Fjords study area, blue for area west of the study area, green for area east of the study area, and black for area south of the study area.

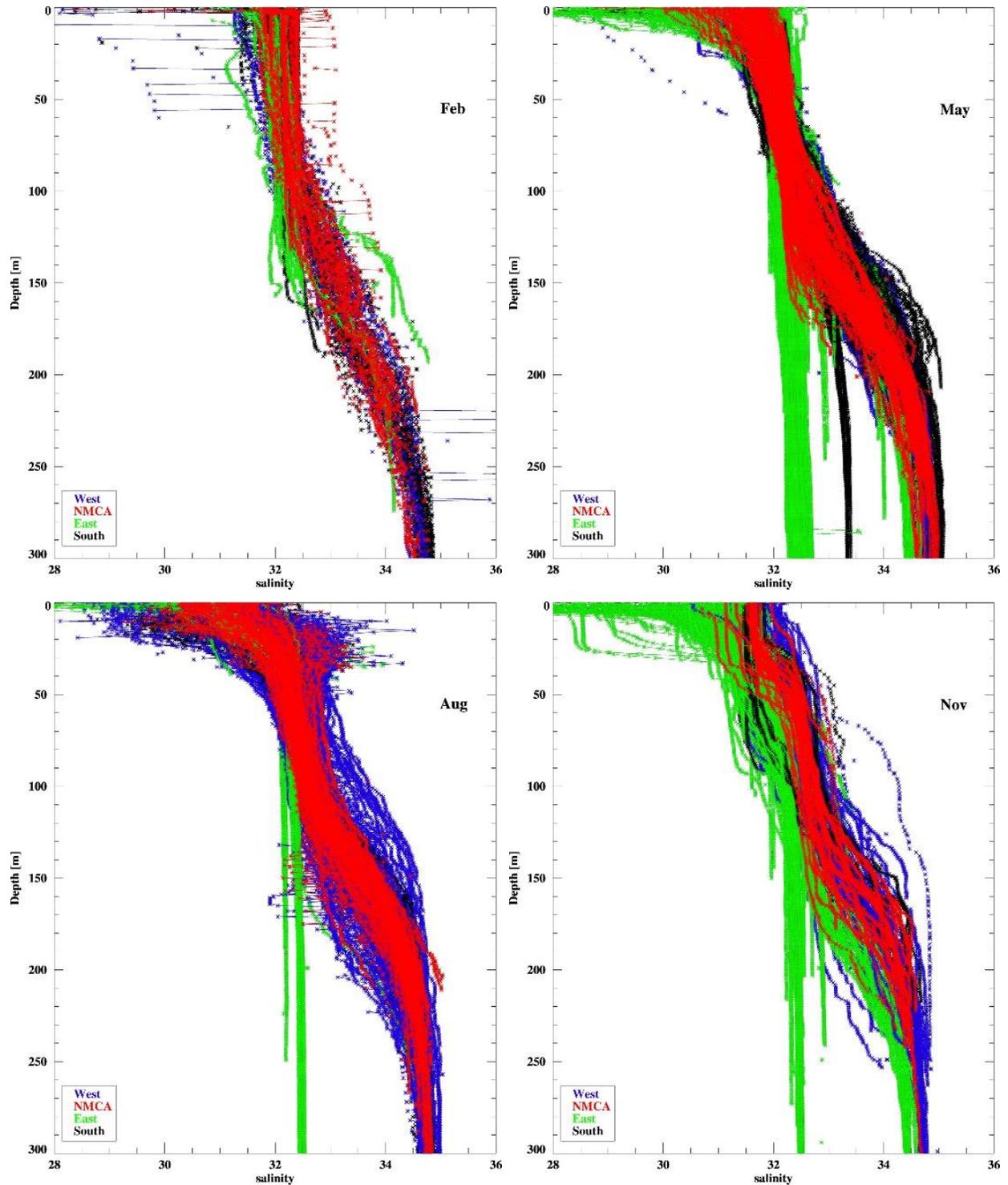


Figure 2.10: Profiles of salinity on the south coast of Newfoundland showing the main seasonal conditions, representing different seasons of the year, for four sub-areas (see Figure 2.8 for a map of the sub-areas): red for the South Coast Fjords study area, blue for area west of the study area, green for area east of the study area, and black for area south of the study area.

The analysis of sea level data measured using pressure loggers within Acoustic Doppler Current Profilers, moored at different locations to the east of the South Coast Fjords study area (Ratsimandresy et al. 2019), shows that sea level variance is dominated by tides (~83%) with the expectation that it is the same in the study area.

Ocean current measurements within the study area are very limited including few observations carried out within the fjords. Most measurements were done by the aquaculture industry as part of the requirement for aquaculture license requests (DFO 2022a, 2022b, 2022d, 2024d, 2024f, 2025b, 2025c; note that the aquaculture industry oceanographic data were not available for analysis at the time of writing). DFO has carried out ocean current studies in the region east of the study area (Ratsimandresy et al. 2019). We use these data to describe the water flow conditions within the fjords in the region, with the assumption that ocean currents in the fjords in the study area present similar behaviour. In the region, the tidal contribution to the ocean current variance is generally low (less than 10%). For the circulation within the fjords, the dominant current direction is along the direction of the fjord and affected by the local change of direction. For current speed, the analysis of measured ocean currents in the eastern side of the study area shows that the median current speed in the upper 20 m is generally 1.3 times larger than that of the deeper layer (water below 20 m depth) with some differences among bays and within the same bay (Ratsimandresy et al. 2019). Near the bottom, some areas have shown stronger currents which might trigger resuspension of particles deposited on the seafloor (e.g., current speed above 9.5 cm/s has been considered the threshold for particle resuspension by the aquaculture waste deposition model, DEPOMOD; Cromey et al. 2002)

For the circulation in the offshore part of the study area, ocean current information from an ensemble of model outputs is used to assess the circulation and its variability (Chassé et al. in prep.<sup>1</sup>). The preliminary analysis shows that the water circulation in the offshore region of the study area also follows the general circulation which is a westward circulation from surface to bottom with some seasonal variability. Ocean current speed is higher during the month of October through March and lower for the rest of the year. This is the case for the whole water column (see Figure 2.11 and Figure 2.12 for 0–20 m and 100–500 m vertically averaged current speed, respectively). The high current speed during fall-winter season has also been seen in the fjords as shown by the analysis for Connaigre Bay ocean currents (Figure 2.13).

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<sup>1</sup> Chassé, J., Lambert, N., Drozdowski, A., Brickman, D., Han, G., Wang, Z., Lavoie, D., Riche, O., and Dumas, J. In prep. Model-based environmental conditions in Atlantic Canada. Can. Tech. Rep. Hydrogr. and Ocean. Sci. X: viii + xx p.

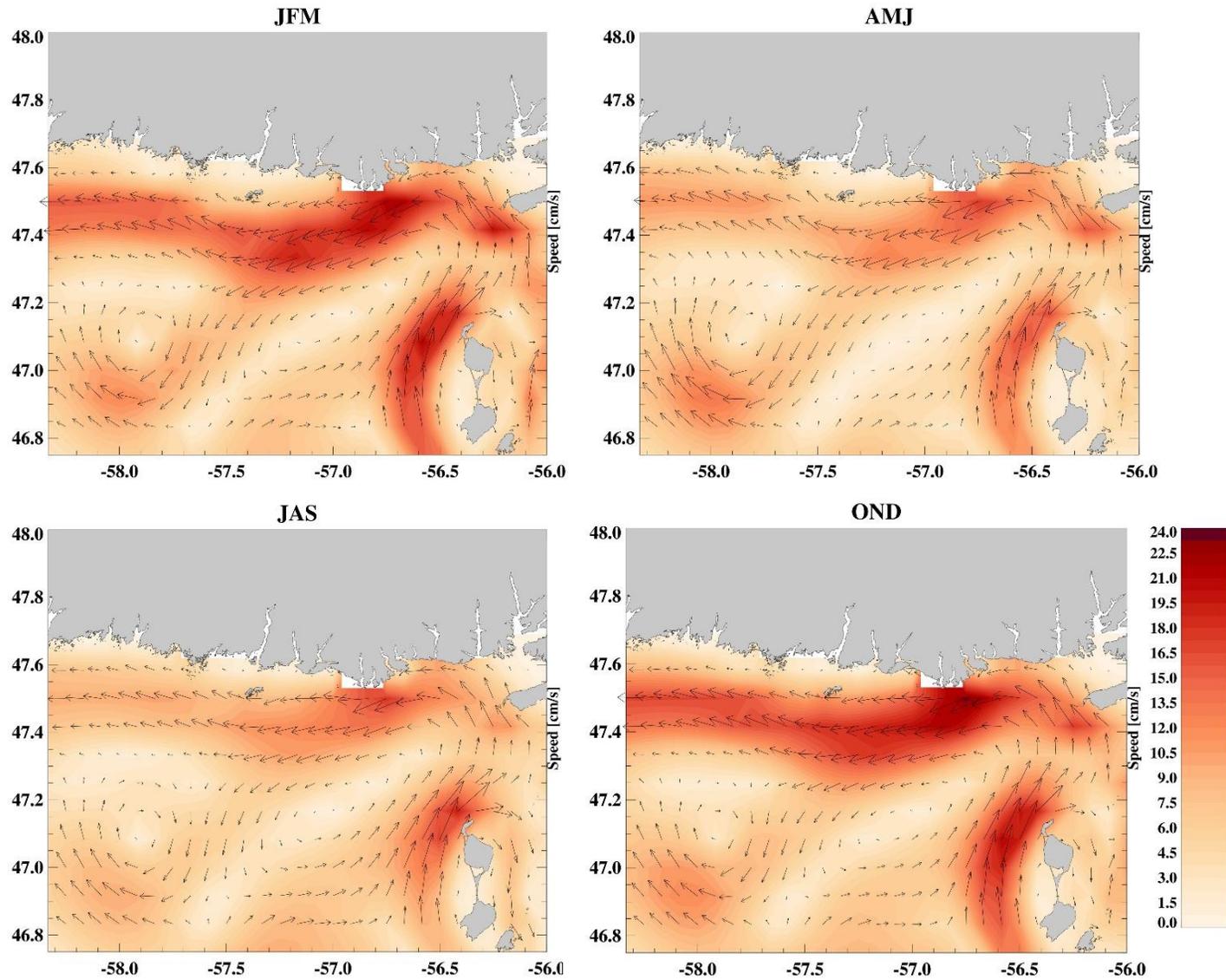


Figure 2.11: Seasonal ocean current speed for the near surface layer (0–20 m) computed from an ensemble of model outputs (Chassé et al. in prep.1). JFM = January through March; AMJ = April through June; JAS = July through September; and OND = October through December.

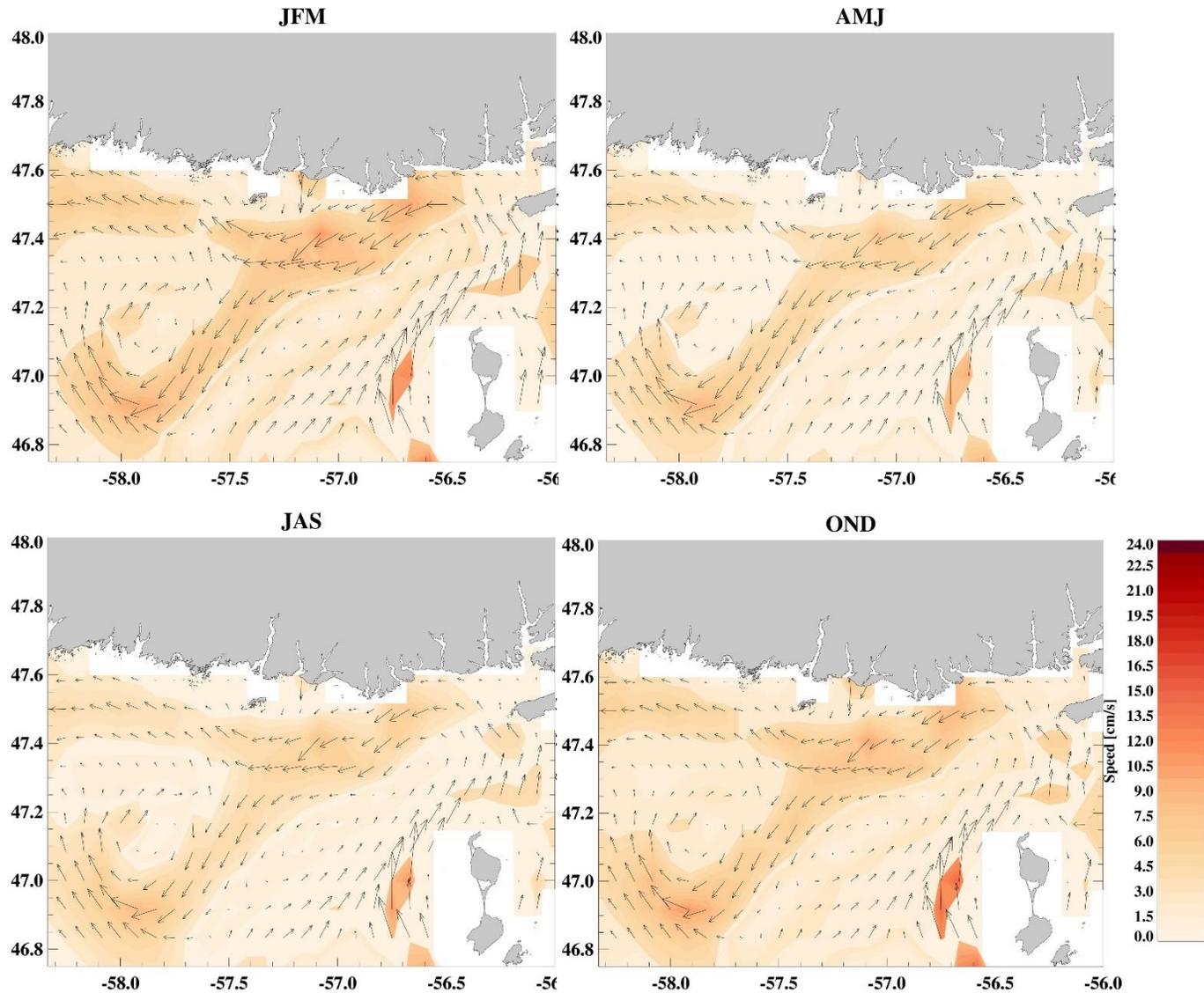


Figure 2.12: Seasonal ocean current speed for the deep layer (100–500 m) computed from an ensemble of model outputs (Chassé et al. in prep<sup>1</sup>). JFM = January through March; AMJ = April through June; JAS = July through September; and OND = October through December.

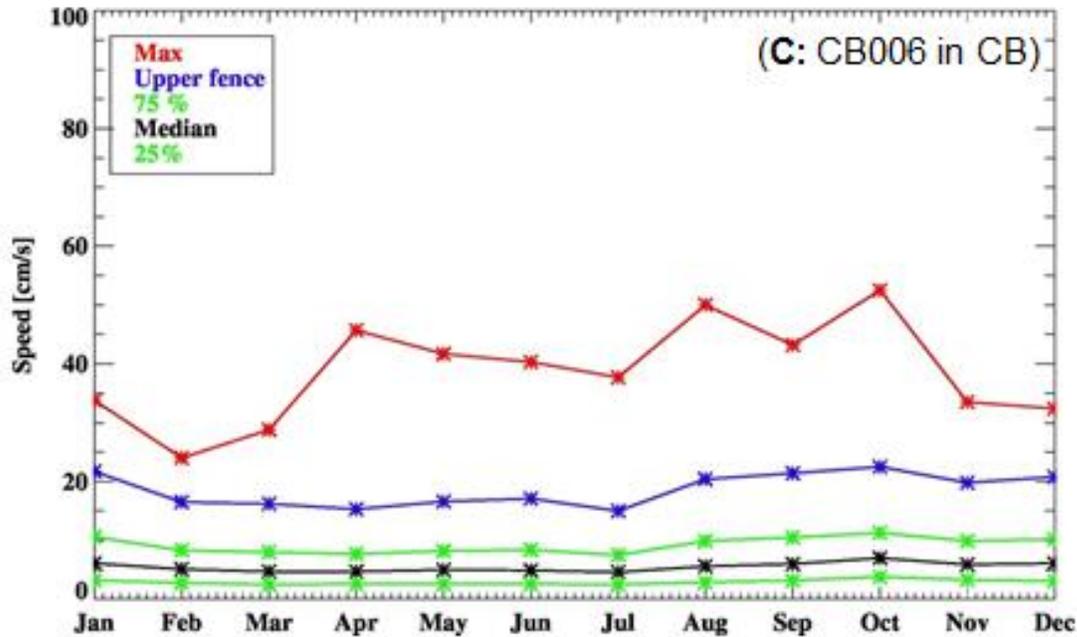


Figure 2.13: Monthly variability of the current speed in the upper layer (0–20 m) for ocean currents measured in Connaigre Bay. 25%, median, and 75% represent the 25, 50, and 75 percentiles; upper fence is the value computed from a boxplot of the current speed; and max is the maximum recorded current speed (Ratsimandresy et al. 2019).

## Light

Sunlight is an important environmental factor that regulates the growth cycle, productivity, and community structure of phytoplankton in the northwest Atlantic and Subarctic regions (Harrison et al. 2013). Solar energy that reaches the coastal waters along the Newfoundland south coast is seasonally highly variable with extreme low levels during late autumn and winter transitioning to long daily periods of insolation during late spring and summer. This makes the availability of sunlight one of the major limiting factors for plant-based photosynthesis in northern latitudes. The seasonal irradiance levels vary by latitude with peak energy during June–July and very low levels from late October through until March. Light energy is captured by a series of pigments in phytoplankton, of which chlorophyll-a is the most important and is commonly used as a proxy of the standing stock of marine plants (Huot et al. 2007).

Given the limited amounts of sea ice in the South Coast Fjords study area, light availability is principally influenced by the annual solar cycle and local atmospheric conditions (e.g., clouds, fog) along with mixing processes and attenuation with depth related to absorption and scattering properties of the water mass (Kirk 1977). Measurements of local light levels indicate significant levels of attenuation due to cloud cover (> 70%) in the Newfoundland region throughout the seasonal growth cycle (Figure 2.14). High frequency irradiance measurements in 2023 at a coastal buoy near the Avalon Channel illustrate large daily variation (up to 7-fold variability) in incident solar radiation levels due to local atmospheric conditions (Figure 2.14).

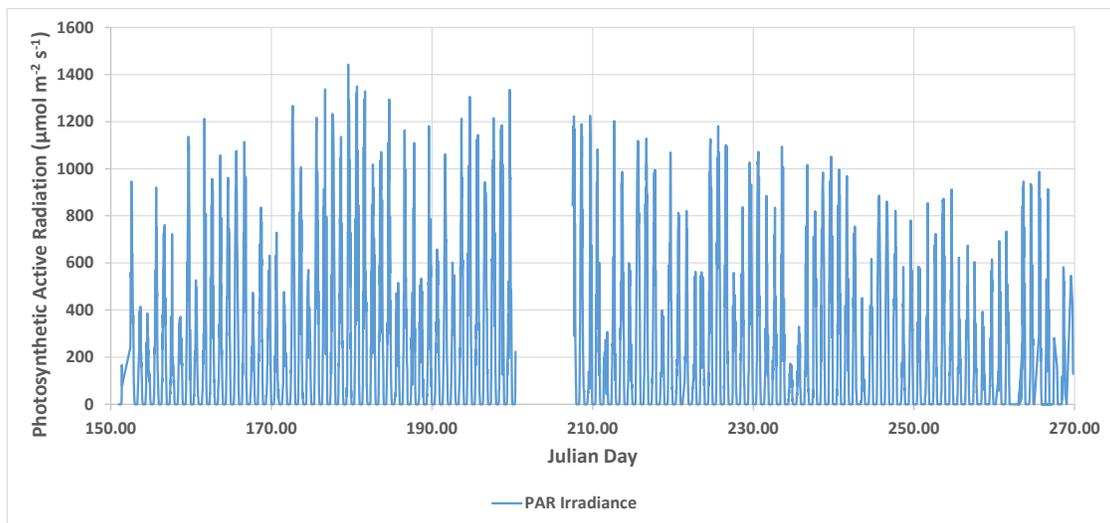
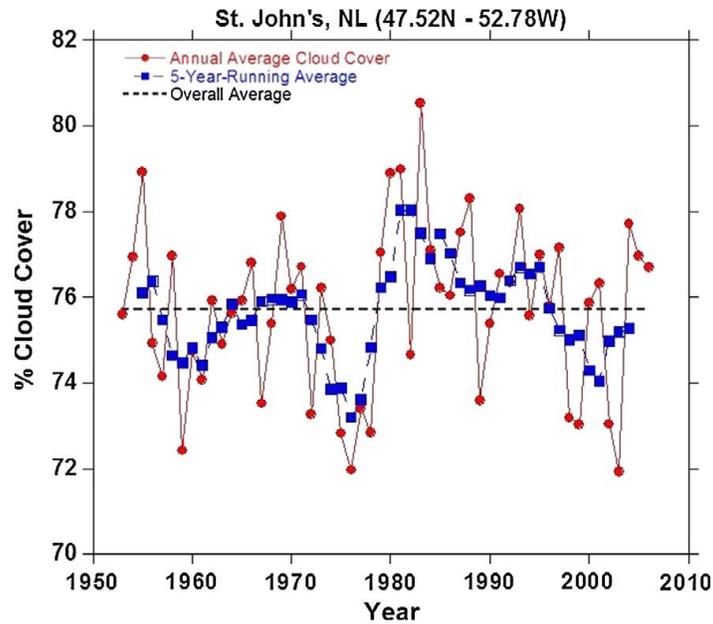


Figure 2.14: Time-series of annual average percent cloud cover and 5-year running mean at St. John's, NL (47.5°N, 52.78°W), Environment Canada land station from 1955 to 2006 (top panel; figure obtained from Harrison et al. 2013). High frequency coastal measurements of photosynthetic active radiation (PAR; 400–700 nm wavelengths) from Viking Buoy at Station 27 (47.515°N, 52.849°W) illustrating daily variation in incident solar radiation in the Newfoundland region from June 1 to September 28, 2023 (bottom panel; data unpublished).

## Nutrients

Seawater macronutrient concentrations are important in the formation of new biological materials (phytoplankton primary production). The main macronutrients in seawater regulating phytoplankton productivity consist of nitrate, silicate, and phosphate (Doyle et al. 2022). The main limiting nutrient in the northwest Atlantic region is nitrate which tends to be depleted first during the spring and fall blooms. The levels of preformed nutrients that are present in source water masses, upwelling, and the amount of mixing between water masses and transport are also important renewal processes. Although light is considered to regulate the initiation of growth of phytoplankton blooms, the availability of nutrients is also important to the growth

cycle. Plant cells require both nitrogen (primarily nitrate and ammonium) and phosphorus for growth; silicon (e.g., silicate) can also be important for certain taxa such as diatoms and silicoflagellates. Direct observations of nutrient levels are limited within the study area, but available zonal measurements can provide some inference into seasonal nutrient dynamics along the Newfoundland south coast (Bélanger et al. 2023).

Time series inventories of deep (50–150 m) nitrate are available along the dedicated St. Pierre Bank ocean sections in NAFO Subdiv. 3Ps (see map in Figure 2.5) along with areas further east and west as part of the AZMP (Figure 2.15). Deep nitrate is a proxy for availability in the next production cycle via renewal and mixing processes. The general trend inferred from the time series indicate above normal levels observed over the 2000s with conditions transitioning to below average during the first-half of the 2010s. Nitrate inventories returned to near and above normal since the mid-2010s to 2021. Corresponding time series of integrated chlorophyll-a (0–100 m), a proxy of phytoplankton biomass, follow the general mean trend in nitrate availability (Figure 2.15). This would imply the importance of nitrogen in regulating the growth cycles of primary producers.

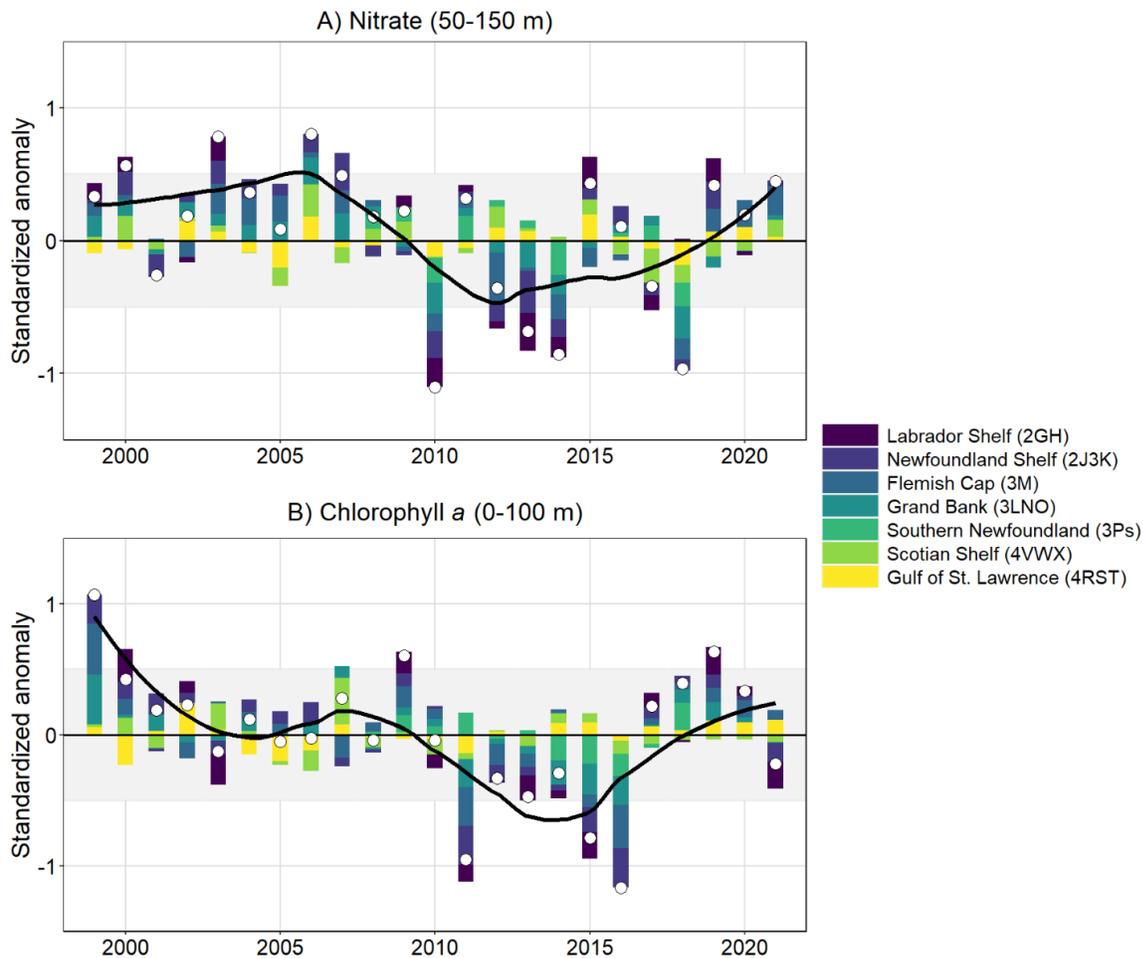


Figure 2.15: Annual trends in standardized anomalies in A) deep (50–150 m) nitrate and B) chlorophyll-a (0–100 m) inventories over the northwest Atlantic area including the Newfoundland southern shelf during 1999–2021. Figures obtained from Bélanger et al. (2023).

## Phytoplankton

Marine phytoplankton represent the base of the marine food web consisting of plant cells that utilize inorganic carbon (e.g., dissolved carbon dioxide), macronutrients, and sunlight to grow and reproduce as primary producers. We used 20 years of available satellite ocean color imagery from the study area to derive the seasonal climatology of chlorophyll-*a* pigment which represents a proxy for phytoplankton biomass (Clay et al. 2021).

The seasonal climatology of chlorophyll-*a* concentration indicates phytoplankton biomass varies between 0.5 and 3 mg m<sup>-3</sup> in the South Coast Fjords study area (Figure 2.16). Peak chlorophyll-*a* levels occur in April-May during the timing of the spring bloom with a return to background levels before a gradual increase in concentration is observed during the weaker fall bloom. Interannual variation in 8-day composite chlorophyll-*a* concentrations indicates relatively consistent timing of the spring bloom with above average levels observed in certain years in the study area (Figure 2.16). The timing of the fall bloom based on the composite data is much broader, from September through late November, over the available climatology (Figure 2.16).

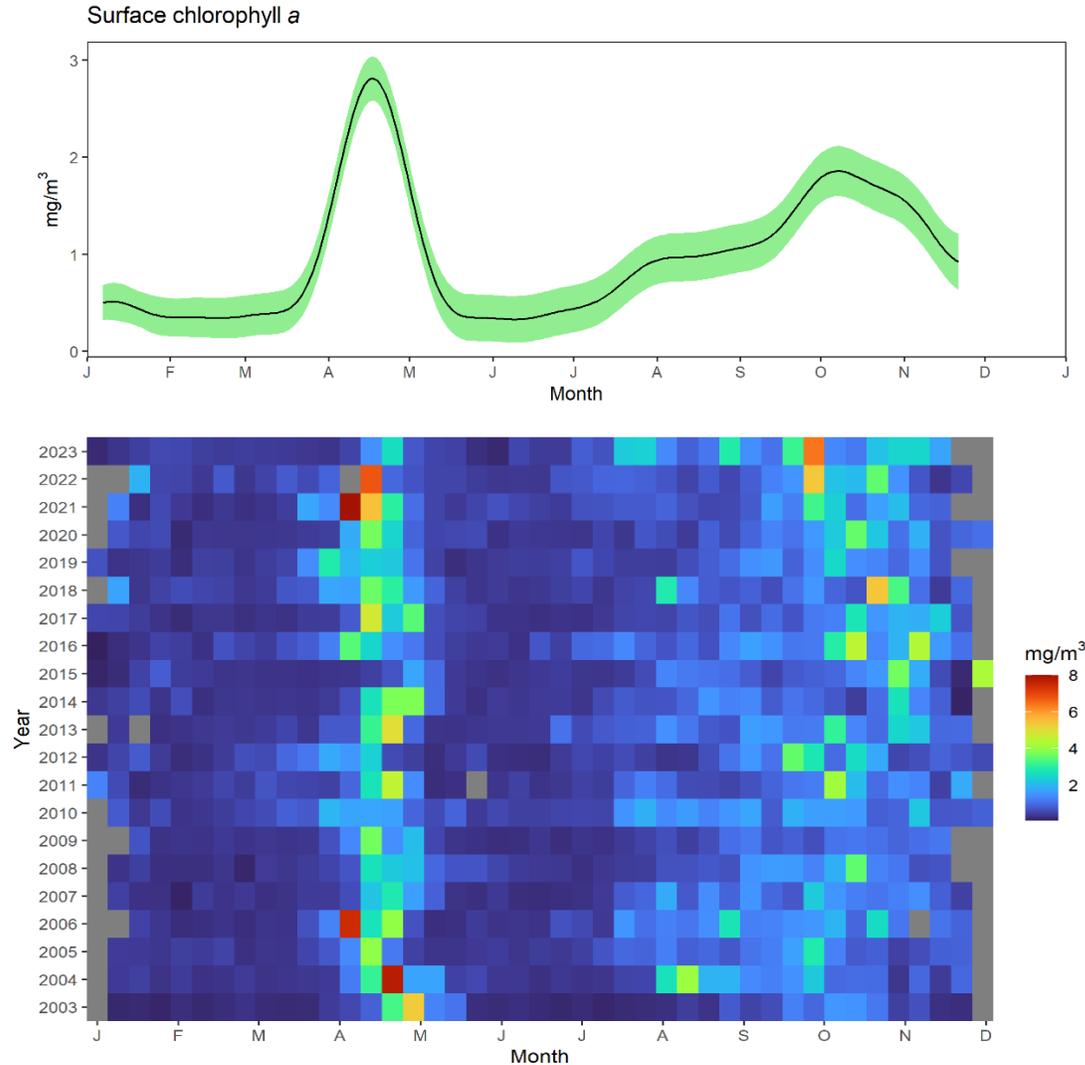


Figure 2.16: Average 20-year (2003–2023) seasonal climatology and  $\pm 95\%$  confidence interval (green shaded area) of chlorophyll-a concentration in  $\text{mg m}^{-3}$  obtained from MODIS-Aqua R2022.0 POLY4 (regional, band ratio; top panel) in the South Coast Fjords study area. Interannual chlorophyll-a concentration during years 2003 through to 2023 within the study area (bottom panel). Data extracted from Clay et al. (2021) using 8-day composite imagery.

Contrast of phytoplankton spring bloom parameters in the study area versus the northwest Atlantic are also available from remote ocean color satellite data over a standard reference period (Bélanger et al. 2023). The initiation of the bloom (when concentration reaches 20% of maximum) on the southern shelf is consistent with observations further south and northward of the study area (Figure 2.17). The duration of the spring bloom on the southern shelf is somewhat more limited compared to the Grand Bank, northeast, and Labrador shelves. The overall magnitude of the bloom is the second lowest compared to the Labrador Shelf (Figure 2.17). Overall, the various bloom indices indicate somewhat more limited productivity over the south coast compared to northern regions but comparable to conditions observed on the Scotian Shelf and Gulf of St. Lawrence.

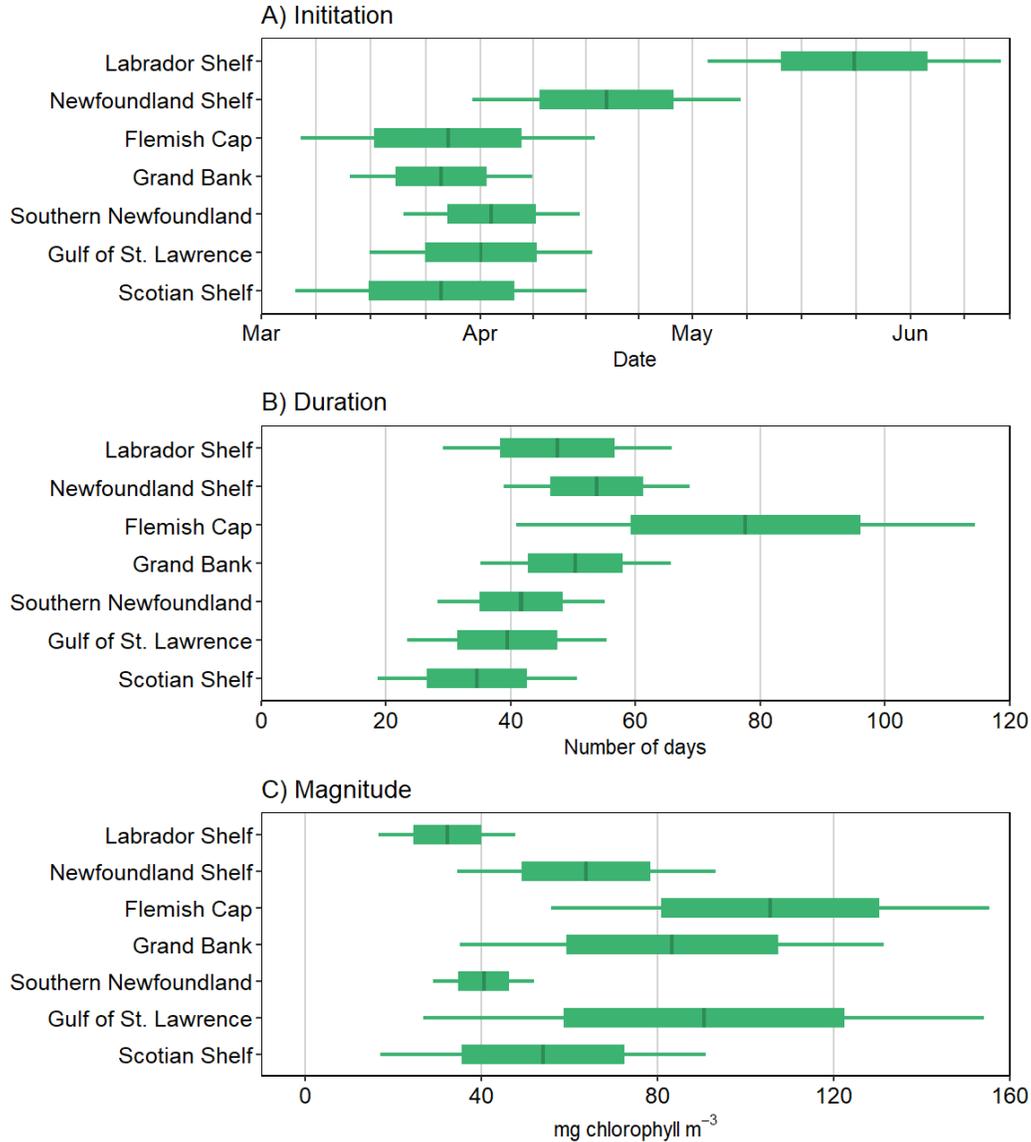


Figure 2.17: Contrast of phytoplankton spring bloom parameters in the northwest Atlantic based on ocean colour satellite data over the 2003–2020 reference period. Figures obtained from Bélanger et al. (2023).

## Zooplankton

Zooplankton are composed of a variety of herbivore (plant feeders), omnivore (combined plant and animal feeding), and carnivorous (exclusively other zooplankton) animal taxa that remain suspended in the water column for the most-part with some limited ability to move vertically. Zooplankton represent the intermediate link between phytoplankton and higher trophic levels such as fish, seabirds, and marine mammals. Many zooplankton taxa exhibit an annual life cycle with new generations developing during the spring and summer by feeding on the seasonal phytoplankton bloom. The abundance of copepods that are the dominant taxa of the mesozooplankton (typical size range is 0.2–20 mm) community in the northwest Atlantic, represent an important bioenergetic link between primary producers and higher trophic levels such as pelagic fishes and early life stage of demersal species (Pepin et al. 2011, Zeldis and

Décima 2020). The mean abundance of copepods has generally increased over the past two decades (Bélanger et al. 2023) and has remained above normal from 2015–2022 (Figure 2.18). Similarly, the abundance of non-copepods (mostly soft-bodied plankton and predatory taxa) have also significantly increased over the same time period throughout the northwest Atlantic (Figure 2.18). Records of gelatinous zooplankton that include jellyfish (cnidarian), ctenophores, and pelagic tunicates indicate these taxa are generally increasing since 2014 in the northwest Atlantic. Two particularly important copepods include the energy-rich *Calanus finmarchicus* and *Pseudocalanus* spp. and represent preferred prey to a variety of higher trophic levels as they contribute significantly to the total biomass of mesozooplankton throughout the northwest Atlantic (Figure 2.19). *Calanus finmarchicus* remained above normal through the 2000s but the abundance of this taxa began decreasing in the early 2010s reaching a record low by 2015. Since the record low in 2015, the abundance has transitioned back to near-normal to above normal levels in recent years (2018–2022). The abundance of the smaller calanoid (*Pseudocalanus* spp.) showed generally the opposite pattern to *C. finmarchius* with lower levels through the 2000s and reaching a record-high in 2015 (Figure 2.19). The abundance of this taxa has also transitioned to near normal in recent years (2018–2022).

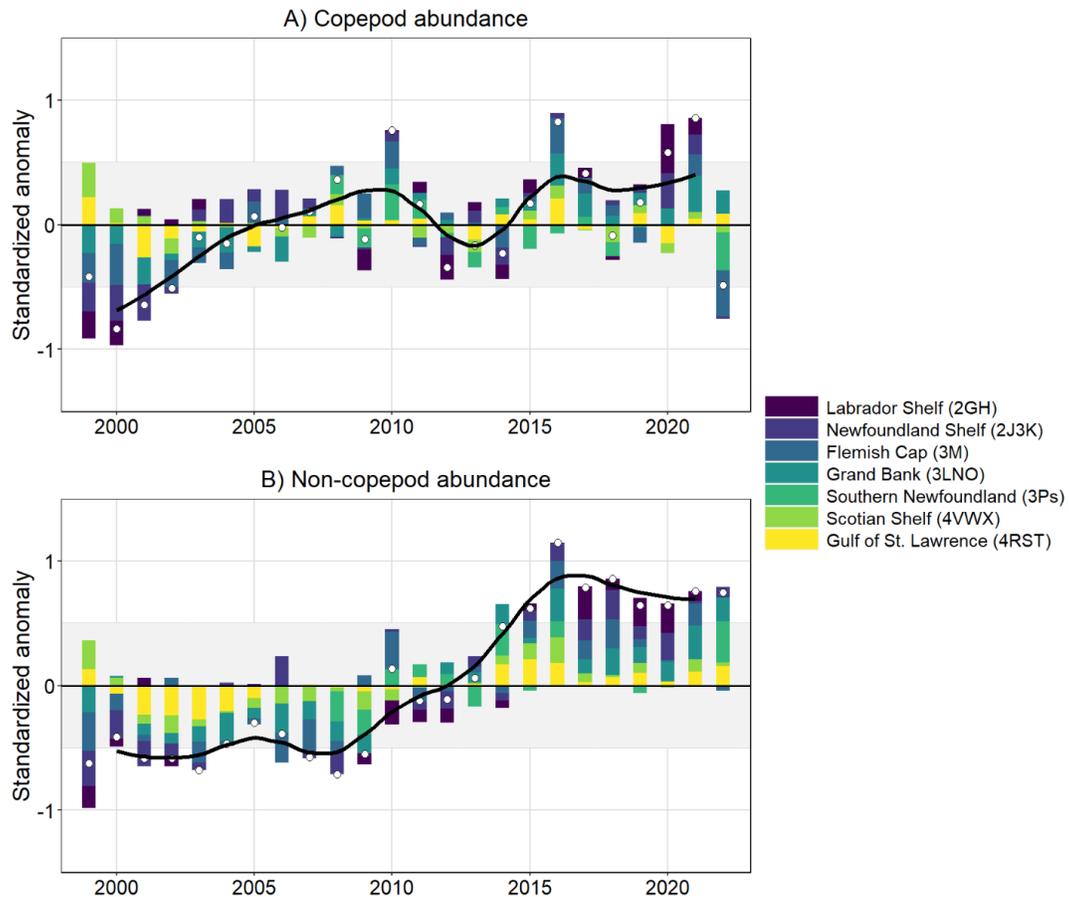


Figure 2.18: Annual trends in standardized anomalies in A) copepod and B) non-copepod abundance inventories over the northwest Atlantic area including the Newfoundland southern shelf during 1999–2022. Figures obtained from Bélanger et al. (2023).

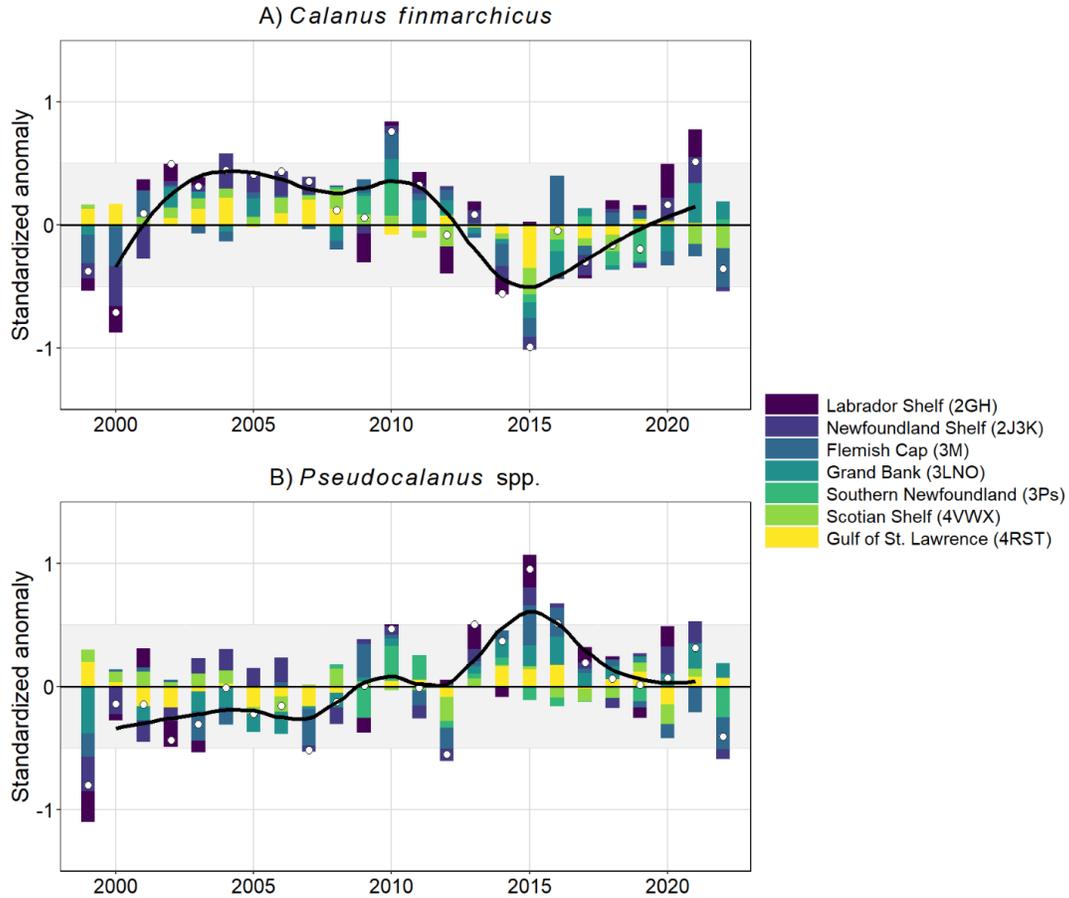


Figure 2.19: Annual trends in standardized anomalies in (A) *Calanus finmarchicus* and (B) *Pseudocalanus* spp. abundance inventories over the northwest Atlantic area including the NL southern shelf during 1999-2022. Figures obtained from Bélanger et al. 2023.

Annual indices of zooplankton biomass (combined dry weight of < 1 mm and > 1 mm size classes) have varied over the available time series (Bélanger et al. 2023). The biomass index includes contributions from a variety of different plankton taxa that can vary substantially spatially and temporally (Figure 2.20). A record low biomass occurred over the northwest Atlantic in 2000 but quickly transitioned to a record high observed in 2002. Biomass indices were generally above normal through the 2000s and mostly below normal during the 2010s and in 2022.

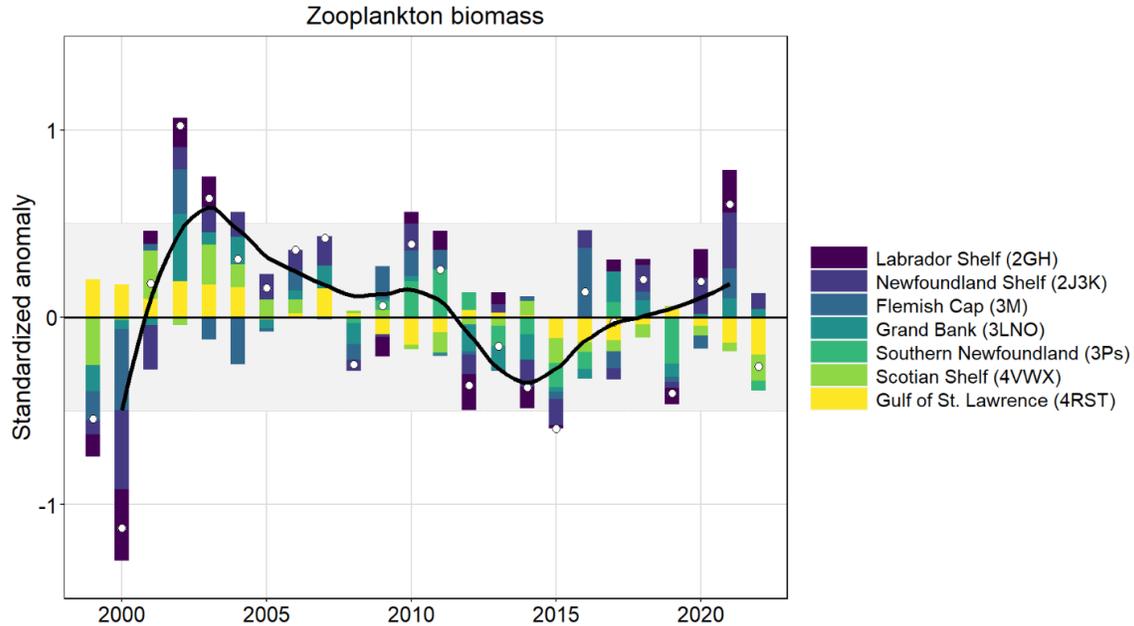


Figure 2.20: Annual trends in standardized zooplankton biomass (dry weight) anomalies over the northwest Atlantic area including the Newfoundland southern shelf during 1999–2022. Figure obtained from Bélanger et al. (2023).

## Sensitive Species and Habitats

### Ocean Acidification

Studies investigating the impact of ocean acidification (OA) indicate a variety of potential responses that may alter growth, physiology, and in some cases may be beneficial or detrimental to calcifying marine taxa. Calcifying organisms rely on seawater saturation of carbonate ions to form both internal and external structures, principally in the form of aragonite and calcite. The acidity of the ocean in general is increasing due to anthropogenic increase in carbon dioxide concentration worldwide (Doney et al. 2009). Limited observations in inshore coastal areas on the Newfoundland south coast can provide some inference as to the present state, although information from south coast deep fjords is generally lacking at present. Some representative ocean profiles have been collected in Bay d'Espoir and Fortune Bay in recent years (fall 2023) by CEBP and Bay Management Areas Program (DFO NL Region) that suggest the deeper waters may be becoming more acidic (lower pH) along with undersaturation with respect to aragonite (Figure 2.21). The limited coastal data on the Newfoundland south coast indicate that water depths in excess of 200 m are the main horizon of increasing acidity and undersaturation of calcium carbonate (Figure 2.21). This observation is in general consistent with a zonal monitoring program investigating ocean acidification parameters throughout the northwest Atlantic (Gibb et al. 2023).

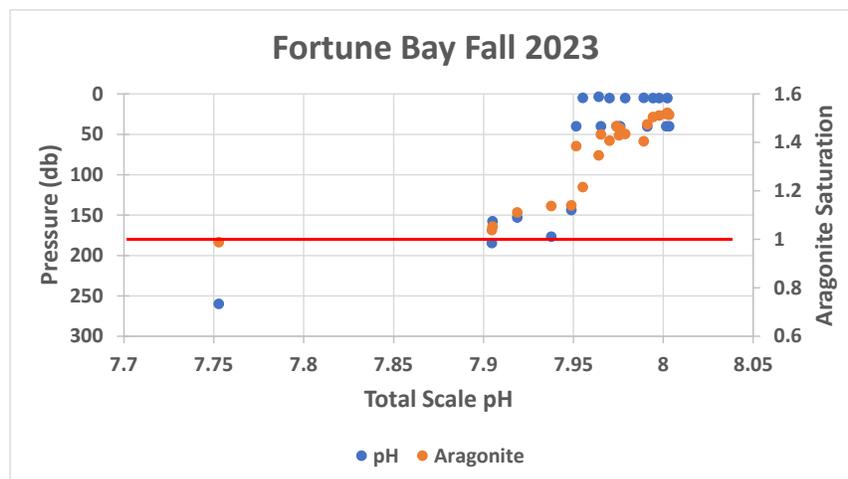
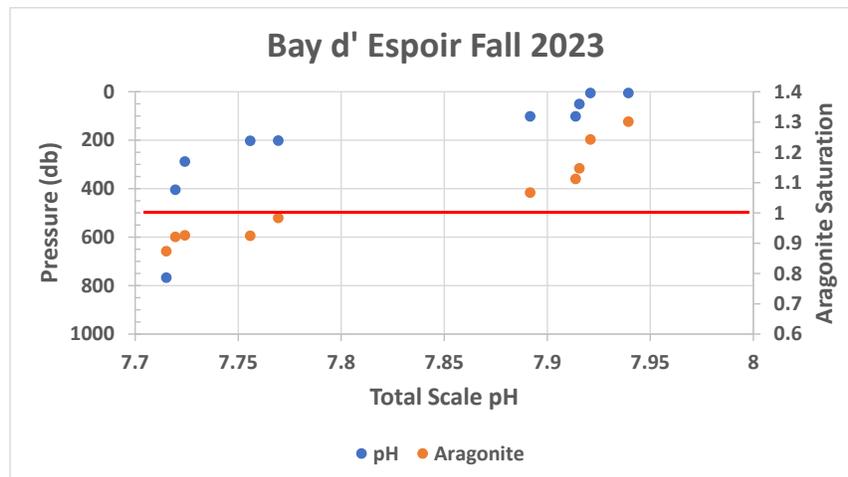
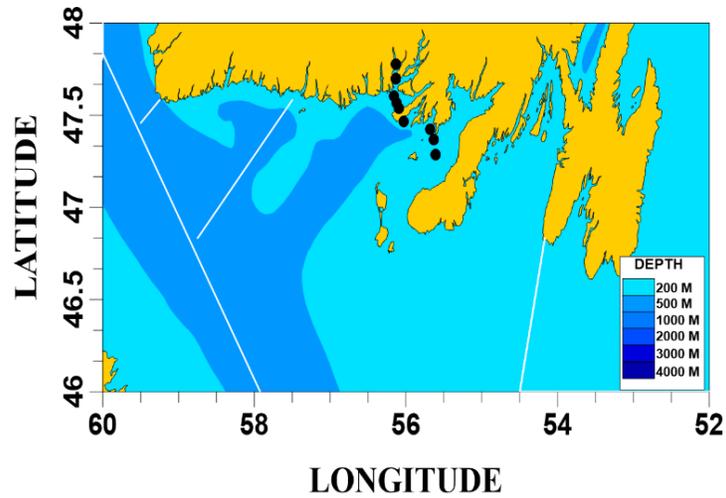


Figure 2.21: Map of sampling stations for analysis of ocean acidification parameters collected in Bay d'Espoir and Fortune Bay in fall 2023 (top panel) by CEBP and Bay Management Area Program (DFO NL Region). Depth profile plots of ocean acidification parameters (pH and aragonite saturation) for Bay d'Espoir (middle panel) and Fortune Bay (bottom panel). The solid red line demarcates the saturation state of aragonite with values  $> 1$  indicating levels above saturation and  $< 1$  under-saturation levels.

Evidence based on sustained ocean measurements indicates carbon dioxide emissions are changing the acid-base chemistry of estuarine, coastal, and oceanic waters. This will continue to negatively impact carbonate chemistry (lowering of saturation extent) and ocean pH conditions in the marine environment well into the future, with calcifying organisms at highest risk with the potential to alter food web dynamics. In addition, the solubility of carbonate is affected by temperature, making polar and subpolar areas more vulnerable, and place these regions as a high priority for continued assessment of acid-sensitive taxa. DFO is continuing to assess the threat to marine species in relation to ocean acidification that is altering the saturation horizons of calcite and aragonite throughout the water column. Part of this effort is directed to monitoring coastal areas along the Newfoundland south coast along with standard ocean sections on the shelf and deep-water basins across Canada's oceans (through the AZMP and Aquatic Climate Change Adaptation Services Program (ACCASP)). The need to sustain ocean time series measurements is required to evaluate the influence of lowered saturation states and higher acidity and associated impacts on the marine environment and biota. These changes will not occur in isolation and will require coordination of effort across many different disciplines in oceanography to protect a wide variety of ecosystem services offered by marine fauna and flora (Cooley et al. 2009, Kroeker et al. 2013, Doney et al. 2020).

### **Influence of Ocean Climate**

Changes in ocean climate conditions have potential to influence ecosystem productivity and particularly of primary and secondary producers with implications for energy transfer to higher levels in the food chain (Cyr et al. 2024a). The links between a Newfoundland climate index and bloom timing and secondary production in shelf waters indicate that ocean warming along with freshening of NL waters from higher ice melt further north may alter the stratification of the water column and phenology of plankton communities with impacts to the feeding of fish, seabirds, marine mammals, and invertebrates (Cyr et al. 2024a). Climate change due to anthropogenic release of greenhouse gases (GHG's) can have both direct and indirect consequences to ocean ecosystems such as ocean warming, altered acid-base chemistry, rising sea levels, higher stratification resulting in limited mixing of euphotic waters, altered oceanic and coastal circulation, freshwater inputs, and reduction in subsurface concentration of dissolved oxygen (Doney et al. 2012). Future climate change scenarios are projected to result in a 25% reduction in total *Calanus* biomass on the Newfoundland south coast based on model estimates by the end of the 21<sup>st</sup> century (Lehoux et al. 2024). Lower biomass is the result of reduced abundance along with the reduction in individual body weight of *Calanus* spp., implying future environmental conditions will be detrimental for these ecologically important taxa.

### **Data Gaps and Recommendations**

As limited knowledge of the biological and physical oceanography exists from the South Coast Fjords study area, establishing biophysical information regarding the seasonal trends in abundance and biomass of major functional phytoplankton (e.g., diatoms) and zooplankton (e.g., calanoid copepods) groups along with their responses to ocean climate conditions would improve our understanding of important ecological drivers in the ecosystem. The study area represents a transition zone between the Gulf of St. Lawrence waters to the west and the Labrador Current to the east. Changes in ocean climate conditions may lead to differential impacts to primary and secondary producers due to changes in various physiological processes and changes in seasonal phenology (e.g., timing of primary and secondary production). The timing of seasonal production of plankton which coincides with rapid changes in solar irradiance and physical stability in the water-column represents a critical period characterized by a tight coupling of primary and secondary productivity and relatively large fluxes of energy to the higher trophic levels. Few direct oceanographic studies have been conducted on the Newfoundland

south coast to evaluate the distribution, abundance, and biomass of plankton within the study area.

While an understanding of the plankton dynamics and important physical forcing conditions are being made through seasonal collection of ongoing time series from standard ocean stations and sections conducted by CEBP, Bay Management Area investigations, and the AZMP/ACCASP, oceanographic sampling within the South Coast Fjords study area remains very limited. The long-term trends derived from repeated oceanographic sampling in the near vicinity (downstream and adjacent areas) is likely to provide some indication of the trends and important drivers in this region. The abundance of primary and secondary producers available to higher trophic levels varies; based on seasonal and annual observations conducted by the AZMP, the abundance of these standing stocks can change substantially from year-to-year. The absence of observations of primary productivity limits our ability to infer the effect of phytoplankton standing stock on secondary productivity and phenology. Understanding variations in secondary production are also confounded by the potential for differential effects of ocean climate variables (e.g., temperature) on the physiological processes that affect arctic, sub-arctic and boreal zooplankton taxa.

The majority of the data provided in this report are derived from conventional sampling systems such as plankton nets, and instrumented CTD-rosette and moored platforms. Sampling and observation systems are advancing rapidly and we recommend consideration of new and existing automated sensor technologies such as underwater profilers (e.g., ocean gliders, vertical profilers) and moored systems using a variety of biophysical sensors to infer the physical and biogeochemical conditions within the water column. Satellite remote sensing technologies are also in further development with new platform deployments to infer near-surface conditions for a variety of biophysical variables (e.g., [International Ocean Colour Coordinating Group](#)). Consideration of the use of automated sensor buoys and acoustic sampling of the water column (from moorings or ship-based systems) to understand the seasonal changes in water mass transport and ocean current fields could provide a better understanding of the depth distribution of pelagic organisms as well as establishing baseline environmental DNA (eDNA) conditions. Physical and biogeochemical sensors along with sediment trap equipped moorings could provide important information on benthic-pelagic coupling and water properties which may be affected by the interannual variability in productivity across the South Coast Fjords study area.

Finally, more in-depth analysis of the existing oceanographic data is recommended as it will provide a better understanding of the connection among the offshore domain of the study area, the various fjords present within it, and the surrounding waters.

### 3. ESTUARINE AND COASTAL FEATURES

*Authors: Courtney King, Margaret Warren, Philip S. Sargent, and Robert S. Gregory*

#### Available Information

Available information on estuarine and coastal features within the proposed study area is limited. The proposed study area is described as having a variety of physical features, from complex and highly indented steep bedrock-dominated fjord coast, to estuaries, tidal flats, and beaches found along the heads of numerous bays (Mercier 2008). Coastal dunes, beaches, barriers, and eroding bluffs are found near the town of Burgeo. Environment and Climate Change Canada (ECCC) has produced a shoreline classification dataset which contains some of these features. Figure 3.1 presents the classifications for the lower intertidal zone and includes other features that typify the coast, such as shoreline and backshore type. Further information on this data source can be found in ECCC (2018). The coast around the island of Newfoundland is typically exposed to sea ice, due to environmental and oceanographic factors. However, the proposed study area is not affected by the most extreme of these conditions, meaning long-term and stable shore communities of plants and invertebrates can exist along the south coast.

The fauna of the study area is typical of the northwest Atlantic ecosystem. The components of this ecosystem that are known to be resident in the coastal zone of the study area include: Razor Clams (*Ensis leei*), Atlantic Surf Clam (*Spisula solidissima*), Shortfin Squid (*Illex illecebrosus*), Sand Shrimp (*Crangon septemspinosa*), American Lobster (*Homerus americanus*), Rock Crab (*Cancer irroratus*), American Eel (*Anguilla rostrata*), Atlantic Herring (*Clupea harengus*), Capelin (*Mallotus villosus*), Atlantic Salmon (*Salmo salar*), Brook Trout (*Salvelinus fontinalis*), Rainbow Smelt (*Osmerus mordax*), Atlantic Cod (*Gadus morhua*), White Hake (*Urophycis tenuis*), Fourspine Stickleback (*Apeltes quadracus*), Threespine Stickleback (*Gasterosteus aculeatus*), Ninespine Stickleback (*Pungitius pungitius*), Cunner (*Tautoglabrus adspersus*), Ocean Pout (*Zoarces americanus*), Rock Gunnel (*Pholis gunnellus*), Sand Lance (*Ammodytes americanus* and *A. dubius*), Atlantic Mackerel (*Scomber scombrus*), Longhorn Sculpin (*Myoxocephalus octodecemspinosus*), Shorthorn Sculpin (*Myoxocephalus scorpius*), Common Lumpfish (*Cyclopterus lumpus*) and Winter Flounder (*Pseudopleuronectes americanus*). Refer to Chapters 4 (Anadromous and Catadromous Fishes), 5 (Marine Fishes), and 7 (Invertebrates) for more information on the distribution of these species and the caveats associated with the limited knowledge of their spatial distribution in the coastal areas. Species considered to be less common but known to occur in the greater area of Newfoundland's south coast include Banded Killifish (*Fundulus diaphanous*) and Mummichog (*Fundulus heteroclitus*), both listed under Federal or Provincial protection regulations, respectively.

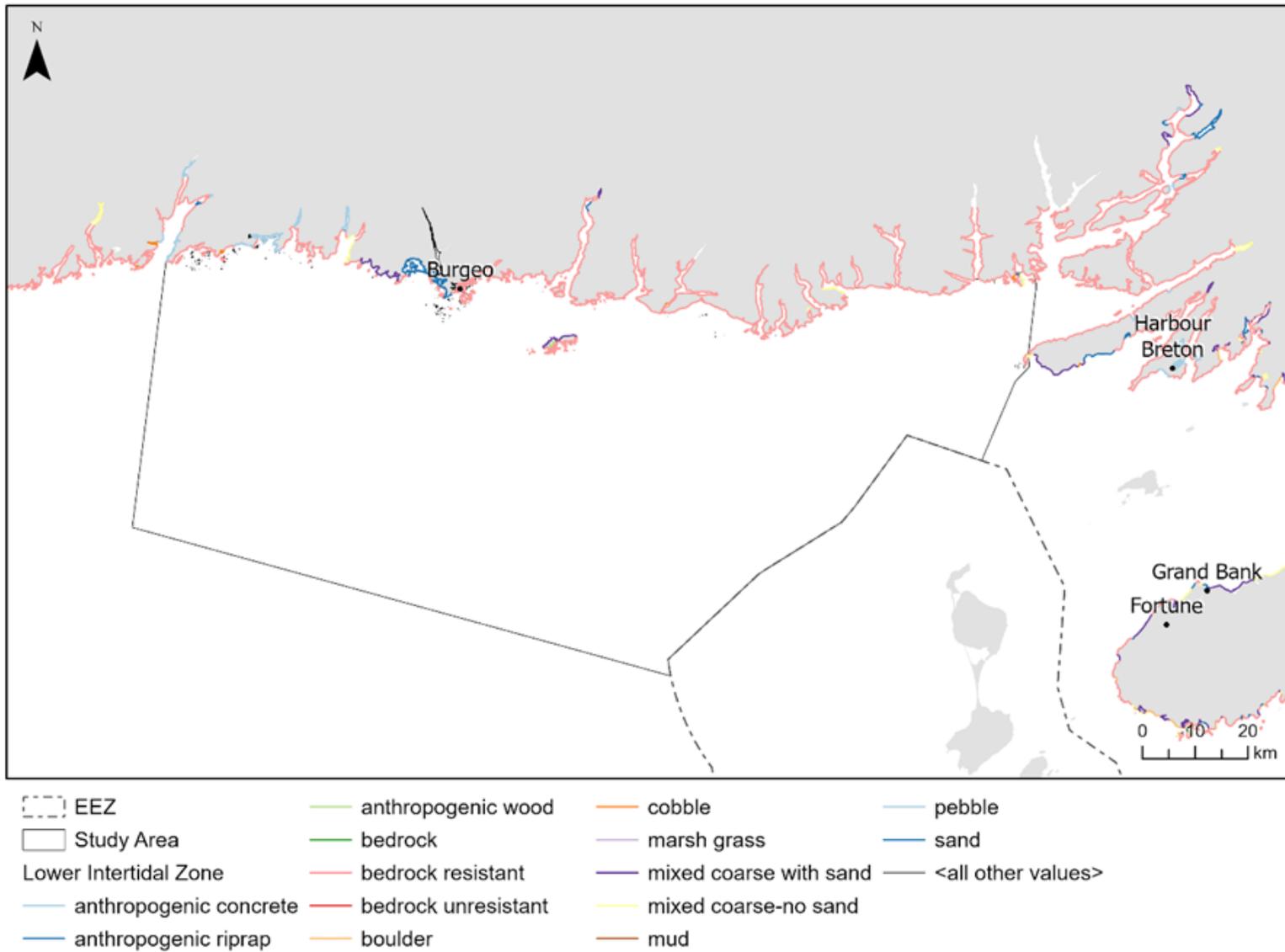


Figure 3.1: Environment and Climate Change Canada shoreline classification data of the lower intertidal zone (ECCC 2018).

## Sensitive Species and Habitats

Eelgrass (*Zostera marina*) is recognized federally as an Ecologically Significant Species (ESS) for its substantial influence on overall coastal productivity (marine and terrestrial) and ecosystem services far exceeding that of any other species in the coastal zone (DFO 2009). Eelgrass provides biogenic physical structure to the coastal zone as it stabilizes sediment and buffers shorelines against erosion. The plant supports small-bodied fish survival for notable species such as juvenile Atlantic Cod (Laurel et al. 2003, Laurel et al. 2004, Warren et al. 2010). Eelgrass has been under threat throughout eastern Canada and has been declining in many areas (e.g., Placentia Bay). Threats to its distribution include anthropogenic stressors and invasive species, specifically European Green Crab (*Carcinus maenas*) which is now well-established on the south coast. In the Newfoundland region, eelgrass has been expanding in the past ten years (Murphy et al. 2021). Known and potential locations of eelgrass in the Newfoundland region is captured by Rao et al. (2014). Reported occurrences rely on dated aerial imagery and local environmental knowledge. Eelgrass commonly occurs in intertidal and subtidal mudflats of shallow, protected bays. Given the diversity of physical features along the south coast, including steep bedrock fjords, eelgrass in the proposed area is generally limited to the west of the town of Burgeo (Figure 3.2).

Other coastal marine flora and macroalgae species occur along the coast of the proposed study area and provide complex habitat features where coastal fish aggregate for food and predatory cover. Some incidental observations are recorded in the Community-based Coastal Resource Inventory (CCRI) database, however, it does not cover the full potential extent of these species distribution and therefore is not presented here.

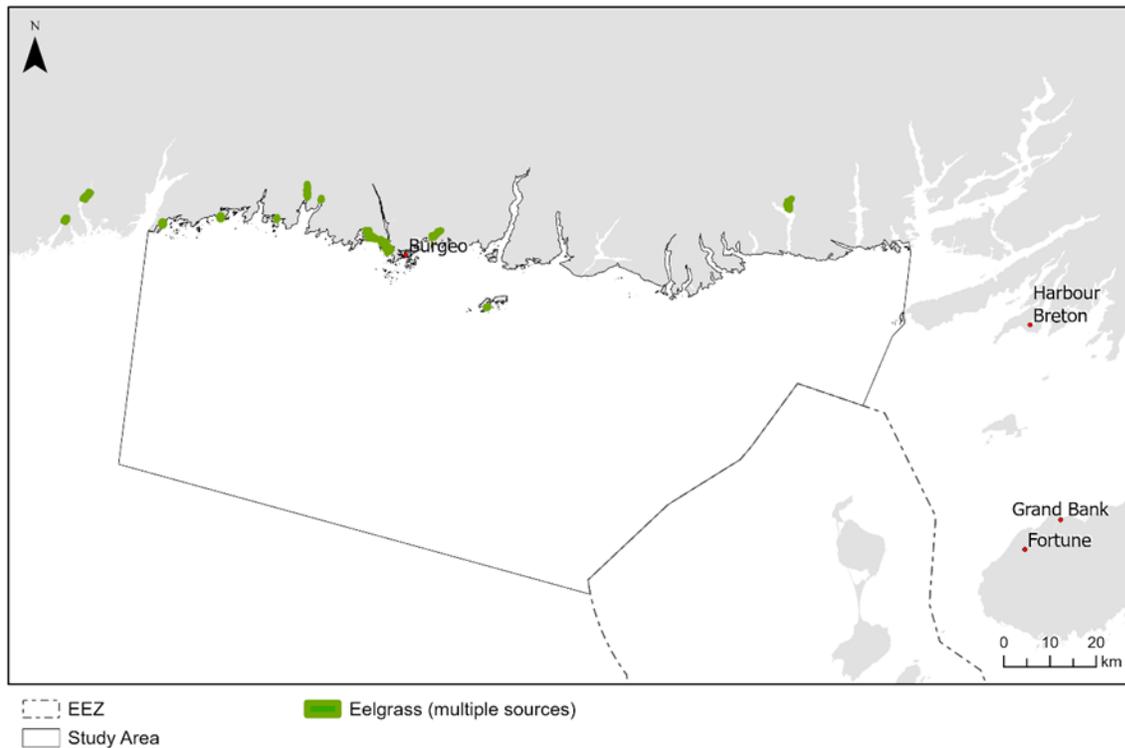


Figure 3.2: Eelgrass (*Zostera marina*) areas identified through multiple sources, including Rao et al. (2014) and DFO Science.

Banded Killifish is listed as a Species of Special Concern under the Species at Risk Act (COSEWIC 2014), and the Mummichog is listed under Newfoundland Provincial Status Assessment as Threatened (D2 Status; SSAC 2016). Originally considered to have limited distributions around the island, recent investigations have identified more widespread populations than previously presupposed, including a confirmed population of Banded Killifish on Ramea Island (Sargent et al. 2020). These species rely on clear water, low current systems with muddy and vegetated bottoms, therefore protecting fresh and coastal habitat features from disturbed water column and destruction of habitat features is considered a priority.

The south coast region is experiencing environmental changes linked to temperature and ocean currents (see Chapter 2: Oceanographic Conditions). In response, species less common to the region historically have recently been observed more frequently in the area. For example, the Longfin Inshore Squid (*Doryteuthis pealeii*), which are considered to be currently extending the northern limit of its range (Dawe et al. 2001), have been observed along the coast and are now regularly caught by locals near wharves (P. Sargent pers. comm.). Northern Pipefish (*Syngnathus fuscus*) and the Atlantic Silverside (*Menidia menidia*) have likewise been observed along much of the south coast of Newfoundland; they rely on coastal habitat features common in the study area, including eelgrass (e.g., Le Bris and Wroblewski 2018), but have yet to be reported within the proposed boundary.

### **Data Gaps and Recommendations**

Scientific investigations within the study area boundary are limited, and many observations have not been updated and verified in decades. The data presented on eelgrass, Banded Killifish, and Mummichog, for example, require confirmation from field surveys. Reports of historically less common species that now frequent the region due to northerly range expansion should be explored. It is recommended that effort is made to document the occurrence and distribution of coastal species and habitat features and how these components are responding to environmental change.

## **4. ANADROMOUS AND CATADROMOUS FISHES**

*Authors: Nicholas I. Kelly, Ian Bradbury, Chantelle Burke, Steven J. Duffy, and Don Keefe*

### **Available Information**

Anadromous and catadromous fishes are species that move between freshwater and estuarine or marine environments during their lifecycle including Atlantic Salmon and American Eel. These fish are a diverse taxonomic group that form an important part of the study area's ecosystem as they transfer energy between the marine environment and freshwater. This group includes several species in the region that are of significant cultural and commercial importance. General data on the distribution of anadromous and catadromous fishes in the study area are available from multiple sources. Historical observations of species presence in the area are contained in the Province of Newfoundland and Labrador's Provincial Aquatics Database and Archive (e.g., Crowley et al. 2024) and Porter et al. (1974). More recently an eDNA survey extensively surveyed rivers reporting several species of fish present in the area (see Crowley et al. 2024). Finally, electrofishing has occurred over the last two years targeting Atlantic Salmon in rivers across the region.

## **Atlantic Salmon (*Salmo salar*)**

### *Freshwater Distribution, Life History, and Stock Status*

The South Coast Fjords study area is in the western portion of Salmon Fishing Area (SFA) 11, one of 15 Atlantic Salmon management areas in the NL region (DFO 2024j). There are 15 watersheds within the study area known to have native anadromous Atlantic Salmon populations (Reddin et al. 2010), from Cinq Cerf River in the west to Allans Cove Brook in the east (Figure 4.1, Table 4.1). The spatial area encompassed by, and west of the study area boundary, is part of a large spatial gap in historical and contemporary Atlantic Salmon monitoring in Newfoundland (DFO 2023a, DFO 2024j). The abundance and life history of salmon populations within the study area are poorly understood. Genetic and genomic data suggest the Atlantic Salmon populations in this region of the province are distinct from elsewhere and are part of the southern Newfoundland West Designatable Unit recently recognized by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; Bradbury et al. 2014, Lehnert et al. 2023).

The trend and status of juvenile and adult Atlantic Salmon populations in the study area remains unclear. Prior to the commercial Atlantic Salmon fishery moratorium, implemented in 1992, an average of 23,408 salmon in SFA 11 (1974–1991) and 32,585 salmon in SFA 12 (1974–1983) were captured during their marine migration (O’Connell et al. 1992), likely negatively impacting returning adult salmon abundance on rivers across southern Newfoundland (Dempson et al. 2001, Dempson et al. 2004). Monitoring efforts over the past few decades have primarily focused on the Bay d’Espoir and Fortune Bay regions of SFA 11 (DFO 2023a, DFO 2024j), located to the east of the study area. In Bay d’Espoir, monitored salmon populations have declined by more than 90% over the past three generations (15–16 years; DFO 2022e, DFO 2023a, Dempson et al. 2024) and recent assessments suggest declines in Conne River smolt abundance as well (DFO 2024j). Atlantic Salmon populations within the South Newfoundland Designatable Unit were designated as Threatened under COSEWIC (2010) and are currently being re-assessed (Lehnert et al. 2023).

Juvenile Atlantic Salmon most often utilize fluvial habitats during their freshwater residency, however, lacustrine habitats are also frequently occupied in Newfoundland watersheds likely due to a lack of predators and competition for resources (Gibson 1993, O’Connell et al. 2006). In Newfoundland populations, Atlantic Salmon parr typically spend three to four years in freshwater prior to undergoing smoltification and migrating to sea as smolts (DFO 2022e, DFO 2023a). Information on Atlantic Salmon parr abundance is sparse for southwest Newfoundland rivers, including those in the South Coast Fjords study area.

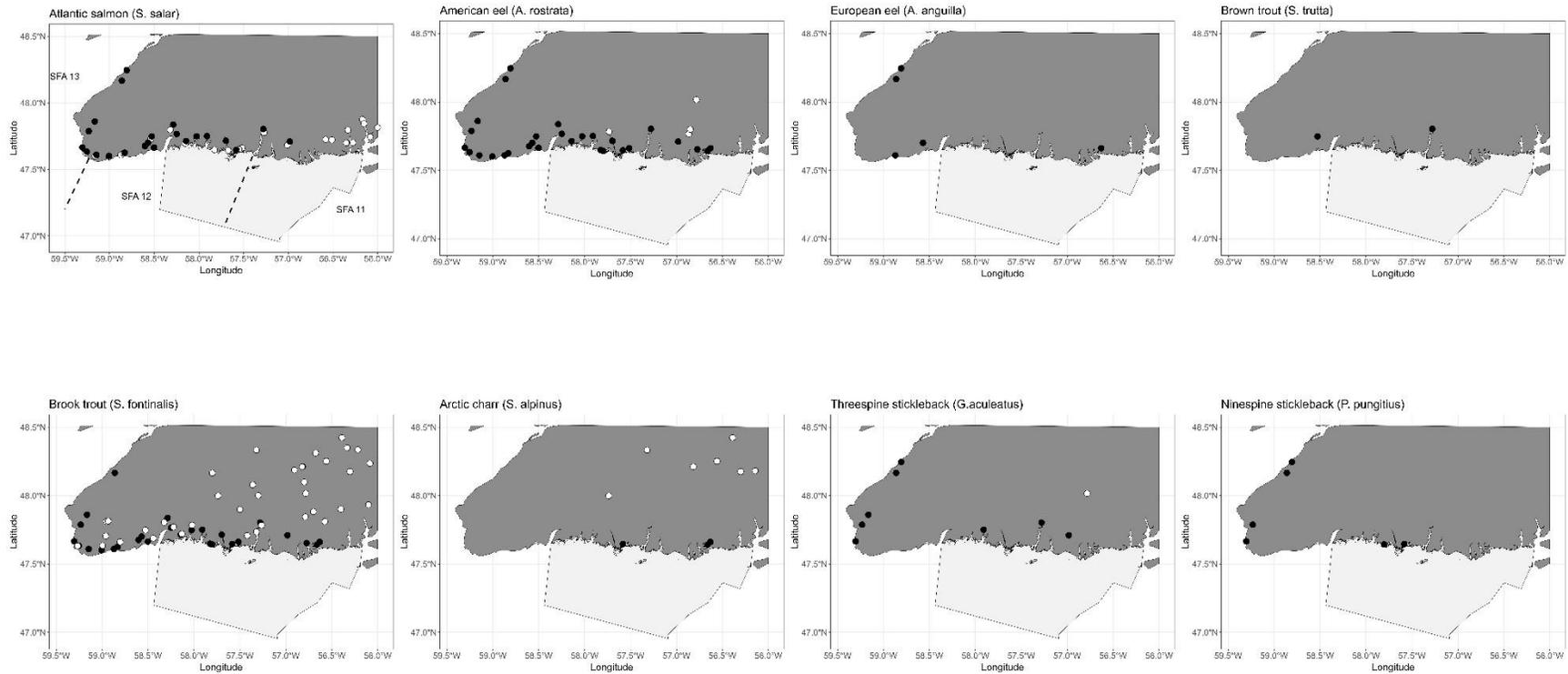
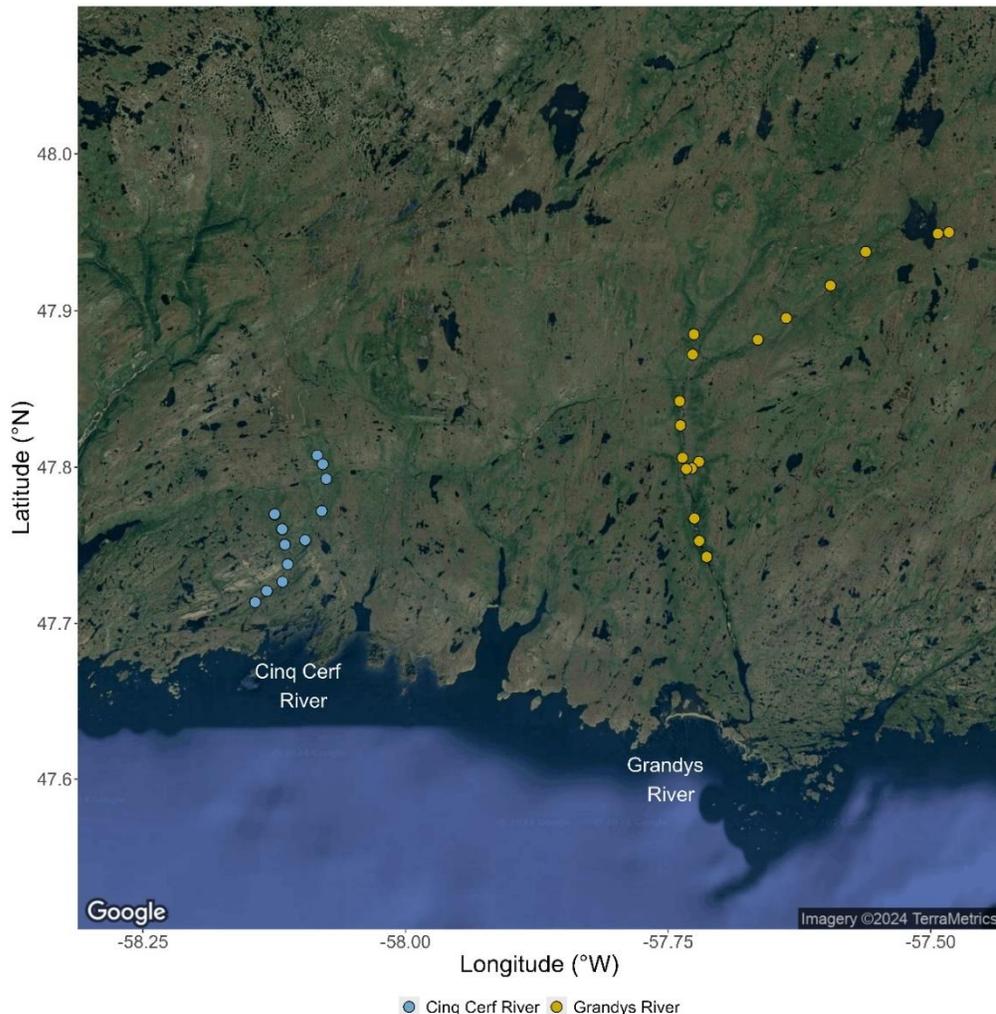


Figure 4.1: Multi-panel plot of the freshwater spatial distribution of anadromous and catadromous species in the South Coast Fjords study area. The South Coast Fjords study area is represented by the grey polygon. Species presence based on detections from eDNA sampling conducted from 2019–2021 (see Crowley et al. 2024) are represented by black circles. For Atlantic Salmon, white circles represent known populations based on Reddin et al. 2010. For American Eel, Arctic Charr, Brook Trout and Threespine Stickleback, white circles represent known presence from data provided by the provincial government of Newfoundland and Labrador.

Table 4.1: Recreational angling estimates for Atlantic Salmon rivers located within the South Coast Fjords study area. Angling estimates include average ( $\pm$  SD) angler effort (rod days), number of retained salmon, and number of released salmon on individual rivers from 1994–2023. The number of years in which angling estimates were derived in that period is provided. River names with superscript (<sup>s</sup>) indicate a scheduled river.

| River                            | Latitude | Longitude | Accessible Drainage Area (km <sup>2</sup> ) | Number of Years with Angling Estimates (1994–2023) | Average Angling Effort (Rod Days) $\pm$ SD | Average Number of Retained Salmon $\pm$ SD | Average Number of Released Salmon $\pm$ SD |
|----------------------------------|----------|-----------|---|--|--|--|--|
| Allan's Cove Brook <sup>s</sup>  | 47.70    | -56.28    | 41  | 21   | 13.4 $\pm$ 10.2                            | 1.8 $\pm$ 3.0                              | 0.7 $\pm$ 1.5                              |
| Bottom Brook <sup>s</sup>        | 47.80    | -56.33    | 175   | 21   | 35.3 $\pm$ 24.8                            | 10.6 $\pm$ 6.9                             | 3.4 $\pm$ 3.6                              |
| Brent Cove Brook                 | 47.70    | -56.35    | 44  | -  | -  | -  | -  |
| Morgan Brook <sup>s</sup>        | 47.72    | -56.51    | 178   | -  | -  | -  | -  |
| Dolland Brook <sup>s</sup>       | 47.73    | -56.58    | 688   | 26   | 116.9 $\pm$ 65.5                           | 30.9 $\pm$ 20.8                            | 42.3 $\pm$ 49.3                            |
| Grey River <sup>s</sup>          | 47.68    | -57.01    | 2,394                                       | 30   | 606.5 $\pm$ 406.0                          | 131.5 $\pm$ 101.8                          | 400.7 $\pm$ 319.7                          |
| White Bear River <sup>s</sup>    | 47.78    | -57.27    | 2,027                                       | 30   | 784.6 $\pm$ 387.9                          | 194 $\pm$ 126.6                            | 204.8 $\pm$ 130.6                          |
| Bay de Loup Brook <sup>s</sup>   | 47.66    | -57.52    | 55  | 12   | 20.6 $\pm$ 10.3                            | 4.0 $\pm$ 4.3                              | 4.0 $\pm$ 9.6                              |
| Kelly Brook                      | 47.65    | -57.55    | 2   | -  | -  | -  | -  |
| Kings Harbour Brook <sup>s</sup> | 47.64    | -57.58    | 128   | 20   | 27.1 $\pm$ 25.3                            | 9.8 $\pm$ 8.4                              | 5.5 $\pm$ 11.3                             |
| Grandys River <sup>s</sup>       | 47.64    | -57.67    | 264   | 28   | 992.0 $\pm$ 659.7                          | 248.8 $\pm$ 196.6                          | 314.6 $\pm$ 174.3                          |
| Middle Brook                     | 47.65    | -57.83    | 8   | -  | -  | -  | -  |
| Connoire Brook                   | 47.75    | -57.91    | 311   | 21   | 34.4 $\pm$ 21.9                            | 12.5 $\pm$ 8.8                             | 14.0 $\pm$ 14.4                            |
| Couteau Brook                    | 47.74    | -58.03    | 132   | -  | -  | -  | -  |
| Cinq Cerf Brook <sup>s</sup>     | 47.70    | -58.15    | 205   | 26   | 83.1 $\pm$ 58.4                            | 29.7 $\pm$ 19.3                            | 32.0 $\pm$ 29.6                            |

In 2023, DFO Science initiated a three-year project to improve our understanding of the abundance, size and distribution of juvenile Atlantic Salmon on watersheds in the South Coast Fjords study area. In August of 2023 and 2024, quantitative (open and closed) electrofishing techniques (Dauphin et al. 2019, Malcolm et al. 2019) were applied on 13–17 sites on Grandys River and Cinq Cerf Brook, located in the western portion of the South Coast Fjords study area (Figure 4.2, Table 4.2). Several environmental variables were measured at each site to investigate the effects of factors such as temperature, dissolved oxygen, substrate, flow, depth, and conductivity on salmon density and capture probability. Size and age data were collected to investigate parr growth and condition. Additionally, standard electrofishing methods were applied on several rivers across southwest Newfoundland to collect samples for baseline genetic analysis (Table 4.3). The use of electrofishing methods to estimate juvenile Atlantic Salmon abundance has proven to be an effective monitoring tool in many jurisdictions (Malcolm et al. 2019, Niemelä et al. 2000, 2005). While this information alone cannot provide estimates of stock status as defined per the Precautionary Approach Framework (DFO 2015, DFO 2023a) applied in DFO Atlantic Salmon stock assessments, previous research suggests that juvenile Atlantic Salmon density data can be a potential proxy for adult abundance (Niemelä et al. 2005, Bowlby and Gibson 2012) and be an informative tool for tracking population changes.



*Figure 4.2: Map of sites on Cinq Cerf Brook and Grandys River where quantitative electrofishing methods were used in August of 2023 and 2024 to estimate juvenile Atlantic Salmon abundance and growth rate.*

Table 4.2: Summary of the number of sites and fish sampled by age group during quantitative juvenile Atlantic Salmon electrofishing surveys conducted on Grandys River and Cinq Cerf Brook in August of 2023 and 2024 as part of a three-year (2023–2025) baseline Atlantic Salmon monitoring and research project in the South Coast Fjords study area.

| River           | Year | N Sites Sampled per River | N Open (CPUE) Sites | N Closed (Barrier Net) Sites | N Sites Sampled with Open and Closed Methods | N Sites Sampled Twice with CPUE Methods | Number of Juvenile Salmon Sampled per Age Group |    |    |
|-----------------|------|---------------------------|---------------------|------------------------------|--|---|---|----|----|
|                 |      |                           |                     |                              |  |   | YOY   | 1+ | 2+ |
| Cinq Cerf River | 2023 | 13                        | 13                  | 3                            | 3  | 1                                       | 93  | 66 | 23 |
|                 | 2024 | 13                        | 9                   | 4                            | 0  | 0                                       | 99  | 67 | 9  |
| Grandys River   | 2023 | 17                        | 16                  | 4                            | 2  | 1                                       | 131   | 85 | 50 |
|                 | 2024 | 16                        | 12                  | 5                            | 1  | 0                                       | 87  | 67 | 40 |

Table 4.3: Number of juvenile Atlantic Salmon sampled in southwest Newfoundland during August of 2023 and 2024 for baseline genetic analysis. All fish were captured via standard electrofishing methods targeting roughly 100 samples across age classes. Totals are separated by age group (young-of-the-year [YOY], 1+ and 2+) estimated based on fork length.

| River                           | 2023 |    |    | 2024 |    |    |
|---------------------------------|------|----|----|------|----|----|
|                                 | YOY  | 1+ | 2+ | YOY  | 1+ | 2+ |
| Couteau Brook                   | 47   | 11 | 2  | 42   | 24 | 7  |
| Grand Bay River                 | 35   | 66 | 12 | 52   | 29 | 5  |
| Isle aux Morts                  | 68   | 28 | 16 | 38   | 36 | 8  |
| Grandy's Brook (Burnt Islands)  | 48   | 9  | 7  | 23   | 24 | 8  |
| White Bear River                | 48   | 25 | 28 | 25   | 33 | 6  |
| Grey River                      | 36   | 14 | 20 | 36   | 59 | 3  |
| Salmon Brook (Bay d'Espoir)     | 18   | 6  | 28 | 15   | 25 | 38 |
| d'Espoir Brook                  | 13   | 25 | 11 | 0    | 2  | 16 |
| Bottom Brook                    | 5    | 0  | 1  | 15   | 2  | 24 |
| Garia Brook                     | 97   | 3  | 21 | 22   | 22 | 18 |
| Brent Cove Brook                | NA   | NA | NA | 0    | 0  | 0  |
| North West Brook (Bay La Moine) | 0    | 0  | 0  | 0    | 7  | 14 |
| Farmer's Brook                  | 113  | 52 | 9  | 51   | 36 | 16 |
| La Poile River                  | 69   | 7  | 18 | 22   | 42 | 5  |
| King's Harbour Brook            | 9    | 4  | 6  | NA   | NA | NA |
| East Bay Brook                  | 10   |    | 15 | 0    | 0  | 0  |
| Dolland Brook                   | 55   | 26 | 5  | 14   | 31 | 21 |
| Allan Cove Brook                | 5    | 0  | 1  | 0    | 0  | 2  |

The abundance and capture probability ( $p$ ) of young-of-the-year (YOY), 1+ parr, and 2+ parr were estimated for each closed site each year with depletion models using the FSA package in R (Ogle et al. 2023). Following this, we modelled the capture probability estimates for each size group with electrofishing effort and relevant environmental covariates as main effects and site as random effect (beta Generalized Linear Mixed Model) to account for variation both among sites and size groups. For open sites, we estimated juvenile salmon density by dividing the total catch by the area sampled (squared meters) and the adjusted capture probability estimate for each size group. Subsequently, we modeled the density estimates across all sites using GLMMs (gamma distribution), with electrofishing effort, river, and year as main effects, site as a random effect, and additional environmental covariates included as necessary. Model selection was performed using the Akaike Information Criterion (AIC) to identify the best-fitting model for YOY, 1+, and 2+ salmon, separately. The adjusted mean densities ( $\pm$  95% CIs) from the GLMMs for each size group are in Figure 4.3.

The capture probability of YOY salmon was significantly affected by the availability of run habitat, pebble and cobble substrate ( $p < 0.001$ ), conductivity ( $p < 0.01$ ), and latitude ( $p < 0.05$ ). In contrast, the capture probability of parr was influenced by longitude and gravel substrate availability for 1+ parr ( $p < 0.05$ ), and water temperature ( $p < 0.001$ ) and mean flow rate ( $p < 0.05$ ) for 2+ parr. The adjusted capture probabilities were similar across years for each age group, ranging from 0.51–0.57 for YOY salmon, 0.70–0.76 for 1+ parr, and 0.79–0.80 for 2+ parr across years (Figure 4.3).

There is limited data regarding juvenile salmon density or abundance on the south or southwest coast of Newfoundland. Fitzgerald et al. (1998) analyzed 10 years of electrofishing data on Harrys River (western Newfoundland). The density of YOY, 1+, and 2+ Atlantic Salmon per 100 m<sup>2</sup> estimated for Cinq Cerf River and Grandys River in 2023 and 2024 are similar to values reported in that study, albeit near the lower end of their range. There was no significant effect of river or year on the density of YOY, 1+ parr, or 2+ parr ( $p > 0.05$ ). When controlling for electrofishing effort, model selection suggested significant relationships between YOY density and both riffle habitat and pebble substrate ( $p < 0.05$ ), and 1+ parr density and latitude ( $p = 0.05$ ). There were no significant relationships with spatial or environmental covariates and 2+ parr density when controlling for effort. This underscores the importance of habitat structure and hydrological conditions in shaping fish population dynamics across the different size groups.

The growth rate of juvenile salmon in Grandys River and Cinq Cerf Brook was estimated using age estimates based on field measurements of fish size using a nonlinear mixed-effects models, including von Bertalanffy growth parameters:  $L_{\infty}$  (asymptotic length) and  $K$  (growth coefficient). Separate models were compiled with either river or year as fixed effects, both of which included site as a random factor. The year-based model indicated no significant variation in  $L_{\infty}$  ( $p = 0.52$ ) and  $K$  ( $p = 0.81$ ) between 2023 and 2024. The river-based model, which had a lower AIC value, estimated  $L_{\infty}$  at 163.2 mm (SE = 9.7 mm) with no significant variation between Cinq Cerf Brook and Grandys River ( $p = 0.76$ ). Similarly, the growth coefficient  $K$  was estimated at 0.5 (SE = 0.07), with no significant variation between rivers ( $p = 0.32$ ). While spatial variability was better captured by the model with river as the main effect, which had the lowest AIC, the overall differences in  $L_{\infty}$  and  $K$  between rivers and years were not statistically significant. Model estimates will be updated once parr scale samples are processed and aged.

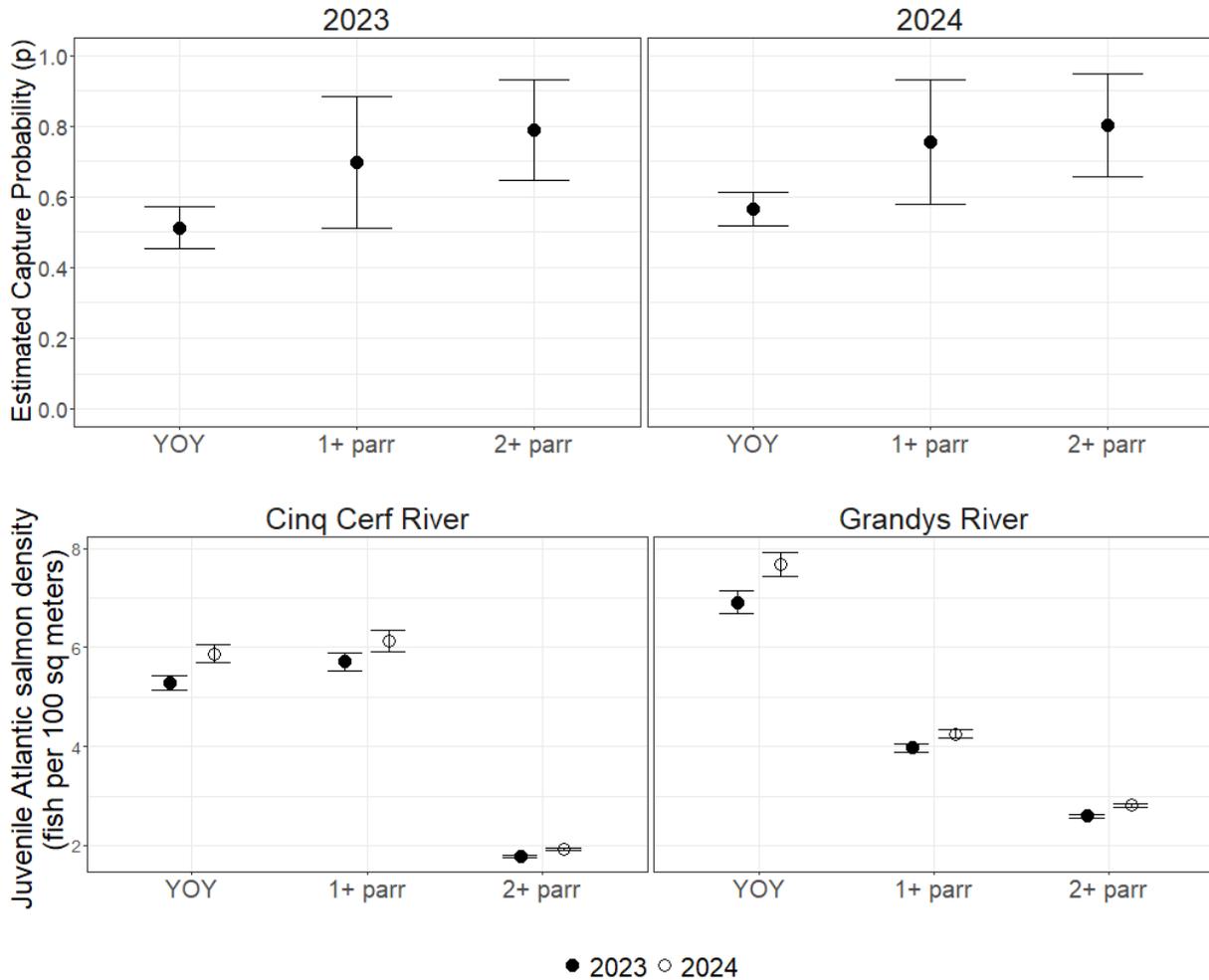


Figure 4.3: Capture probability (top panels) and density (fish per 100 square meters; bottom panels) of juvenile salmon on Cinq Cerf River and Grandys River, by age group (YOY, 1+ parr, and 2+ parr). Data used to derive estimates were from quantitative electrofishing surveys conducted in August of 2023 and 2024. All estimates were derived from GLMMs with site as a random factor and additional covariates where necessary to adjust estimates for environmental variation.

### Marine Distribution and Migration

Historical commercial salmon catch data and tag returns suggest that southern Newfoundland is migratory habitat for salmon from populations across southern Newfoundland and other regions of Atlantic Canada (May and Lear 1971, Lear 1973, Reddin and Short 1981, Ash and O'Connell 1987, Reddin and Lear 1990, Dufresne et al. 2025). In the 1970s, Atlantic Salmon tagged in locations like St. Lawrence (1973), Placentia Bay (1975), and throughout the east coast of Newfoundland were recaptured across the south coast as far as Burgeo and Port aux Basques (Reddin and Lear 1990). Genetic analysis of samples collected annually from the St. Pierre-Miquelon mixed-stock fishery (Bradbury et al. 2016, ICES 2024) in recent years has generally been dominated by contributions from the Gulf and Gaspé Peninsula regions, with a smaller contribution from the northeast coast of Newfoundland. A large-scale telemetry project investigating Atlantic Salmon habitat use offshore Newfoundland recorded detections of acoustic-tagged post-smolts from Maritime rivers in estuaries in multiple bays along southern

Newfoundland (Lilly et al. in prep<sup>2</sup>). It is likely that individuals from southern Newfoundland populations, along with salmon from other regions, regularly migrate through this area and could be present in the South Coast Fjords study area.

The timing of the Atlantic Salmon smolt marine migration is impacted by factors such as water temperature, photoperiod, and water discharge (Otero et al. 2014). The downstream smolt migration typically occurs in May and early June on monitored rivers along the south and southeast Newfoundland coast (SFAs 9–11), ranging from Bay d’Espoir to St. Mary’s Bay, NL (Dempson et al. 2011, Bøe et al. 2019, DFO 2023a). While smolt run timing on rivers within the study area is unclear, it is likely to occur within a similar time frame as other south coast Newfoundland rivers. This assumption is supported by data collected in 2023 and 2024 from Grandys River near Burgeo, NL, as part of an ongoing acoustic telemetry study (N. Kelly pers. comm.).

Smolts spend a period of time ranging from one tidal cycle ranging from days or weeks (Friedland et al. 1998, Dempson et al. 2011, Bøe et al. 2019) in estuaries at the base of river systems before fully transitioning to the marine environment. Estuaries offer smolts an opportunity to adapt to marine conditions and increase energy reserves through feeding. However, entry into marine environments has also been linked to increased mortality associated with heightened predation and interactions with anthropogenic activities (Gudjonsson et al. 2005, Thorstad et al. 2007). Dempson et al. (2011) estimated survival rates of 54–85% for smolts transitioning from the estuary to the fjord exit in Bay d’Espoir, NL, and longer residency in estuaries was associated with increased estuary survival. Similar survival estimates were observed from a recent four-year smolt tracking study on two populations in northwest Placentia Bay (Kelly et al. in prep<sup>3</sup>).

Post-smolts from southern Newfoundland rivers migrate around the east coast of Newfoundland to the south Labrador Sea and/or the shelf off eastern Newfoundland where they overwinter (Reddin 2006, Reddin et al. 2011, Dufresne et al. 2025), and a smaller proportion from south coast rivers migrate into the Gulf of St. Lawrence through the Cabot Strait (Lilly et al. in prep.<sup>2</sup>). There is potential for salmon migrating along the south coast to become intercepted in the St. Pierre-Miquelon mixed-stock Atlantic Salmon fishery (Bradbury et al. 2016, ICES 2024). However, genetic analyses of samples collected annually suggest that salmon caught in this fishery are predominantly from other regions of Atlantic Canada (ICES 2024). Most post-smolts from Newfoundland rivers are 1SW (one-sea-winter) salmon that return to their natal river as a spawning adult after one year at sea. Salmon that spend two (two-sea-winter; 2SW) or more (multi-sea-winter; MSW) years at sea before returning to spawn in freshwater comprise a much smaller component of the returning adult population, and is generally negligible on most Newfoundland rivers aside from populations in the Bay St. George area of SFA 13 (DFO 2023a, ICES 2024). These salmon migrate further north to West Greenland where they can potentially be intercepted in the mixed-stock Atlantic Salmon fishery occurring there (Reddin et al. 2012, Bradbury et al. 2016, ICES 2024). Although life history data are limited for salmon rivers within

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<sup>2</sup> Lilly, J., Burke, C., Denny, S., Denny L., Carr, J., LaVoie, D., Whoriskey F., Gillis, C.A., and Robertson, M. In prep. The early marine migration pathways of Atlantic salmon post-smolts from multiple rivers in eastern Canada.

<sup>3</sup> Kelly, N.I., Fitzsimmons, M., Duffy, S.J., Allison, A., and Robertson, M.J. In prep. The early migration, residency, and survival of acoustic-tagged Atlantic salmon (*Salmo salar*) smolts in northwest Placentia Bay, Newfoundland.

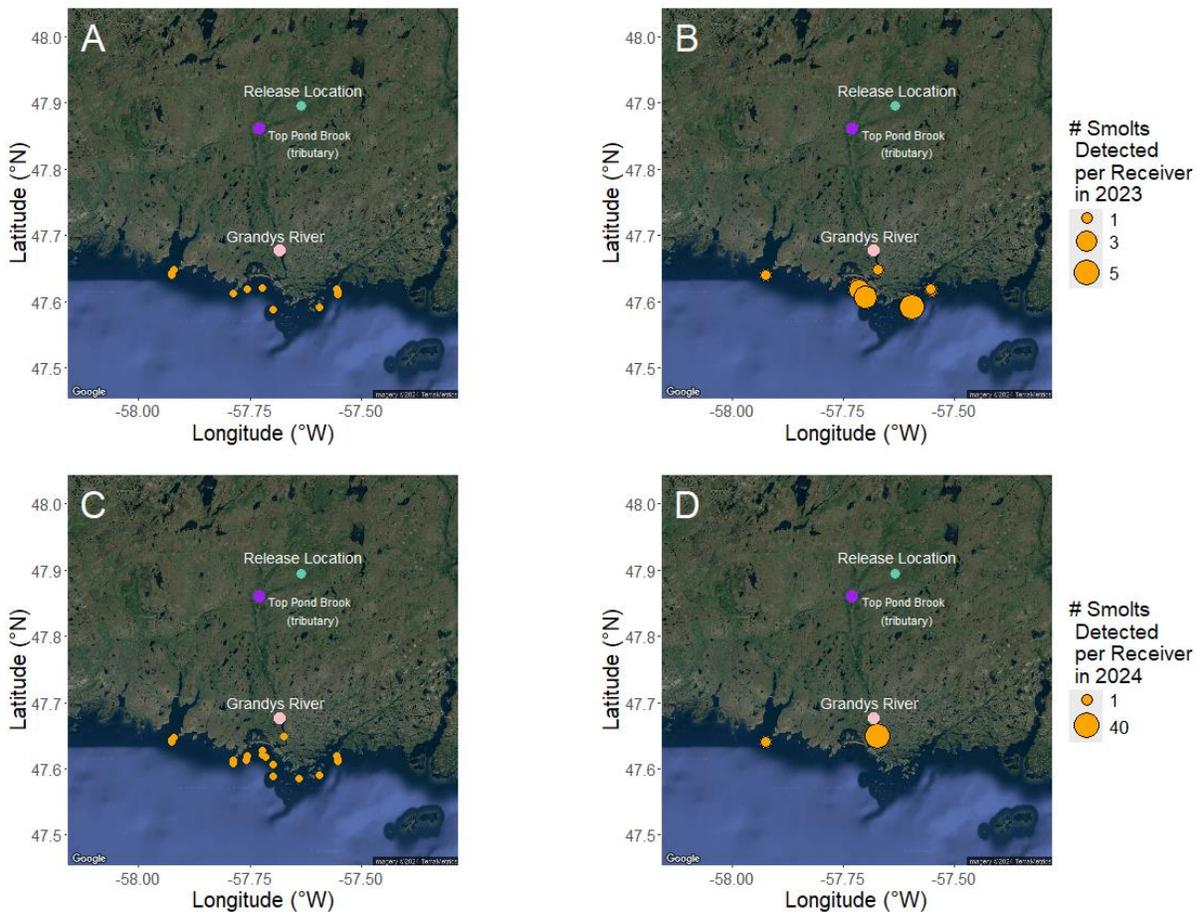
the South Coast Fjords study area, those populations are likely dominated by 1SW salmon as well, thus impacts from this mixed stock fishery are likely negligible.

Estimates of marine survival from post-smolt to returning adult are derived annually for five monitored rivers in the NL Region for stock assessment updates (DFO 2022e, DFO 2023a), two of which are in SFA 11: Conne River in Bay d'Espoir and Garnish River in Fortune Bay. Most adult Atlantic Salmon returning to Newfoundland rivers are 1SW fish, so survival estimates are calculated by dividing the smolt count in year $_i$  by the count of returning small (< 63 cm) salmon in year $_{i+1}$  (DFO 2023a). Marine survival estimates on monitored rivers outside of SFA 11 and 12 usually vary between 5–10% in most years (DFO 2023a). In contrast, survival rates have been much lower in Conne River and Garnish River in recent years (< 3% since 2018; DFO 2023a). The causes of reduced marine survival and declines in adult abundance recorded in SFA 11 are poorly understood and are likely influenced by a complex combination of at-sea factors known to impact salmon survival, including local aquaculture operations (Vollset et al. 2018, Bradbury et al. 2020a, Shephard and Gargan 2021), thermal habitat availability (Strøm et al. 2020), and the spatiotemporal distribution of predators (Strøm et al. 2019) and prey (Mills et al. 2013, Dixon et al. 2019). There is no information available on Atlantic Salmon smolt abundance or survival during the marine migration for populations in the South Coast Fjords study area.

Water temperature plays a crucial role in the transition to the marine environment (Halfyard et al. 2012, Thorstad et al. 2012), subsequent migration behavior (Bøe et al. 2019, Strøm et al. 2020), and the run timing of returning adults (Dempson et al. 2017) due to its direct influence on metabolic rate, and the salmon's ability to avoid predation and capture prey. Atlantic Salmon generally occupy marine temperatures ranging from 4°C to 15°C and depths less than 10 m (Reddin 2006, Strøm et al. 2017, Strøm et al. 2018, Rikardsen et al. 2021) and occasionally make deeper dives that are potentially associated with foraging behaviour (Reddin et al. 2011, Hedger et al. 2017). Ocean climate variability during the first months at sea (Friedland et al. 2003, Friedland et al. 2014) and in the overwintering habitat (Reddin and Friedland 1993) appears to be crucial for the survival of North American post-smolts. Although temperature directly influences the growth and physiology of Atlantic Salmon during their marine migration, recent research suggests that climatic warming in the marine environment along coastal Newfoundland will primarily impact Atlantic Salmon through changes in the marine ecosystem and prey availability versus thermal effects on salmon physiology and growth (Mills et al. 2013, Strøm et al. 2023).

Prey consumption and rapid growth during the initial phase of the marine migration are essential for post-smolt survival (Thorstad et al. 2012), particularly from wild predation (Halfyard et al. 2012, Daniels et al. 2019, Strøm et al. 2019). Atlantic Salmon post-smolts are opportunistic predators, feeding on a variety of species depending on what is available (Renkawitz et al. 2015, Dixon et al. 2019, Hellenbrecht et al. 2023). During the early phase of their marine migration, post-smolts generally feed on krill (*Euphausiidae*), fish larvae, planktonic amphipods, and insects (Andreassen et al. 2001, Hellenbrecht et al. 2023). Available evidence suggests that as post-smolts grow larger, their diet transitions to preying more heavily on fish species like Capelin (*Mallotus villosus*) and Sand Lance (*Ammodytes spp.*) (Lear 1972, Dutil and Coutu 1988, Mills et al. 2013, Dixon et al. 2019, Power et al. 2023). Post-smolt growth in the first months at sea is beneficial for escaping predation by several predators including marine mammals (Hammill and Stenson 2000, Strøm et al. 2019), ectothermic and endothermic fishes (Strøm et al. 2019), and various piscivorous seabird species (Montevecchi et al. 1988, Montevecchi and Cairns 2003). The impact of prey and predator abundance, in both freshwater and marine habitats, represents a significant knowledge gap for understanding trends in the marine survival of Atlantic Salmon in Newfoundland and Labrador (DFO 2023a).

Using passive acoustic telemetry, DFO Science aims to enhance our understanding of the residency, survival, migration direction, and potential impact of wild predation during the early phase of the migration through the South Coast Fjords study area. In May of 2023 and 2024, Atlantic Salmon smolts were captured using fyke nets during their downstream migration on Top Pond Brook, a tributary of Grandys River, NL (Figure 4.4). Atlantic Salmon smolts (N = 27 in 2023 and 46 in 2024) were anaesthetized, surgically implanted with an InnovaSea acoustic tag (V8 in 2023, V7DT, V8 or V9 in 2024), and released in freshwater 50 m downstream of the capture location when fully recovered. The acoustic-tagged smolts were passively tracked in Barasway Bay, adjacent to Burgeo, NL, and approximately 15 km east and west, using InnovaSea acoustic receivers (VR2AR and VR2AR-X) deployed each May (Figure 4.4). Eleven acoustic receivers were deployed in May of 2023, ten of which were retrieved, downloaded, and redeployed in May and June of 2024. To improve detection probability in the region, seven additional acoustic receivers were deployed in May of 2024, including one in the estuary of Grandys River (Figure 4.4).



**Figure 4.4:** Maps of acoustic receiver deployments near Barasway Bay and Burgeo, NL, in A) 2023 and C) 2024, and maps showing the number of unique smolt tag IDs detected on each acoustic receiver in B) 2023 and D) 2024. For panels B and D, the size of the circle represents the number of unique smolts detected. Sample sizes for fish tagged on Top Pond Brook were 27 in 2023 and 46 in 2024. Note that the acoustic detection data shown for 2024 are very preliminary and it is based on downloaded data from two receivers obtained on June 6, 2024. Data from the remaining 16 acoustic receivers in the marine environment were retrieved in summer of 2025 and are being processed for analysis.

The tagging location on Top Pond Brook is approximately 8.8 km from the main stem of Grandys River, 30.1 km from the river mouth, and 34.1 km from the first receiver deployed in the estuary during 2024. In 2023, 7 out of 27 (25.9%) of the tagged smolts released on Top Pond Brook were detected in the marine receiver array 40 km or more from the release location. This proportion is much lower than recorded in other similar studies in Newfoundland (Dempson et al. 2011, Bøe et al. 2019, Kelly et al. in prep<sup>3</sup>). However, environmental conditions in spring impacted receiver deployments and detection coverage, suggesting that some tagged smolts may have passed through the array undetected. Due to the low sample size it is difficult to assess migration direction, however, tagged smolts were detected on receivers located approximately 15 km east and west of the entrance to Barasway Bay (Figure 4.4). Of the 46 smolts tagged in May of 2024, 41 (89%) have been detected during their downstream migration on the acoustic receiver deployed in the estuary (Figure 4.4). The average migration time from the release of these tagged smolts on Top Pond Brook to the estuary receiver (~34 km distance) was 7.8 days (range: 4–15). Smolt residency time near the receiver deployed in Grandys River estuary averaged 1.17 days (range: 0.01–6.27) across tagged smolt. The average ( $\pm$  min and max) temperature calculated for 20 smolts tagged with V7DT tags and detected in the estuary is shown in Figure 4.5. The average individual mean water temperature across 20 smolts tagged with V7DT tags, weighted by the number of temperature sensor detections per fish, was 10.5°C (range: 8.9°C–13.4°C), consistent with previous research on Atlantic Salmon thermal habitat preference (Reddin 2006, Strøm et al. 2017, Strøm et al. 2018, Rikardsen et al. 2021). At the time of writing, there were a small number of tag detections from the receiver arrays. Further data on the movements and survival of the tagged smolts, including those detected on the western receiver array, will be available when the receivers are retrieved and analyzed.

The impact of wild predation on post-smolt marine survival, in both freshwater and marine habitats, represents a significant knowledge gap for Atlantic Salmon in Newfoundland and Labrador (DFO 2023a). To investigate the effect of marine predation, 21 V7DT acoustic tags equipped with digestion sensors were deployed on Grandys River in May 2024. These tags feature an inert polymer that is eroded by stomach acid if ingested, triggering the digestion sensor (Daniels et al. 2019). Of the 21 predation tags deployed, 20 (95%) were detected in the estuary 1–2 weeks after release, with no signs of predation detected. This preliminary data suggests that predation by avian and marine species was negligible over the 34 km distance between the release site on Top Pond Brook and the estuary receiver (Figure 4.4).

In addition to Grandys River, predation-style acoustic tags were also deployed on Atlantic Salmon smolts migrating from Conne River in spring 2024. Collectively, this represents the first known application of predation-style acoustic tags on Atlantic Salmon in the NL region. This research aims to provide insights into predation rates on wild post-smolts early in their migration through southwest Newfoundland and the South Coast Fjords study area. The results will contribute to a better understanding of the potential impact of wild predation during their critical early marine migration phase.

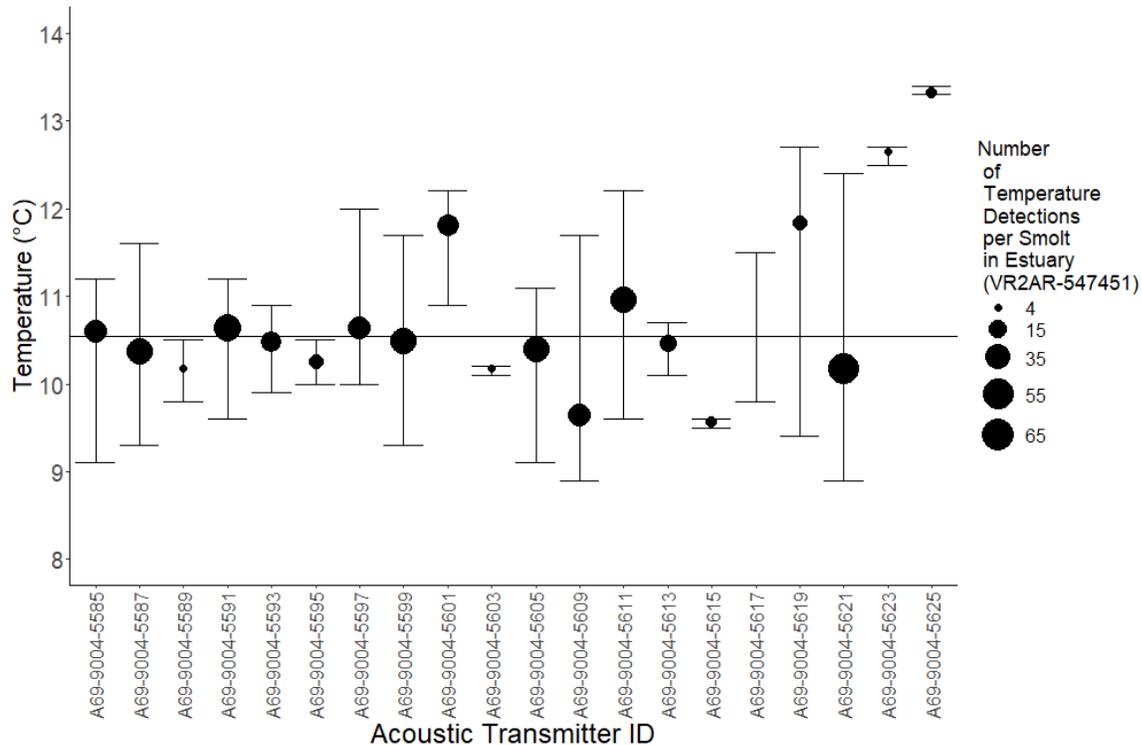


Figure 4.5: Water temperature data collected from 20 Atlantic Salmon smolts acoustic tagged (V7DT tags) on Top Pond Brook, a tributary of Grandys River, in May of 2024. All temperature data were recorded on an acoustic receiver deployed in Grandys River estuary. The solid horizontal line represents the average temperature across all fish weighted by the number of detections per individual (10.5°C). The solid black circle represents the average temperature recorded for each smolt. The minimum and maximum temperatures recorded for each smolt are represented by the vertical error bars. The size of the black circle is scaled to reflect the number of detections for each smolt.

### American Eel (*Anguilla rostrata*)

American Eel (*Anguilla rostrata*) are found in brackish, freshwater, and marine habitats throughout insular Newfoundland, and their range in Labrador extends as far north as Lake Melville (Jessop et al. 2009, Veinott and Clarke 2011). Recent eDNA surveys in the region suggest that American Eel is widespread throughout the area of interest (Figure 4.1) and supports the hypothesis that it is a dominant component of freshwater and coastal ecosystems in the region (Crowley et al. 2024). Interestingly, the survey also detected the presence of European Eel (*Anguilla Anguilla*) DNA in the study area (Figure 4.1) as well as more broadly throughout southern Newfoundland (Crowley et al. 2024). Subsequent genomic analysis of eels collected in this region suggests these are North American-European hybrids and represents the first documented hybrid zone outside of Iceland (Crowley et al. in prep.<sup>4</sup>). The prevalence of hybrids and the mechanism responsible for their occurrence in the study area remain unknown.

American Eel are long-lived with an estimated generation time ranging from 8–23 years (COSEWIC 2012). They are catadromous and semelparous, living much of their life in

<sup>4</sup> Crowley, S.E., Kess, T., Bentzen, P., Neville, V., Bloom, C., Smith, N., Fahner, N., Berghuis, L., Hobrecker, K., Hajibabaei, M., Duffy, S.J., and Bradbury, I.R. In prep. eDNA metabarcoding and whole genome sequencing detect European-American Eel hybrids in northeastern Canada.

freshwater before migrating to the Sargasso Sea to spawn before death (Jessop et al. 2008, Pratt et al. 2014). Larvae drift with oceanic currents and metamorphose into ‘glass eels’ at approximately 65 mm in length, at which time they approach coastal estuaries, become pigmented, and are known as ‘elvers’ (Jessop et al. 2008, Jessop 2010). The elver stage lasts between 3 to 12 months, during which they may migrate up rivers or remain in brackish or salt waters, eventually becoming ‘yellow eels’. The yellow stage marks the growth phase where the skin thickens, and sexual differentiation occurs. Previous research suggests that some eels move between freshwater, estuarine, and marine habitats frequently, and that growth is considerably higher in estuarine versus freshwater habitats (Jessop et al. 2008, Jessop et al. 2009). After 8 to 23 years, they undergo a physiological and physical transition into ‘silver eels’ and begin the migration back to their spawning grounds in the Sargasso Sea to spawn before death (Tesch 2003, Jessop et al. 2006). There remain considerable knowledge gaps regarding specific spawning locations, early larval development at sea, and fine-scale details of their residency and migration in coastal and marine habitats (COSEWIC 2012).

Identified threats to the survival of American Eel include habitat alteration (via dams and turbines, and contaminants), fisheries, climate-driven changes in ocean conditions, and parasites (COSEWIC 2012). American Eel is a species of special significance for food, social and ceremonial needs, cultural identity, and cultural expression for Indigenous people in Canada. They also play a significant role in aquatic biodiversity, and as such, population declines may also affect aquatic birds, fish, and mammals.

American Eel have experienced significant declines across a substantial portion of its distribution in eastern Canada and have been designated as Threatened by COSEWIC (2012). In Newfoundland and Labrador, American Eel has been listed as a Vulnerable species under the NL *Endangered Species Act* with downward trends recorded during surveys on the Avalon Peninsula and west coast of Newfoundland from the 1980s to the 1990s (Veinott and Clarke 2011), however, contemporary abundance data are lacking. Eels are fished commercially, recreationally, and by Indigenous peoples in Newfoundland and Labrador. These fisheries target the yellow and silver eel life history stages. There are currently a limited number of recreational licenses, however, no new licenses are being distributed by the Government of NL (Wildlife Division 2010). Information regarding the abundance and life history of eel populations in southern Newfoundland and the area of interest is unknown.

### **Arctic Charr (*Salvelinus alpinus*)**

Arctic Charr (*Salvelinus alpinus*) are a cold-adapted salmonid species that exhibits complex life history strategies (Hutchings et al. 2019, Kess et al. 2021). The freshwater distribution of known Arctic Charr populations in the South Coast Fjords study area is shown in Figure 4.1. Through eDNA analysis, Crowley et al. (2024) reported detections of Arctic Charr in three rivers in the study area: Devil Bay Brook, Kings Harbour River, and Little Bay Brook. The population on Parker’s River on the northern peninsula of Newfoundland is the most southerly known anadromous species in their range (Layton et al. 2020), although anadromous individuals have been detected in the Rivière de la Trinité in Quebec (Doucette et al. 1999). There are several known landlocked populations of Arctic Charr in insular Newfoundland (O’Connell and Dempson 2002, Loughlin et al. 2017, Hutchings et al. 2019, Kess et al. 2021) which is likely the case for observed presence in the South Coast Fjords study area. However, the degree of anadromy in these populations is unknown.

### **Brown Trout (*Salmo trutta*)**

Brown Trout (*Salmo trutta*) were introduced to North America in the 1880s near St. John’s, NL (Hustins 2007, Scott and Crossman 1964) and can thrive in a wide range of habitats. Although stocking activities ceased in the early 1900s (Hustins 2007), this species has become

established throughout eastern Newfoundland (Crowley et al. 2024) and has potential to hybridize with wild Atlantic Salmon (Westley et al. 2011, Purchase et al. 2024). Previous studies suggest that the spread of Brown Trout across the region was caused by straying anadromous individuals (van Zyll de Jong et al. 2004, Westley and Fleming 2011). Recent eDNA analysis suggests that Brown Trout occur in one watershed in the study area: Grey River (Figure 4.1; Crowley et al. 2024).

The specific habitats Brown Trout occupy are influenced by a combination of abiotic and biotic factors (Elliot 1994, Armstrong et al. 2003). Habitat use can vary both within and among populations (Klemetsen et al. 2003), shaped by environmental conditions (Armstrong et al. 2003) as well as genetic factors (Charles et al. 2006, Thomsen et al. 2007). Detailed studies examining life history variation and habitat use in Newfoundland's Brown Trout populations remain limited (with exceptions like O'Connell 1982, Gibson and Cunjak 1986, and Warner et al. 2015). Life history, size, and abundance data specific to the Brown Trout population in Grey River within the South Coast Fjords study area is not available.

### **Brook Trout (*Salvelinus fontinalis*)**

Brook Trout (*Salvelinus fontinalis*) are a native salmonid to Newfoundland and are distributed in watersheds throughout the island (Crowley et al. 2024). The freshwater distribution of known Brook Trout populations in the South Coast Fjords study area is shown in Figure 4.1. Brook Trout populations in Newfoundland are dominated by individuals that remain in freshwater for their life cycle. However, some populations have small anadromous components which spawn in freshwater streams and migrate to coastal areas for growth. The freshwater abundance and marine migration of Brook Trout in coastal Newfoundland are knowledge gaps for the Newfoundland region, including in the South Coast Fjords study area.

### **Stickleback Species**

Two species of stickleback are known to occur in the study area: Three-spined Stickleback (*Gasterosteus aculeatus*) and Ninespine Stickleback (*Pungitius pungitius*). Both species exhibit considerable adaptive variation and have been studied intensively due their plasticity in morphology (Haines 2023, Scott et al. 2023), life history (Barret and Stein 2024), and physiology (Bruneaux et al. 2014, 2018). They are able to tolerate a range of environmental conditions and are found in freshwater, brackish, and coastal marine environments throughout Newfoundland (Crowley et al. 2024). The distribution of both species in the South Coast Fjords study area based on freshwater eDNA sampling (Crowley et al. 2024) and historical sampling (Department of Fisheries, Forestry and Agriculture) is shown in Figure 4.1. Three-spined Sticklebacks were detected on three of 14 rivers in the South Coast Fjords study area sampled for eDNA analyses (Connoire Brook, Grey River, and White Bear River). Details about the abundance and life history of populations in southwest Newfoundland are unknown.

## **Sensitive Species and Habitats**

### **Freshwater Habitat and Climate Change**

The South Coast Fjords region is isolated and pristine relative to most other regions of Newfoundland (see Chapter 12: Resource Utilization and Anthropogenic Influences). The freshwater and estuarine habitats in this region are critical to several anadromous and catadromous species which use them for majority of their life cycle. It is important to protect these habitats from anthropogenic activities and improve our ability to detect climate-induced changes.

Climate projections for Newfoundland, based on average output of seven climate change models, predict an increase in mean daily air temperature of 2 to 3 degrees Celsius by 2070

(Finnis 2013). Climate indices suggest that air and seawater temperatures have been above normal in recent years (Cyr et al. 2024b) and DFO Science data suggests similar trends in freshwater (Geissinger et al. 2024). Changes to environmental conditions in freshwater (e.g., temperature, flow rate, water level) will have direct consequences for salmonids (Jonssen and Jonssen 2009, Thorstad et al. 2021, Price et al. 2024), sticklebacks (Des Roches et al. 2020, Cominassi et al. 2022), and American Eel (Drouineau et al. 2018).

Predicted impacts of climate change on salmonids in freshwater include impacts on physiological processes and growth (Price et al. 2024), phenology (Shuter et al. 2012), reproduction (Whitney et al. 2016, Smialek et al. 2021), and changes to the distribution and abundance of prey and predator species. Olusanya and van Zyll de Jong (2018) conducted a vulnerability assessment for salmonids in Newfoundland and Labrador and found that all four species of salmonids in this chapter were vulnerable to climate-related habitat changes, particularly Atlantic Salmon, Arctic Charr, and Brook Trout. Water temperature approaching the upper thermal tolerance of Atlantic Salmon and other salmonids have been observed on several rivers in Newfoundland during 2022 and 2023 (DFO 2024j, DFO 2025d). The capacity for anadromous species and populations in southern Newfoundland, including the South Coast Fjords region, for genetic adaptation and/or phenotypic plasticity in thermal tolerance is unknown, but will be essential for the long-term persistence of many populations.

Species distribution modelling (SDM) has recently been used to explore changes in the distribution of Atlantic Salmon under climate change scenarios in the region in question (Figure 4.6). Here separate SDMs were created using MAXENT for each of the three main genomic clusters of Atlantic Salmon in Atlantic Canada (Nugent et al. 2025) allowing regional differences in environmental adaptation to be considered. Future projections (2060–2080) indicate a loss of suitable habitat for Atlantic Salmon in the region in the coming decades (Figure 4.6). More extreme climate scenarios (e.g., SSP 8.5) indicate a greater loss of habitat and low probability of occurrence in the study area (Figure 4.6). The results support the hypothesis of climate change associated impacts on production and distribution of Atlantic Salmon in the South Coast Fjords study area in the coming decades.

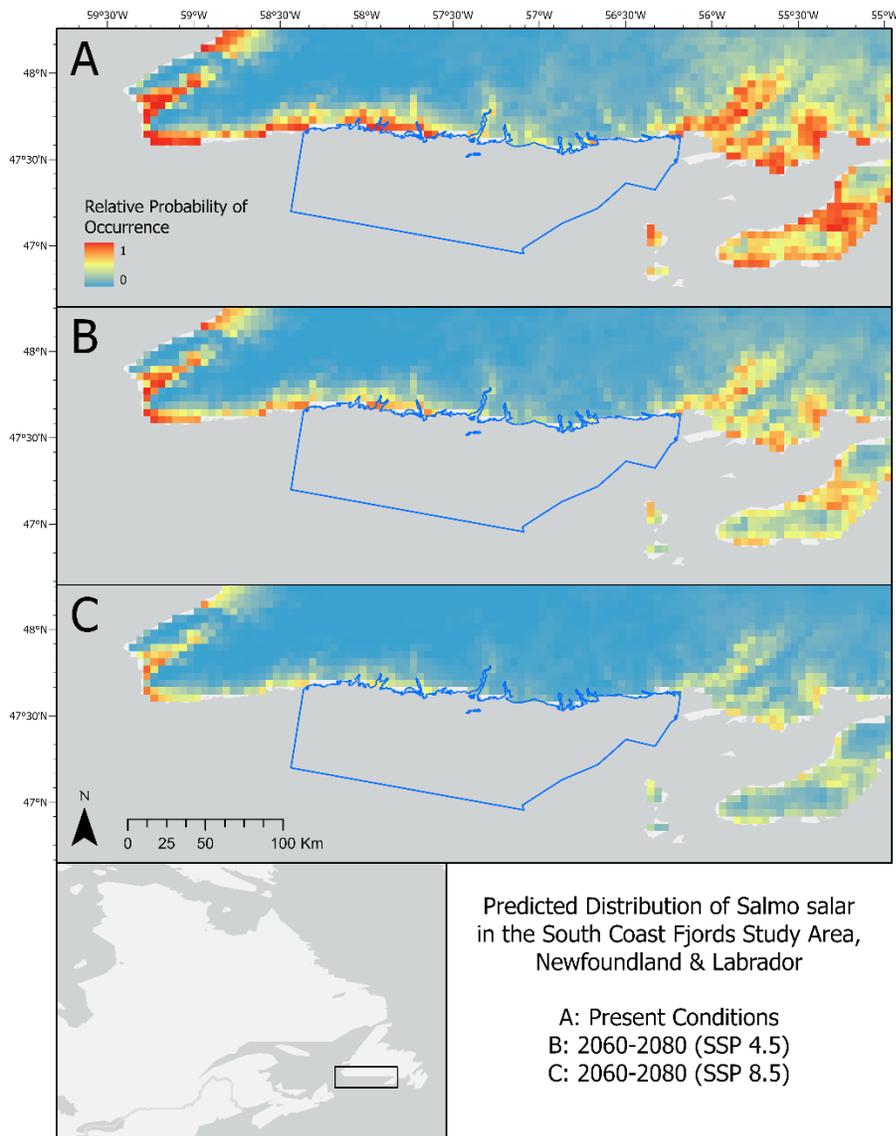


Figure 4.6: The predicted distribution of Atlantic Salmon in the South Coast Fjords study area by 2060–2080 under A) present climate conditions, B) climate scenario SSP 4.5 (medium emissions pathway), and C) climate scenario SSP 8.5 (high emissions pathway) using species distribution modeling.

Water temperature directly affects the morphology, physiology, and reproduction of sticklebacks (Bruneaux et al. 2014, Ramler et al. 2014). Exposure of Threespine Stickleback to short-term heat waves can have negative effects on parental behaviour and reproductive success in freshwater (Hovel et al. 2017, Barrett and Stein 2024). Des Roches et al. (2020) suggest that environmental change related to climate is causing a reduction in genetic variation of Threespine Sticklebacks. Significant variation in metabolic rate in response to thermal acclimation has been observed for Threespine (Bruneaux et al. 2014) and Ninespine Sticklebacks (Cominassi et al. 2022). Thermal environments also impact DNA methylation across the Threespine Stickleback genome (Metzger and Schulte 2017). Given the considerable thermal adaptation and plasticity observed in both species across several regions and the lack

of knowledge regarding the abundance and status of stickleback populations in southern Newfoundland (Figure 4.1), it is challenging to predict how climate change will impact populations in the South Coast Fjords study area.

### **Aquaculture Impacts on Wild Salmon Populations**

Interactions between wild Atlantic Salmon and net-pen salmon aquaculture have been associated with both genetic and ecological impacts on wild salmon throughout the North Atlantic. The risk of direct genetic interactions from the interbreeding between wild and escaped farmed Atlantic Salmon and their offspring was recently assessed for southern Newfoundland including the study area (DFO 2024c). The assessment concluded that the risk of salmon abundance in the region being impacted due to escapees ranged from low to high (depending on escapement level) and the risk for genetic character of wild salmon being altered due to escapees was high under present conditions. Building on this work, Dempson et al. (2024) evaluated the potential causes of dramatic population decline in the Conne River, which is adjacent to the South Coast Fjords study area, and the results from both qualitative and quantitative analyses suggest an association between salmon aquaculture and wild population decline. These conclusions are supported by research in southern Newfoundland which has documented extensive hybridization with aquaculture escapees (Keyser et al. 2018, Sylvester et al. 2018, Wringe et al. 2018), reduced survival of the hybrid offspring (Sylvester et al. 2019, Crowley et al. 2022, San Román et al. 2023), and predicted negative impacts on wild population size (Bradbury et al. 2020a). Furthermore, eight years of genetic monitoring (2014–2021) suggests escapees were regularly present and demonstrates that smaller populations displayed evidence of significant genetic change (40–60% domestic ancestry) due to introgression with escapees (Holborn et al. 2022). This work suggests that the precocial maturation of male wild-farm hybrid parr likely fast-tracks introgression (i.e., transfer of genetic material from farmed escapees to wild populations) and subsequent genetic impacts (Holborn et al. 2022). The recent detection of European ancestry in aquaculture salmon and escapees likely elevates this risk to wild populations in the region (Bradbury et al. 2022, Nugent et al. 2025) as European salmon have been shown to differ significantly from North American salmon across a variety of important genes and traits (Lehnert et al. 2019, 2020). Recent simulations of farmed escapees and associated genetic impact suggest that under current maximum licensed production in the region, several salmon populations in the South Coast Fjords study area are already likely being impacted by escapees with predictions of the proportion of escapees present ranging from 10–30% of the wild population size including Grey River, White Bear River, Dolland Brook, and Allan’s Cove Brook (DFO 2024c). In addition to genetic interactions, aquaculture associated factors such as disease and/or parasite transfer and ecological interactions (i.e., competition or predation) have been implicated as contributing to declines of wild salmon populations in Norway, Scotland, and Ireland (Bradbury et al. 2020b for a review). These sorts of interactions are less understood in southern Newfoundland but work is ongoing. The presence of wild salmon smolts from both the region in question and more broadly from eastern Canadian populations in southern Newfoundland near aquaculture sites suggests the impacts could extend beyond populations in the immediate area. Additional information can be found in Chapter 11 (Aquaculture Science).

### **Data Gaps and Recommendations**

#### **Atlantic Salmon**

The abundance, trend, and stock status of Atlantic Salmon populations within and adjacent to the study area represent significant knowledge gaps for the Newfoundland region (DFO 2024j). Allocating resources to fund a counting fence in this region would benefit annual Atlantic Salmon stock assessments and advice for resource managers. Additional monitoring methods

such as quantitative juvenile electrofishing surveys in summer, fall spawner surveys, and genetic and genomic analyses of salmon of populations are valuable and possibly more cost-effective alternatives to counting fences that would enhance annual assessments by tracking population changes over time, however they are more challenging to use for designating stock status zones.

The marine ecology of Atlantic Salmon populations from rivers within the study area is poorly understood. DFO Science is conducting an acoustic tracking project on Grandys River, near Burgeo, NL. The use of tracking methods (acoustic, PIT, PSAT) that improve our understanding of the behaviour and migration routes of Atlantic Salmon from other populations in the study area would improve our ability to advise on the potential impacts of stressors such as climate change or aquaculture expansion.

Climate-induced changes in freshwater temperatures pose a major threat to all the species discussed in this chapter, especially salmonids. Collection of long-term environmental data on freshwater habitats (e.g., air water temperature, water level, flow rate) and estuarine habitats (e.g., water temperature, dissolved oxygen, salinity) in the study area would improve DFO Science's ability to monitor changes to these habitats over time and to understand potential implications for species and populations in the study area.

### **American Eel**

The migratory behaviour of American Eels in estuarine and coastal marine habitats along southern Newfoundland is a significant knowledge gap. Information regarding their residency and behaviour in estuarine and coastal habitats would enhance the ability of DFO Science to advise on impacts of climate change or industry on populations in the study area.

Improved knowledge of their distribution, health (size, condition), and genetic or genomic variation in NL could be used to inform stock status in future COSEWIC assessments.

Experiments investigating the temperature tolerance in southern Newfoundland populations would inform their capacity to cope with climate-induced temperature elevations in freshwater.

## **5. MARINE FISHES**

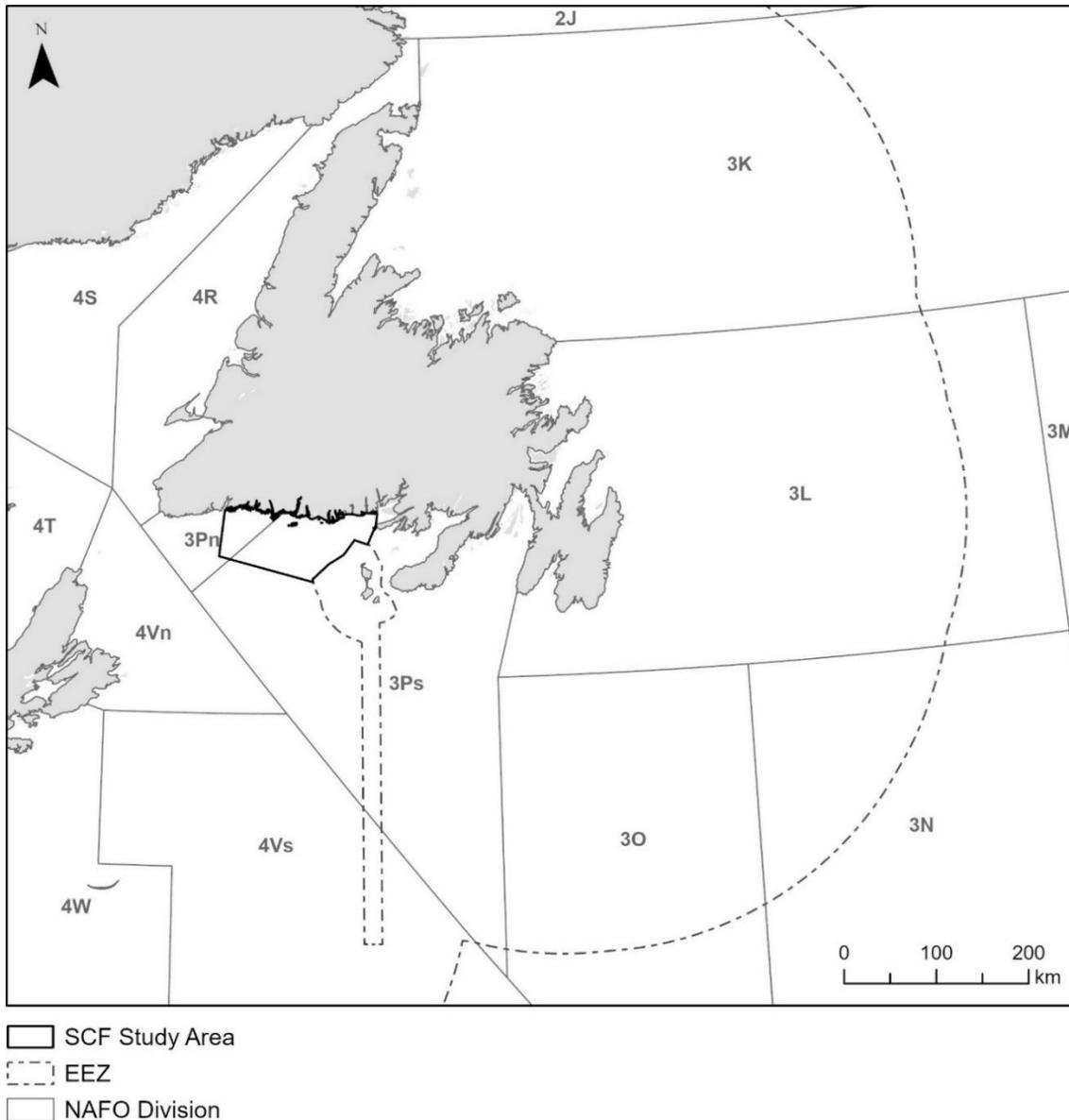
*Authors: Aaron T. Adamack, Luiz G.S. Mello, and Hannah Munro*

### **Available Information**

The main sources of information on commercially important fish stocks and species at risk along the South Coast of Newfoundland are from DFO NL Region's spring multispecies survey, which has been conducted in various formats since 1986 and covers portions of NAFO Div. 3LNOPs (Rideout et al. 2022), and the Northern Gulf of St Lawrence bottom trawl survey, which has been conducted in various formats since 1984 in August of each year and covers NAFO Div. 4RS and the northern part of 4T (Benoît et al. 2024, Bourdages et al. 2023, Figure 5.1). There is limited recent survey coverage for the waters of Subdiv. 3Pn, which covers the western portion of the proposed South Coast Fjords study area.

Data from the DFO multispecies survey (1995–2017) was used to map average relative densities (i.e., persistent areas of relatively high/low density) of 40 individual species (Wells et al. 2021), including several of the commercial species described below. While not presented in this document, these maps show areas important to marine fish within the DFO multispecies survey footprint and are appropriate as decision support tools for conservation initiatives, although there is limited data available for the nearshore and coastal areas.

Additionally, a summer survey has been performed intermittently across Subdiv. 3Pn and 3Ps during the summer for redfish (Kulka and Atkinson 2016). Parts of 3Pn and 3Ps were surveyed in winter as a part of a 3-year (2022–2024) program to determine winter distribution of fish in deep waters in anticipation of a reopening of the redfish fishery (Chamberland and Benoit 2024). Portions of 3Pn are surveyed through a [sentinel fishery survey](#). There were also a series of acoustic trawl surveys conducted by the Marine Institute's Centre for Fisheries Ecosystem Research in 2012, 2013, 2014, and 2016 along the south coast of Newfoundland from Burgeo Bank to the Grand Banks (Centre for Fisheries Ecosystems Research 2016).



*Figure 5.1: Map of NAFO Divisions with the South Coast Fjords study area. DFO's spring multispecies survey currently covers portions of NAFO Div. 3LNOPs; the Northern Gulf of St Lawrence bottom trawl survey covers Div. 4RST.*

Between 1996–2021, the DFO spring multispecies survey completed 378 sets within the South Coast Fjords study area (Figure 5.2). A list of all fish taxa reported in these sets can be found in Table 5.1. Overall, a broad variety of fish are known to inhabit the South Coast Fjords area with several of them being either commercially important or classed as species at risk. The main commercially important species known to inhabit the region are American Plaice (*Hippoglossoides platessoides*; Morgan et al. 2020), Atlantic Cod (*Gadus morhua*; Taggart et al. 1994), Atlantic Halibut (*Hippoglossus hippoglossus*; Johnson et al. 2024), Atlantic Herring (*Clupea harengus*; Bourne et al. 2023), Capelin (*Mallotus villosus*; Templeman 1948), Haddock (*Melanogrammus aeglefinus*; Wheeland et al. 2020), Mackerel (*Scomber scombus*; Ware and Lambert 1985), Pollock (*Pollachius pollachius*; DFO 2019b), redfish (*Sebastes* spp.; Cadigan et al. 2022), Silver Hake (*Merluccius bilinearis*; DFO 2024e), Thorny Skate (*Amblyraja radiata*; Simpson et al. 2012), and Witch Flounder (*Glyptocephalus cynoglossus*; Wheeland et al. 2019).

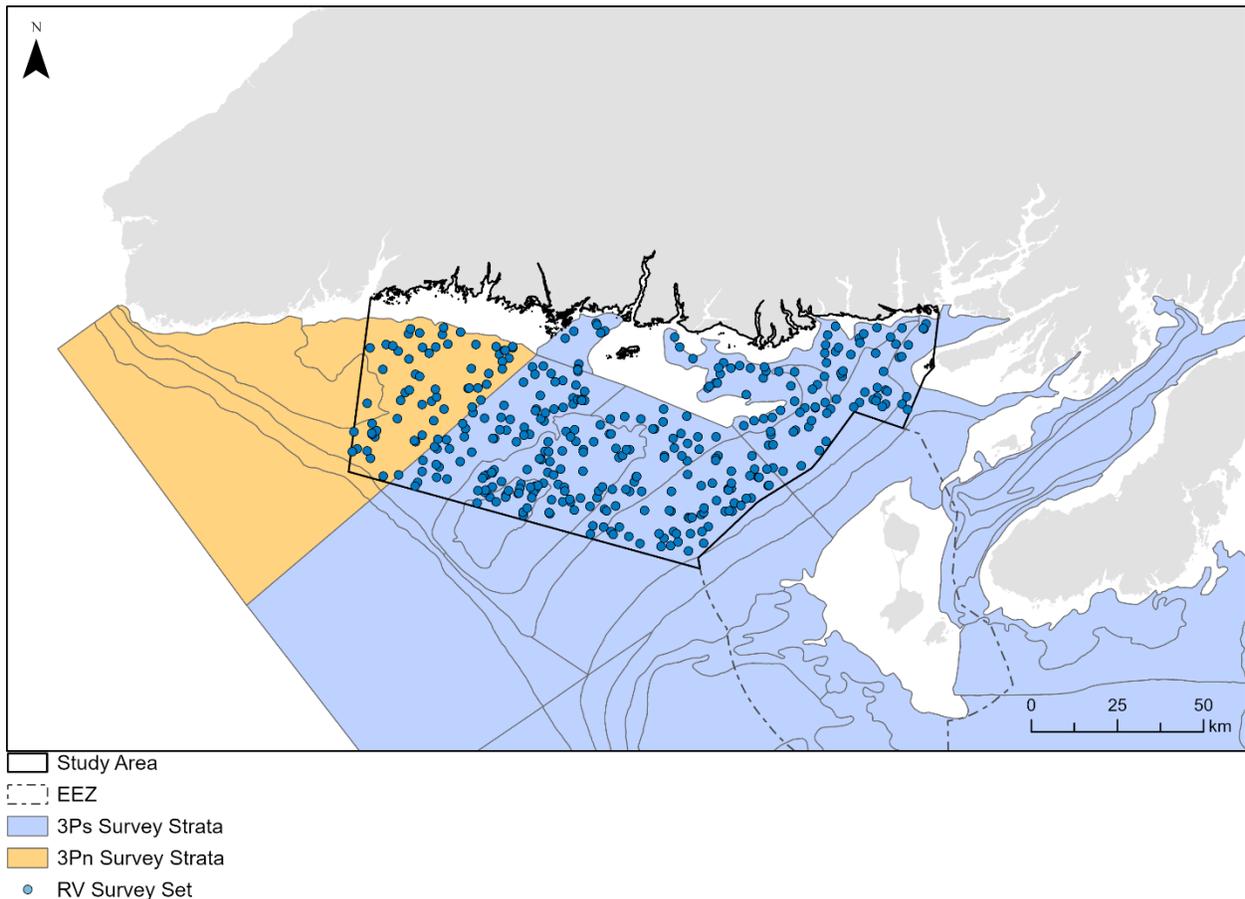


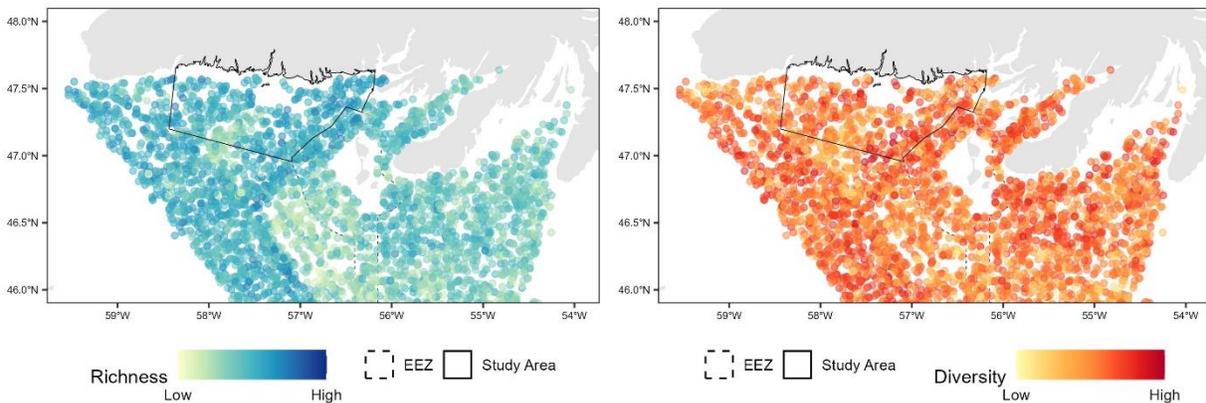
Figure 5.2: DFO multispecies survey sets completed in the study area between 1996–2021. Survey strata in NAFO Subdiv. 3Pn (orange) have not been sampled since 2013. See Rideout et al. (2022) and references therein for details of the DFO multispecies survey.

Table 5.1: Fish taxa reported in the annual DFO spring multispecies survey within the South Coast Fjords study area. Numbers presented below reflect the average annual number of fish caught by taxonomic group across all sets within the study area averaged across five year periods from 1996–2019. Note that some taxa are reported at a higher taxonomic level than species.

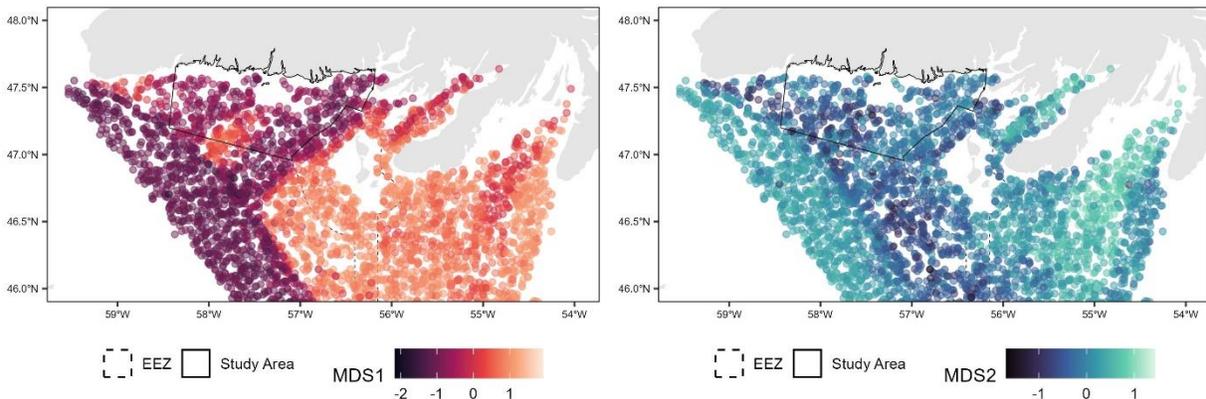
| Common Name                | Scientific Name                     | 1996–1999 | 2000–2004 | 2005–2009 | 2010–2014 | 2015–2019 |
|----------------------------|-------------------------------------|-----------|-----------|-----------|-----------|-----------|
| Redfish                    | <i>Sebastes spp.</i>                | 3482      | 6181      | 88646     | 9551      | 3074      |
| Atlantic Cod               | <i>Gadus morhua</i>                 | 624       | 1441      | 984       | 637       | 293       |
| Atlantic Herring           | <i>Clupea harengus</i>              | 299       | 453       | 783       | 1634      | 574       |
| Capelin                    | <i>Mallotus villosus</i>            | 3527      | 65        | 35        | 48        | 27        |
| Witch Flounder             | <i>Glyptocephalus cynoglossus</i>   | 451       | 563       | 393       | 644       | 454       |
| Atlantic Argentine         | <i>Argentina silus</i>              | 381       | 350       | 95        | 266       | 841       |
| Atlantic Hagfish           | <i>Myxine glutinosa</i>             | 149       | 199       | 125       | 635       | 278       |
| Silver Hake                | <i>Merluccius bilinearis</i>        | 85        | 6         | 90        | 734       | 338       |
| Common Grenadier           | <i>Nezumia bairdi</i>               | 290       | 166       | 153       | 192       | 181       |
| Longfin Hake               | <i>Urophycis chesteri</i>           | 104       | 169       | 158       | 195       | 93        |
| American Plaice            | <i>Hippoglossoides platessoides</i> | 93        | 93        | 82        | 118       | 70        |
| Atlantic Wolffish          | <i>Anarhichas lupus</i>             | 136       | 92        | 71        | 41        | 39        |
| Mailed Scuplin             | <i>Triglops spp.</i>                | 141       | 82        | 53        | 28        | 49        |
| Hookear Sculpin            | <i>Artediellus spp.</i>             | 159       | 68        | 35        | 45        | 21        |
| White Hake                 | <i>Urophycis tenuis</i>             | 16        | 38        | 26        | 91        | 109       |
| Smooth Skate               | <i>Raja senta</i>                   | 35        | 52        | 65        | 60        | 56        |
| Thorny Skate               | <i>Raja radiata</i>                 | 61        | 60        | 38        | 51        | 46        |
| Greenland Halibut (Turbot) | <i>Reinhardtius hippoglossoides</i> | 139       | 34        | 27        | 48        | 22        |
| Fourbeard Rockling         | <i>Enchelyopus cimbrius</i>         | 32        | 40        | 29        | 29        | 18        |
| Barracudinas               | Family Paralepididae                | 55        | 23        | 31        | 12        | 10        |
| Pollock                    | <i>Pollachius virens</i>            | 10        | 63        | 3         | 11        | 6         |

| Common Name              | Scientific Name                        | 1996–1999 | 2000–2004 | 2005–2009 | 2010–2014 | 2015–2019 |
|--------------------------|--|-----------|-----------|-----------|-----------|-----------|
| Lanternfishes            | Order <i>Myctophiformes</i>            | 14        | 9         | 9         | 49        | 24        |
| Eelpouts                 | Family Zoarcidae                       | 21        | 7         | 16        | 7         | 3         |
| Lumpsuckers              | <i>Eumicrotremus spp.</i>              | 8         | 8         | 6         | 10        | 27        |
| Threebeard Rockling      | <i>Gaidropsarus spp.</i>               | 11        | 11        | 11        | 11        | 15        |
| Common Lumpfish          | <i>Cyclopterus lumpus</i>              | 22        | 17        | 2         | 1         | 0         |
| Common Angler (Monkfish) | <i>Lophius americanus</i>              | 8         | 9         | 4         | 11        | 6         |
| Spiny Dogfish            | <i>Squalus acanthias</i>               | 4         | 5         | 1         | 29        | 5         |
| Haddock                  | <i>Melanogrammus aeglefinus</i>        | 3         | 1         | 32        | 8         | 4         |
| Wolf Eel                 | <i>Lycenchelys spp.</i>                | 2         | 7         | 5         | 2         | 31        |
| Atlantic Halibut         | <i>Hippoglossus hippoglossus</i>       | 2         | 3         | 4         | 4         | 5         |
| Common Alligatorfish     | <i>Aspidophoroides monopterygius</i>   | 13        | 5         | 2         | 2         | 3         |
| Argentines               | Family Argentinidae                    | 21        | 0         | 9         | 0         | 2         |
| Blennies                 | <i>Lumpenus spp.</i>                   | 2         | 3         | 4         | 2         | 0         |
| Seasnails                | Family Liparidae                       | 3         | 2         | 2         | 2         | 4         |
| Wrymouth                 | <i>Cryptacanthodes maculatus</i>       | 3         | 1         | 3         | 3         | 2         |
| Sea Raven                | <i>Hemitripteris americanus</i>        | 3         | 3         | 2         | 2         | 1         |
| Sand Lance               | <i>Ammodytes spp.</i>                  | 0         | 0         | 0         | 1         | 25        |
| Yellowtail Flounder      | <i>Limanda ferruginea</i>              | 2         | 2         | 1         | 1         | 1         |
| Spotted Wolffish         | <i>Anarhichas minor</i>                | 1         | 2         | 2         | 1         | 0         |
| Arctic Cod               | <i>Boreogadus saida</i>                | 1         | 2         | 1         | 4         | 2         |
| Winter Skate             | <i>Raja ocellata</i>                   | 0         | 4         | 3         | 1         | 0         |
| Longhorn Sculpin         | <i>Myoxocephalus octodecemspinosus</i> | 4         | 3         | 1         | 2         | 0         |
| Atlantic Mackerel        | <i>Scomber scombrus</i>                | 0         | 0         | 0         | 2         | 2         |

Data from the DFO multispecies trawl survey from 2005–2023 was used to calculate two biodiversity indices: richness and Shannon-Wiener diversity. Richness provides information on the number of species, whereas diversity provides information on the balance of those species by including relative biomass. The highest species richness in the fish community is found along the Laurentian and Hermitage Channels with variable diversity across the entire region (Figure 5.3). A non-metric multidimensional scaling analysis of species biomass was used to assess community composition and provide information on the similarity of fish species across the region over the same time period. This analysis found that the species composition of the study area is similar to Hermitage Channel and Laurentian Channel, composed of fish that prefer deeper, channel waters (Figure 5.4), although they are not identical.



*Figure 5.3: Maps showing fish species richness (left) and Shannon-Wiener diversity index (right) in NAFO Div. 3P based on DFO multispecies trawl survey data from 2005–2023. The black line denotes the South Coast Fjords study area.*



*Figure 5.4: Maps showing fish community composition based on the first (left) and second (right) dimensions of a non-metric multidimensional scaling analysis of species biomass from the DFO multispecies trawl survey (2005–2023) in NAFO Div. 3P. This analysis reduces the community composition to three dimensions. Areas with similar colours reflect similar species compositions. The black line denotes the South Coast Fjords study area.*

The following paragraphs summarize the assessed states of the main commercial fish stocks in and around the study area.

The primary forage fish species in this area are likely Sand Lance (*Ammodytes sp.*; Centre for Fisheries Ecosystems Research 2016) and Atlantic Herring (Bourne et al. 2013). Neither species is assessed in the immediate area and their stock statuses are unknown. Adjacent herring stocks in Fortune Bay were assessed as having a negative outlook in 2021 (DFO 2022f) while the herring stocks in Div. 4R could not be quantitatively assessed at meetings in April 2023 and January 2024 but were determined to be able to sustain a 20,000 tonne total allowable catch in the short term without harm to the stock (DFO 2024g). Atlantic mackerel are seasonally abundant in the region (Ware and Lambert 1985) and are currently assessed as being in the critical zone (Van Beveren et al. 2023).

For groundfish species, data from the 2016 CFER survey (Centre for Fisheries Ecosystems Research 2016) suggest that American Plaice, Atlantic Cod, Atlantic Halibut, redfish, and Silver Hake were amongst the largest contributors to survey catches in the area. American Plaice have been under a moratorium for directed fishing since 1993 (Morgan et al. 2020) with the only catches coming from bycatch. Atlantic Cod stocks in both Subdiv. 3Ps (DFO 2024e) and Div. 3Pn4RS (Benoît and Ouellette-Plante 2023) are considered to be in the critical zone. Atlantic Halibut stocks in both Div. 4RS (DFO 2023c) and 3NOPs4VWX5ZC (DFO 2024a) are considered to be in the healthy zone, though it was determined at the most recent assessment for 3NOPs4VWX5ZC that the stock is at risk of falling into the cautious zone. The study area overlaps with a mixing zone for Unit 1 and Unit 2 redfish and is the main area for Unit 2 redfish. Redfish stocks in the region are a combination of two species, with *Sebastes mentella* having an estimated biomass of 805 kt (607–1090 kt 95% CI) and *S. fasciatus* having a biomass of 101 kt (0–352 kt 95% CI; DFO 2022c). Their combined biomass in 2021 was at the highest level since the time series began in 2000. Finally, Silver Hake is not formally assessed, but populations have increased in Subdiv. 3Ps since they were first consistently observed in the 1990s (DFO 2024e).

Data on when and where marine fish species spawn in this region can be sparse. Templeman (1948) provides some records of Capelin beach spawning along the south coast of Newfoundland near Burgeo. Lack of data on Capelin spawning in this region is likely due to a combination of a small Capelin population and a limited human population in the region resulting in limited reporting on spawning. Similarly, Atlantic Herring likely spawn in the inshore portion of the region, but the locations are not known or may not be reported. Ollerhead et al. (2004) maps the spawning times and locations of 10 commercially important fisheries species (American Plaice, Atlantic Cod, Haddock, redfish, Witch Flounder, Yellowtail Flounder, Northern Shrimp (*Pandalus borealis*), Iceland Scallop (*Chlamys islandica*), Sea Scallop (*Placopectin magellanicus*), and Surf Clam (*Spisula solidissima*)) on the Grand Banks of Newfoundland. Chamberland and Benoît (2024) report that the Gulf of St. Lawrence Greenland halibut stock likely spawns in the deep part of the Laurentian Channel southwest of Newfoundland between January and March. Atlantic Mackerel primarily spawn in the southern Gulf of St. Lawrence but may have secondary spawning sites elsewhere (Mbaye et al. 2019). Pollock likely spawn in Subdiv. 3Ps, but the details do not appear to be well known (DFO 2002). Silver Hake spawning habits in the Gulf of St. Lawrence seem to have received little research attention. Thorny Skate seem to spawn on banks (e.g., Burgeo, St. Pierre, Green Banks) in midsummer and fall (DFO 2022g). Witch Flounder on the Grand Bank spawn mainly from March to June, but will spawn from January to February in the more westerly areas of southwest Newfoundland and the northern Gulf of St. Lawrence (Bowering 1990) in the deepest part of the Gulf.

Fish and shellfish stocks in the region are being affected by multiple stressors (Brennan et al. 2016) with some stocks affected by the linked stressors of increasing water temperatures and declining oxygen levels (Dupont-Prinet et al. 2013, Lavaud et al. 2019, Youcef et al. 2015). Warming water temperatures restrict the amount of habitat available for many cold water

species like Atlantic Cod, Atlantic Halibut and Capelin, but may increase the amount of habitat available to warmer water species such as Atlantic Mackerel, Silver Hake, and tunas. Declining oxygen levels will reduce habitat availability for many species, with a particularly strong effect on deep water and benthic-associated fish species (Dupont-Prinet et al. 2013).

The structure of the ecosystem in Subdiv. 3Ps has already started to show changes as a result of changing ocean climate in recent years. Atlantic Cod was the historically dominant species among predatory fishes in this ecosystem, but its dominance has been markedly reduced in recent years, coinciding with increases in warm water species such as Silver Hake (DFO 2024e). In addition, there has recently been an increase in the proportion of the fish community that has been made up of plank-piscivores (e.g., redfish). While these changes are not well understood, it is important to understand that this area is a dynamic system that is influenced by changing environmental conditions.

Additionally, aquaculture sites are widespread along the south coast of Newfoundland (Figure 12.7) and potential ways in which these aquaculture sites could affect fish species have been identified (DFO 2022a, 2022b, 2022d). Farmed salmon have the potential to spread diseases and parasites to wild salmon and other species such as Atlantic herring. The wastes from aquaculture sites may reduce habitat quality in and around aquaculture sites and may affect the broader bottom waters near sites through increased biological oxygen demand causing episodic hypoxia or anoxia which may kill off many benthic associated species and deny access to habitats for more motile species (DFO 2022a, Strain and Hargrave 2005). Research by Goodbrand et al. (2013) and Piersiak (2021) has shown that the presence of aquaculture sites alters the spatial distribution of many species which could alter natural mortality rates for some species through changes in their encounter rates with predators, with amplified predation in areas close to aquaculture sites and potentially reduced predation in areas without aquaculture or inactive aquaculture sites. Farmed salmon may directly consume wild fish that manage to enter their pens and pest treatments for farmed salmon may be lethal to wild fish (DFO 2022a). The magnitude of these effects are unknown. Further discussion on impacts of aquaculture on wild fish can be found in Chapters 4 (Anadromous and Catadromous Fishes) and 11 (Aquaculture Science).

## **Sensitive Species and Habitats**

### **Schedule 1 of the Species at Risk Act (SARA)**

The current list of marine fish species at risk (SAR) along the south coast of Newfoundland includes Northern Wolffish (*Anarhichas denticulatus*), Spotted Wolffish (*Anarhichas minor*), Atlantic Wolffish (*Anarhichas lupus*), and White Shark (*Carcharodon carcharias*) (Table 5.2).

Wolffish species tend to be found in low densities, have low mobility, and a generally solitary lifestyle; the three wolffish species are widespread in Canadian Atlantic waters and are considered as single Designatable Units (DU). Atlantic Wolffish is the most commonly found wolffish species in coastal shallow Newfoundland waters and as bycatch in inshore fisheries; Spotted and Northern Wolffish are less frequent in inshore waters and tend to be found at greater depths. Mature Atlantic Wolffish move from offshore waters and undergo inshore spawning migrations in spring and summer. During late summer and fall, egg clusters have been observed on boulders and rocky crevices at depths < 40 m and are often cared for by the male spawner. Seasonal movements, spawning behavior, and site characteristics are unknown for Northern and Spotted Wolffish in NL waters (DFO 2024h).

DFO multispecies survey catch data indicate that the majority of the wolffish populations in NL waters are found in Div. 2HJ3KLNO; Subdiv. 3Ps includes marginal habitats where immature and smaller size components of these populations predominate (DFO 2024h).

The presence of White Sharks in coastal Newfoundland waters is deemed rare, and the pelagic habitat occupied by the species is extensive (i.e., Ocean Basin scale). White Sharks move into Canadian Atlantic waters seasonally, including the south coast of Newfoundland, and predominately occur in shallow waters (< 50 m) and mesopelagic depths (200–500 m), depending on migratory and foraging behavior. White Sharks are opportunistic predators, feeding on a variety of prey, including marine mammals and fish (COSEWIC 2021).

There are no estimates of population size for White Sharks in Canadian Atlantic waters, and their population trend in the northwest Atlantic Ocean is uncertain but it is likely stable or increasing (COSEWIC 2021).

*Table 5.2: Species at risk and their status for each population/stock at the time of publication.*

| <b>Common Name</b> | <b>Scientific Name</b>         | <b>Population/Stock</b> | <b>COSEWIC Status</b> | <b>SARA Status</b> |
|--------------------|--------------------------------|-------------------------|-----------------------|--------------------|
| Atlantic Wolffish  | <i>Anarhichas lupus</i>        | -                       | Special Concern       | Special Concern    |
| Northern Wolffish  | <i>Anarhichas denticulatus</i> | -                       | Threatened            | Threatened         |
| Spotted Wolffish   | <i>Anarhichas minor</i>        | -                       | Threatened            | Threatened         |
| White Shark        | <i>Carcharodon carcharias</i>  | Atlantic population     | Endangered            | Endangered         |

### **Potential Threats**

#### *Accumulation of organic material on the seabed in the vicinities of aquaculture sea cages*

Marine fish SAR, particularly Atlantic Wolffish, are likely to be present in the vicinity of current and proposed aquaculture sites adjacent to and within the South Coast Fjords study area. Thus, the accumulation of waste materials from the cages has the potential to negatively impact benthic habitats (e.g., habitat degradation, mortality of prey species) used by wolffish, if such habitats overlap with the proposed sites and Potential Exposure Zone (PEZ; e.g., nesting sites, feeding grounds) (see Chapter 11: Aquaculture Science). Notwithstanding, under the scenario of single DUs, and life history traits as described in the previous section, the anticipated impacts to these species and habitats will likely be low and limited to the surrounding areas of the aquaculture activities. Otherwise, if significant evidence of local populations can be established, then the potential for spatial erosion of those populations should be assessed. The same rationale would likely be applicable in the case of fuel and other spills in the vicinity of aquaculture sites.

#### *Presence of farmed fish in sea cages*

The potential attraction and entanglement of large pelagic fish to anthropogenic marine debris (e.g., fishing gear, ropes), notably sharks and rays, have been reported previously (see Parton et al. 2019 and references within). In terms of marine fish SAR, an increased presence of White Sharks has been observed along the south coast in recent years (Bastien et al. 2020). Hence, the potential for entanglement of White Sharks in sea cages cannot be discarded, considering their feeding behavior and the overlap between the distribution range of the species and the current and proposed aquaculture sites adjacent to and within the South Coast Fjords study area. However, the presence of White Sharks in coastal Newfoundland waters is rare,

suggesting that any impact resulting from aquaculture activities at species or population levels, and their habitat, is negligible.

### *Pesticides*

The use of pesticides in finfish aquaculture has the potential to be a threat to large pelagic fish such as White Sharks (DFO 2006), as pesticides are diluted and dispersed by water currents, as well as to bottom dwelling fish such as wolffish, due to potential exposure to contaminated seabed. The effect(s) of pesticides typically used in finfish aquaculture on marine fish SAR are unknown but will likely be limited to individuals and habitats present within the PEZ and surrounding areas.

## **Data Gaps and Recommendations**

DFO Science data on the distribution and abundance of marine fish species in nearshore and coastal regions of the study area is sparse. While more information is available for the offshore portion of Subdiv. 3Ps, further survey coverage in both the nearshore and coastal regions would help to identify which fish species make use of the area, to determine how they are distributed, and to provide a reference on stock status. Additionally, more information is needed on non-commercial species, including large pelagics (e.g., tunas, sharks, sunfish) that are present in the study area according to local knowledge but for which we do not have comprehensive western science data.

Current DFO multispecies trawl surveys in this area are only completed in the spring, whereas ideally the area would be surveyed during both the summer and the fall or winter as species distributions can shift significantly between seasons.

Further, the Gulf of St. Lawrence is warming rapidly, including in Subdiv. 3Ps and 3Pn. The ecosystem in Subdiv. 3Ps has shown changes with the arrival and increasing dominance of warm water species like Silver Hake and the decline of Atlantic Cod. These changes have all coincided with the population growth of redfish in the area. More information is needed on species composition and distribution shifts in response to warming and how these changes will affect ecosystem functions.

## **6. PINNIPEDS, CETACEANS, AND SEA TURTLES**

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### **Available Information**

#### **Pinnipeds**

Although six species of seals are found in Newfoundland and Labrador waters, only two species, Atlantic harbour seals (*Phoca vitulina vitulina*) and grey seals (*Halichoerus grypus*), are typically found in the study area.

Harbour seals are year round residents along the south coast of Newfoundland and in Saint-Pierre-et-Miquelon. They have a nearshore coastal distribution and are typically associated with isolated sandy beaches, small islands, and rocks and reefs exposed at low tide (Boulva and McLaren 1979). Harbour seals are relatively sedentary, typically remaining within a few hundred kilometers of natal sites (e.g., Sharples et al. 2012, Rosing-Asvid et al. 2020). Although the specific timing of the harbour seal breeding period (timing of pupping) in Newfoundland waters is uncertain, in Atlantic Canada pups are generally born in coastal waters in June–July (Boulva and McLaren 1979, Bowen et al. 2003, Renaud et al. 2023). Bounty return records and information collected from interviews and questionnaires indicate that harbour seals were

historically present in the study area with records of breeding aggregations near Burgeo (Templeman et al. 1957). Following the end of the seal bounty programs in the 1970s, harbour seal numbers in the study area were estimated to be low (~100) and declining (Boulva and McLaren 1979). In 2021, as part of the first Atlantic Canada wide aerial survey to assess harbour seal abundance, areas of the south coast of Newfoundland were surveyed, including a portion of the study area near Burgeo (Hamilton et al. 2023, Figure 6.1A). Although only a small number of harbour seals were identified on Pass Island in the study area (Figure 6.1C), harbour seals typically haulout in groups composed of a small number of seals and can be difficult to spot on the rocky substrates they favour on the Newfoundland coast. It is therefore possible that harbour seals present in the surveyed area were missed. It is also possible that due to timing of this portion of the survey (mid-August) harbour seals had dispersed after the end of the breeding season to nearby portions of the study area that were not included in the survey. To what extent harbour seals identified on haulouts in areas adjacent to the study area on the south and west coasts of Newfoundland (Hamilton et al. 2023, Mosnier et al. 2023) may make use of the study area is unknown.

In contrast to harbour seals, grey seals are seasonal migrants to the Newfoundland and Labrador shelves, primarily moving into the region in the summer months to forage before departing again in the fall to return to breeding colonies in the Gulf of St. Lawrence or on the Scotian Shelf. During the 2021 aerial survey for harbour seals, grey seals were counted on coastal haulouts as part of efforts to collect information on their summer distribution in Atlantic Canada. In the portion of the study area which was surveyed (Figure 6.1A), grey seals were identified on haulouts near Burgeo, Deer Island, east of Ramea, in the Penguin Islands, and on Pass Island (Figure 6.1B). These sightings are consistent with satellite tracking data from individual grey seals showing movement from the Scotian Shelf (Sable Island, Hay Island) and Saint-Pierre-et-Miquelon into the study area in late spring and early summer (Breed et al. 2006, Whoriskey 2021, DFO unpublished data).

In addition to harbour and grey seals, harp (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*) may be brief seasonal visitors to the study area, feeding and transiting through the area during annual migrations to and from breeding locations in the Gulf of St. Lawrence (Sjare and Stenson 1997, Bajzak et al. 2009, Andersen et al. 2013). Juvenile bearded seals (*Erignathus barbatus*) may also be found periodically in the study area. Bearded seals are an Arctic species that breed in north-east Newfoundland and along the Labrador coast, but juveniles of this species are known to disperse widely. In the northwest Atlantic, they have been documented along southern Newfoundland, in the Gulf of St. Lawrence, and as far south as Cape Cod (Mansfield 1963, Gosselin and Boily 1994).

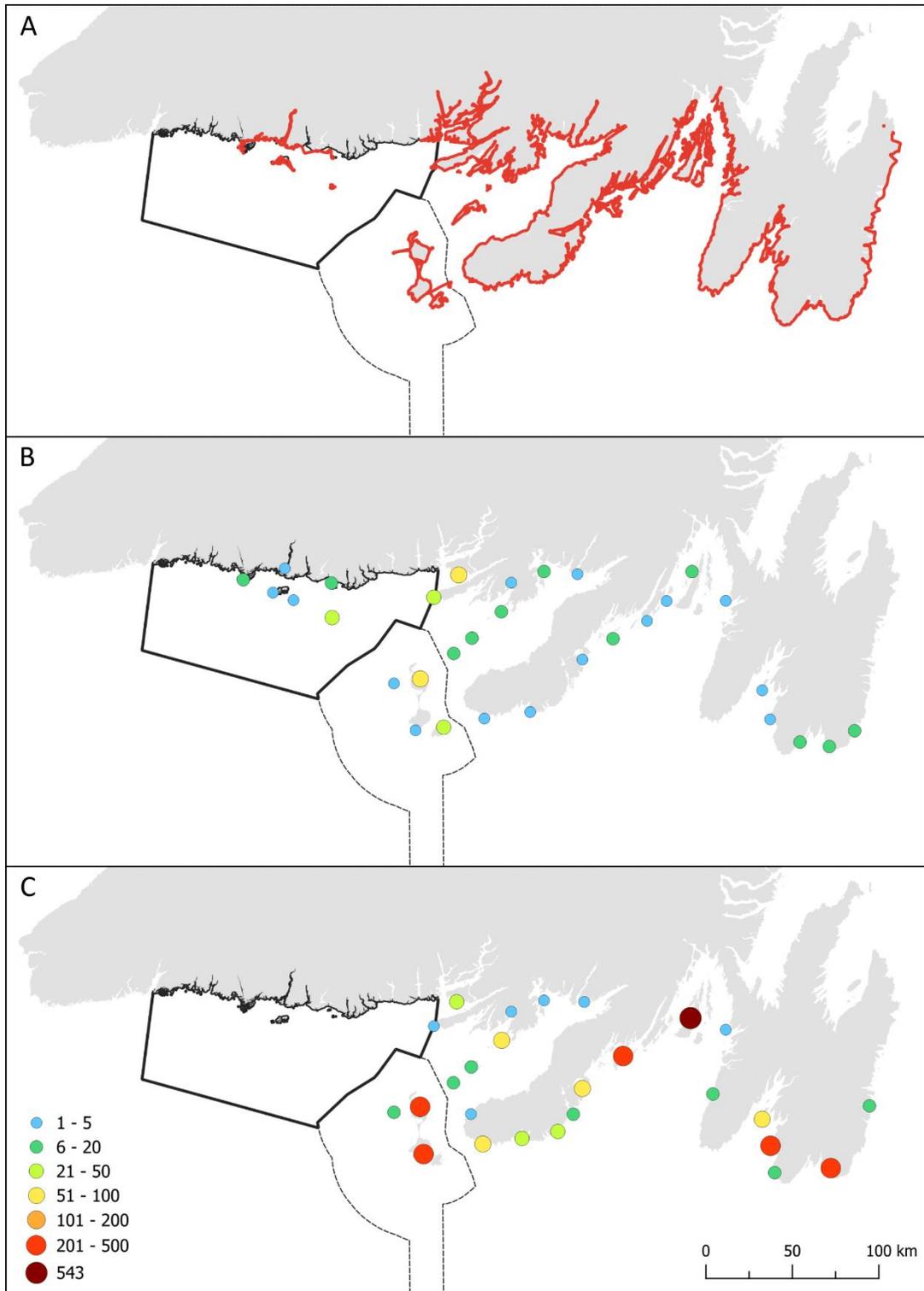


Figure 6.1: Results from the 2021 survey of hauled out harbour seals along the coast of Newfoundland and Labrador showing A) survey track coverage in southern Newfoundland, B) number of hauled out grey seals clustered at 10 km, and C) number of hauled out harbour seals clustered at 10 km.

## Cetaceans

More than 16 species of cetaceans are found in the study area (see Table 6.1, Figure 6.2–Figure 6.4). White-beaked dolphins (*Lagenorhynchus albirostris*) are the most common small cetacean while humpback (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*) are the most common large cetaceans in the study area, according to sightings from a 2016 aerial survey (Lawson and Gosselin 2018). Some cetaceans are found in the study area throughout the year (e.g., blue whales (*Balaenoptera musculus*), white-beaked dolphins) while others are present seasonally (e.g., fin whales, harbour porpoises (*Phocoena phocoena*)), residing in the study area in the summer and autumn to feed on seasonally abundant prey.

While important habitat for cetaceans has not been defined specifically for this study area, important habitat has been defined more broadly in Atlantic Canada for blue whales. The south coast of Newfoundland, including the study area, was defined as important foraging habitat and identified as a high priority area for future monitoring efforts for blue whales (Lesage et al. 2016, Gomez et al. 2017). Main features of important habitat included sufficient quantity and quality of their main prey krill (Arctic krill (*Thysanoessa* spp.) and northern krill (*Meganyctiphanes norvegica*)), unimpeded access to travel corridors, sufficient space to freely maneuver, and an acoustic environment that does not interfere with communication, navigation, and passive detection of prey (Lesage et al. 2016).

Seasonally suitable habitat for 10 cetaceans were predicted by species distribution models (SDMs) from sightings data collected by DFO and other organizations from 1975–2015. Of these 10, six species had seasonally suitable habitat identified in the study area to various extents including the fin whale (summer and autumn), minke whale (*Balaenoptera acutorostrata*, summer and autumn), humpback whale (spring, summer, and autumn), Atlantic white-sided dolphin (*Lagenorhynchus acutus*, summer and autumn), short-beaked common dolphin (*Delphinus delphis*, summer and autumn) and the harbour porpoise (summer) (Gomez et al. 2020). Important environmental variables identified by the SDMs for these species included ocean depth, sea surface temperature, persistence of high chlorophyll-a concentration (both the present and previous season), and regional chlorophyll-a concentration magnitude (both the present and previous season), with the relative importance of each variable varying depending on species and season (Gomez et al. 2020).

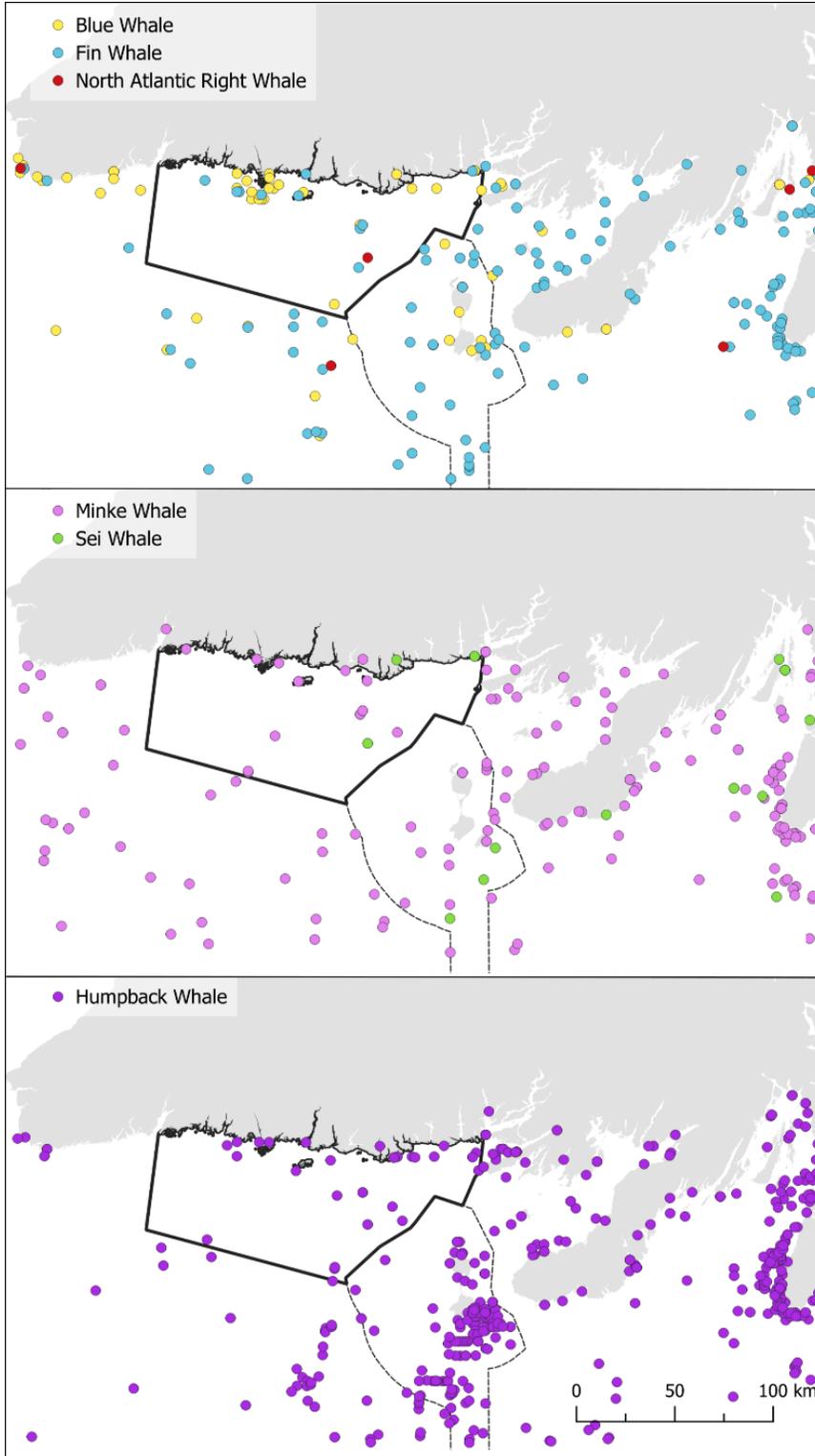


Figure 6.2: Sightings of blue whales, fin whales, North Atlantic right whales (top), minke whales, sei whales (middle), and humpback whales (bottom) in southern Newfoundland between 1904 and 2024. The sightings data includes both opportunistic sightings reported to DFO and sightings from aerial surveys for cetaceans and sea turtles conducted by DFO. Note that the sightings data have not been corrected for effort.

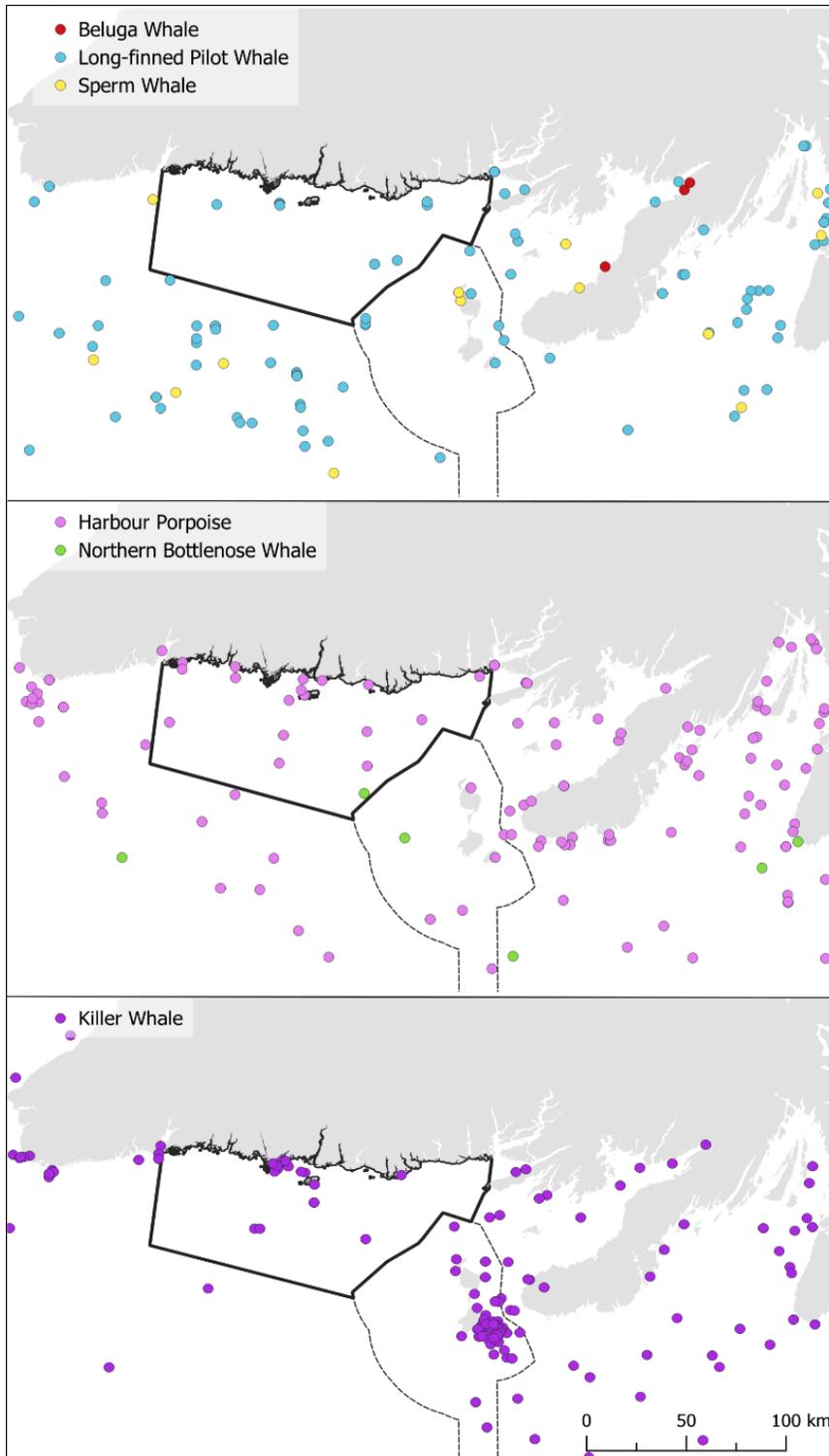


Figure 6.3: Sightings of beluga whales, Atlantic long-finned pilot whales, sperm whales (top), harbour porpoises, northern bottlenose whales (middle), and killer whales (bottom) along southern Newfoundland between 1904 and 2024. The sightings data includes both opportunistic sightings reported to DFO and sightings from aerial surveys for cetaceans and sea turtles conducted by DFO. Note that the sightings data have not been corrected for effort.

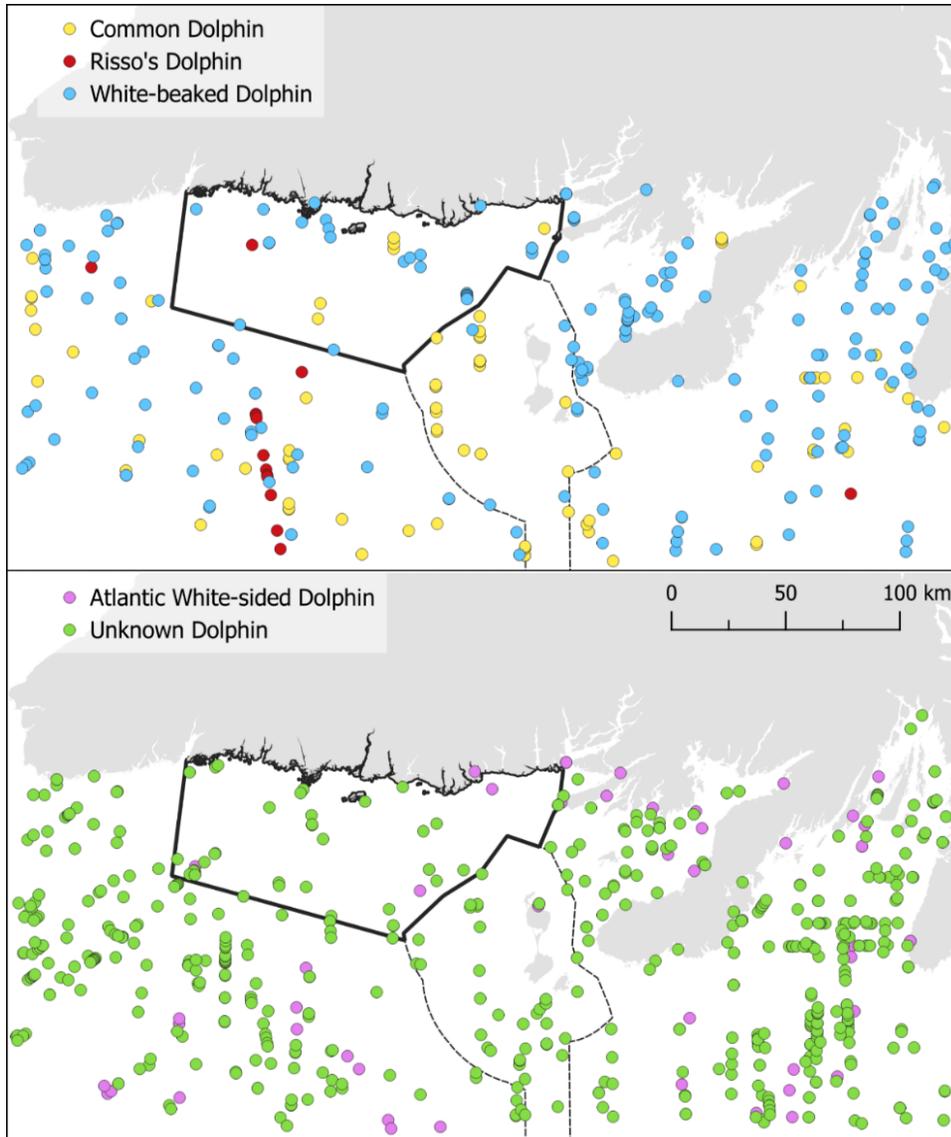
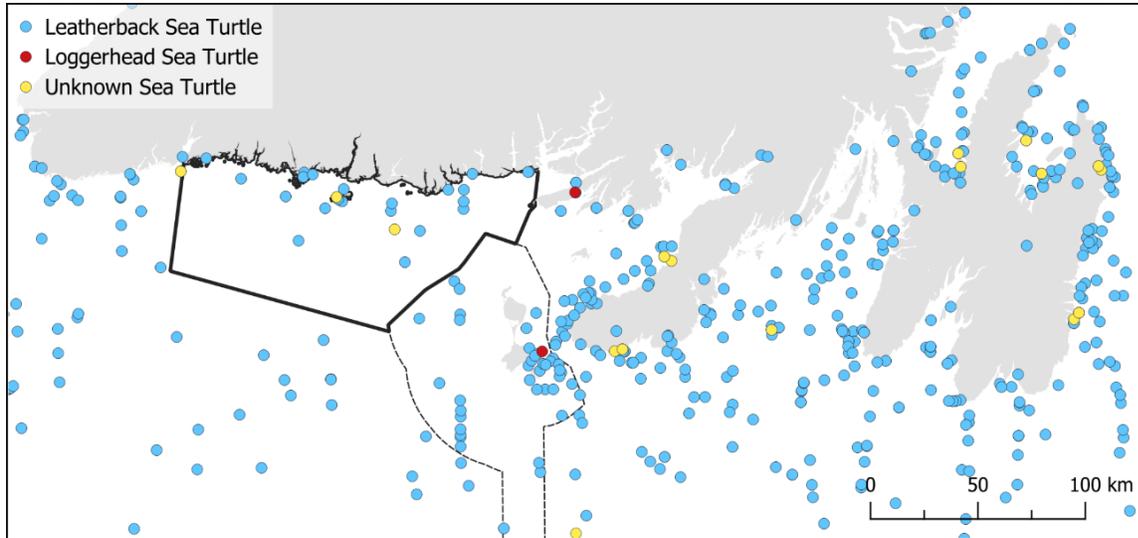


Figure 6.4: Sightings of common dolphins, Risso's dolphins, white-beaked dolphins (top), Atlantic white-sided dolphins and unknown dolphins (bottom) along southern Newfoundland between 1904 and 2024. The sightings data includes both opportunistic sightings reported to DFO and sightings from aerial surveys for cetaceans and sea turtles conducted by DFO. Note that the sightings data have not been corrected for effort.

### Sea Turtles

There are four species of sea turtles found in Atlantic Canada: the leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), and Kemp's ridley sea turtle (*Lepidochelys kempii*). Of these, only leatherback sea turtles have been sighted in the study area and are the most numerous, accounting for >95% of the sightings along the south coast of Newfoundland between 1946–2024 (Figure 6.5; Mosnier et al. 2019, DFO unpublished data). It is likely that many of the unknown sea turtles in the sightings database are also leatherback sea turtles. Two loggerhead sea turtles were reported to DFO along southern Newfoundland to the east of the study area, with no green or Kemp's ridley turtles reported in coastal areas around NL (DFO unpublished data). The majority of the

sightings come from opportunistic platforms such as fishing vessels, research vessels, and tour and recreational boats, with sightings from aerial surveys first occurring in 2003. Care is needed when interpreting opportunistic data as effort is extremely variable in both space and time and the reported sightings represent an unknown, small fraction of the sea turtles present in the area.



*Figure 6.5: All sea turtle sightings between 1946 and 2024, including opportunistic sightings reported to DFO and sightings from aerial surveys for cetaceans and sea turtles conducted by DFO. Note that the sightings data have not been corrected for effort. Note that this map is an aggregation of many years and seasons of data and as such could obscure historical changes in distribution patterns.*

The southwest coast of Newfoundland is an important area for leatherback sea turtles in Atlantic Canada, where they are found in both nearshore and offshore areas. The study area had the second highest density of sightings in Atlantic Canada during the Trans North Atlantic Sightings Survey (TNASS) in July–August, 2007, with the importance of this area corroborated from both opportunistic sighting and satellite tracking data (James et al. 2005, 2006, Mosnier et al. 2019). The use of the south coast of Newfoundland varies seasonally, with opportunistic sightings and monthly predictions from habitat models finding that the highest density of leatherback turtles occurs in August and September (Figure 6.6; Mosnier et al. 2019, DFO unpublished data). There appears to be a south-west to north-east shift in leatherback sea turtle distribution in Atlantic Canada during the summer, with leatherback sea turtles first concentrating along the Scotian Shelf upon their arrival to Atlantic Canada in June and July before shifting towards southern Newfoundland in August and September (James et al. 2006, Mosnier et al. 2019). Leatherback sea turtles generally leave Atlantic Canada to begin their southward migration in October according to satellite tracking data (James et al. 2005). This south-west to north-east shift matches the seasonal variation in environmental conditions, with leatherback sea turtles favouring water over 15°C, plateauing around 22°C around Newfoundland (Mosnier et al. 2019). Habitat analysis of the TNASS sightings found they preferred areas with a relatively flat bottom slope, low mean chlorophyll-a concentrations over the last month, and median values of sea surface height (Mosnier et al. 2019). Median values of sea surface height are related to areas with high probability of convergence of water masses which would favor the aggregation of marine prey such as jellyfish (Maps et al. 2015).

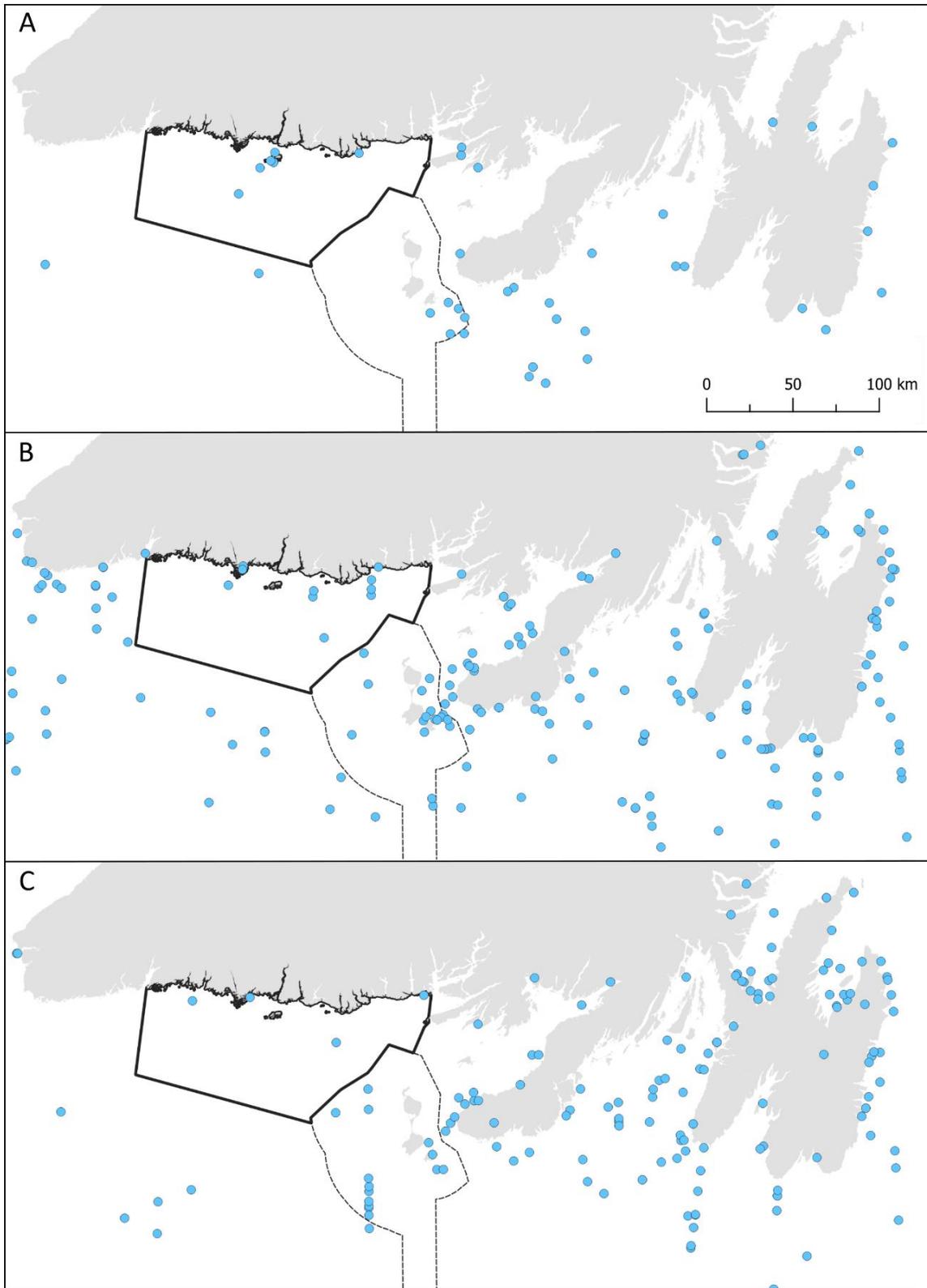


Figure 6.6: Sightings of leatherback sea turtles between 1946 and 2024, including opportunistic sightings reported to DFO and sightings from aerial surveys for cetaceans and sea turtles conducted by DFO, for A) July, B) August and C) September. Note that the sightings data have not been corrected for effort.

Despite leatherback sea turtles being seasonally most abundant in late summer in the study area, these turtles have been reported from coastal waters around Newfoundland in all months except April (DFO unpublished data). It is currently unknown what fraction of the population remains in Atlantic Canada throughout the winter or if this behaviour is more pronounced among certain age-sex classes. Leatherback sea turtles are able to remain in colder water than other sea turtle species, exhibiting thermal gradients of over 8°C between their bodies and the environment through multiple mechanisms including counter-current heat exchange, a layer of fat, and greater activity in colder water (Greer et al. 1973, Goff and Stenson 1988, James and Mrosovsky 2004, Bostrom et al. 2010). That habitat models find a preference for sea surface temperatures over 15°C may be more related to thermal tolerances of their main jellyfish prey, such as *Cyanea capillata* and *Aurelia aurita*, than their own thermal tolerances.

Unlike leatherback sea turtles, loggerhead sea turtles are not as efficient at thermoregulation with their body temperature generally only being 1–2°C warmer than the environmental temperature (Sato 2014). They are normally found in water with a surface temperature over 15°C, with most sightings in areas with sea surface temperatures between 20–25°C, restricting the areas and seasons that they are found in Atlantic Canada. Most of the loggerhead sea turtles in Canada are oceanic juveniles that primarily feed offshore in waters deeper than 200 m, with few sightings occurring in coastal areas (Harris et al. 2010). Although the study area is within the distribution range of loggerhead sea turtles, there are few sightings of this species in coastal areas of Newfoundland. They are also generally only sighted around Newfoundland in the summer months due to their preference for warmer water. Sightings outside of the summer have been reported however, with a cold-shocked loggerhead sea turtle stranding in November in Connaigre Bay, NL (DFO unpublished data).

## **Sensitive Species and Habitats**

### **Pinnipeds**

Their coastal habitat, long-term site fidelity and relatively localized foraging behaviour (typically remaining within 100 km of preferred haulouts) make harbour seals particularly vulnerable to both short-term (disturbance, direct mortality) and long-term (habitat degradation) impacts of nearshore anthropogenic activities. In particular, activities which disturb harbour seal mother-pup pairs during the period of offspring dependence may have significant consequences for the growth and survival of pups which can, in turn, have significant long-term consequences for harbour seal population demographics and trends.

For both harbour or grey seals in the study area, activities which impact the distribution or abundance of their prey may have a significant impact on the ability of these species to acquire sufficient energy to meet their needs.

### **Cetaceans**

Eight of the 16 cetaceans in the study area are listed under SARA (see Table 6.1 for details), with four of these listed as Endangered (blue whale, northern bottlenose whale (*Hyperodon ampullatus*), north Atlantic right whale (*Eubalaena glacialis*) and sei whale (*Balaenoptera borealis*)). Key human activities and stressors of concern for all cetaceans in NL waters include bycatch, entanglement in marine debris or ghost gear, ship strikes, contaminants, and competition with fisheries for prey. Anthropogenic noise is also a concern through its potential impacts on displacement and masking of noise between mother-calf pairs, conspecifics or for passive or active (echolocation) detection of prey. Climate change and its potential impact on seasonal prey distribution is also a concern for all species (see Table 6.1 for details).

## Sea Turtles

Both leatherback and loggerhead sea turtles are listed as Endangered under SARA (2003 and 2017, respectively). The primary threat to both species in Atlantic Canada is bycatch, specifically from pelagic longlines (both species), benthic longlines (leatherback sea turtles), trawls (leatherback sea turtles), gillnets (leatherback sea turtles), traps, pots and barrels (leatherback sea turtles) and rod and reel (leatherback sea turtles). Other potential threats to both species are entanglement in ghost gear or marine debris, ship strikes, marine pollution (including plastics and contaminants), oil and gas production, underwater noise, and climate change (Brazner and McMillan 2008, DFO 2017, 2020). Although bycatch is the only threat that has documented mortality for leatherback and loggerhead sea turtles in Atlantic Canada, ship strikes are also a concern with evidence that ship strikes are a threat to the survival and recovery of leatherback sea turtles in the eastern United States (DFO 2020).

Tests of hearing sensitivity in leatherback sea turtle hatchlings revealed that they can detect the low frequency sounds that are emitted through anthropogenic activities including pile driving, operating wind turbines, vessels, and offshore drilling (Dow Piniak et al. 2012). Detecting anthropogenic noise can elicit behavioural responses in sea turtles, as green and loggerhead sea turtles exposed to air guns displayed general “alarm” and “escape” responses at an estimated distance of two and one km, respectively, from the air gun (McCauley et al. 2000). The physiological effects of anthropogenic noise on sea turtles are currently unknown.

Climate change is recognized as a threat to sea turtles in Atlantic Canada (DFO 2017, 2020). Warming sea temperatures may change the arrival time of sea turtles to Atlantic Canada, potentially impacting their risk of bycatch due to a changing degree of overlap with commercial fisheries. Warming ocean temperature could also impact the timing and distribution of jellyfish that are the primary prey of leatherback sea turtles, which may lead to changes in their seasonal distribution in the study area.

## Data Gaps and Recommendations

### Pinnipeds

Data on seasonal distribution and habitat use within the study area is limited for both harbour and grey seals. Recent aerial surveys have provided some information on haul-out locations and counts for both species during the early summer months in a portion of the study area (Hamilton et al. 2023). However, additional surveys across the entire coastline of the study area are required to: 1) confirm whether or not harbour seals are present along this portion of the south coast of NL and, if so, whether pupping is occurring within the area and 2) identify the full extent of summer haulout areas used by grey seals.

If harbour seals are breeding within the study area, it will be essential to obtain data on the timing of pupping. The breeding period is a highly sensitive period for harbour seal mother-pup pairs and information on the onset and duration of this period is needed to understand the potential for particular activities to create disturbance with negative impacts on pups including, but not limited to, reduced growth and survival.

Additional information on seasonal movements and foraging locations within the study area is needed for both harbour and grey seals. The abundance of harbour seals on the Newfoundland and Labrador shelves is highest on the south coast (accounting for 86% of total counts for the region). Whether harbour seals present in areas adjacent to the study area on the south and west coasts of Newfoundland (Hamilton et al. 2023, Mosnier et al. 2023) may make use of the study area is unknown. Deployment of satellite-linked tags on harbour seals captured at identified haulout locations adjacent to the study area would provide information on whether

there are seasonal movements of harbour seals in and out of the study area and could be used to identify important potential foraging locations within the study area. Similarly, detailed analyses of existing tracking data for grey seals from the Scotian Shelf and Gulf of St. Lawrence herds could provide greater resolution on the timing of movements in and out of the study area and be used to identify important potential foraging locations within the study area.

### **Cetaceans**

Cetaceans vary greatly in size from 1.5 m (harbour porpoise) to 24 m (blue whales). This size difference, along with variation in behaviour (i.e., likelihood of surface breaching, size of groups) and surface intervals (i.e., extended dives of sperm whales (*Physeter macrocephalus*) and beaked whales), results in some species being more easily detected than others. These differences also make certain species more easy to identify, once detected, than others. Some species are also more vocal than others, or vocalize more frequently in certain behavioural states, which affects their detection by autonomous acoustic recorders. Gaps in distribution may be due to gaps in observer effort, with less effort spent in offshore waters or outside of the summer months. Variability in sighting conditions seasonally also make sightings more difficult in some parts of the year.

Few aerial and vessel surveys have been done due to their cost, with transect replication generally occurring across multiple years instead of within a year. Recent satellite track data from humpback, fin, sperm and killer whales (*Orcinus orca*) in NL waters has shown that these cetacean species concentrate their time within certain areas while foraging and can cover large distances quickly while travelling (DFO unpublished data). More satellite track data is needed within the study area to understand both large- and fine-scale habitat movement and how habitat choice and movement varies individually, by sex and age group, seasonally and inter-annually.

Two autonomous acoustic recorders have been placed within the study area in March 2023 and March 2024 (both need to be recovered), with a further seven deployments of autonomous acoustic recorders within 20 km of the study area boundary between 2014–2024 (Figure 6.7). These data have not yet been analyzed for relative presence within and outside the study area for the various cetacean species detected. Such an analysis would give additional information on the relative use of this area seasonally and interannually, assuming vocalization rate is constant over time.

Habitat modelling has not been done for the majority of cetacean species in the study area. The habitat models that do exist for some species are not specific for the study area (e.g., Lesage et al. 2016, Gomez et al. 2017, Gomez et al. 2020). While the results point to potential habitat of greater occupancy for several species, the underlying data are usually proxies for measures such as prey and broader oceanographic integration. Better habitat models can only be created with improved information on prey species (rather than proxies for prey, such as chlorophyll) and greater survey coverage across seasons and years.

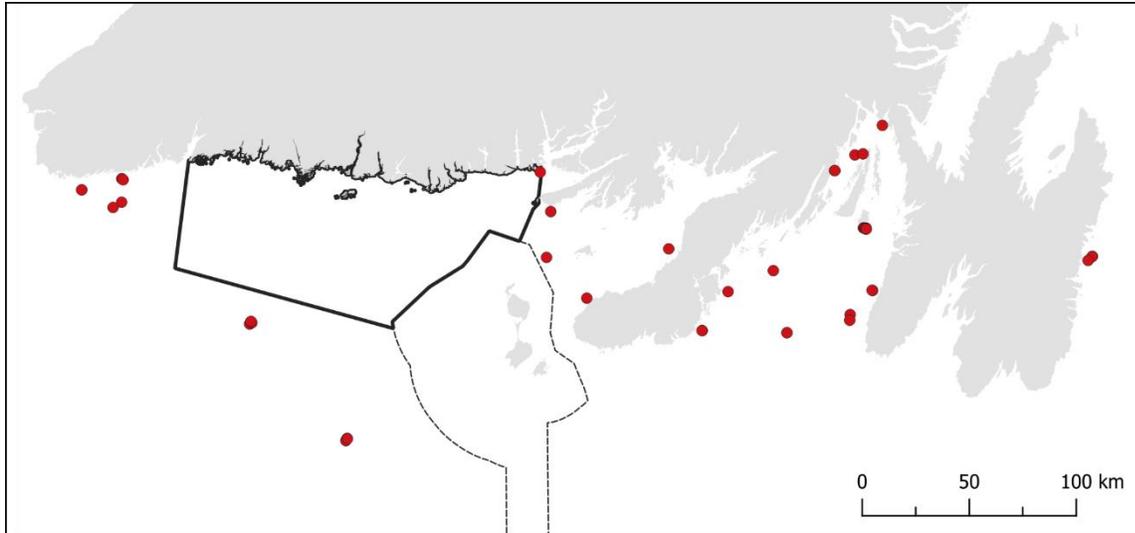


Figure 6.7: Locations of autonomous acoustic recorders deployed by DFO between 2009 and 2024 in southern Newfoundland.

Aggregating sightings data to enhance sample size for habitat models or to understand relative use of an area by species can obscure seasonal and historic changes in species abundance. For example, Atlantic white-sided dolphins and common dolphins are less common currently than they were in the past while the opposite is the case for white-beaked dolphins. Care needs to be taken when analyzing sightings data so that intra- and inter-annual changes in detection are identified.

### Sea Turtles

Most of the sightings data for sea turtles in NL, particularly for outside the time period when aerial surveys typically occur in July and August, comes from opportunistic reports from fishers, recreational or tourism boats or other sources. These opportunistic sightings would only capture an unknown fraction of the sea turtles in the areas with not all sightings being reported to DFO. Furthermore, these opportunistic platforms do not have an even coverage in space or time, and sighting conditions for sea turtles vary. Errors in species identification may also occur when pictures do not accompany the sightings reports. Due to these factors, the opportunistic sightings represent a minimum of the true seasonal distribution of leatherback and loggerhead sea turtles in the study area. The aerial surveys provide a more accurate picture of relative distribution in Atlantic Canada but they are restricted in time seasonally (e.g., August). Furthermore, results for sea turtles have only been analyzed for the TNASS survey in 2007.

Additional surveys are needed to provide information about seasonal distribution of sea turtles in the study area. While existing surveys and opportunistic sightings have confirmed that the study area is an important area for leatherback sea turtles in the late summer, relative use during the remainder of the year is partly unknown. Habitat models for leatherback sea turtles for this area were also built with relatively few sightings. Additional sightings will help refine the habitat model and potentially point out key areas for leatherback sea turtle use within the study area.

Table 6.1: Overview of information available for the cetaceans that overlap with the study area, including their SARA/COSEWIC status, designation of critical habitat (CH), description of stock status, trends, potential stressors and data gaps, and links to recent science advisory reports and status update reports.

| Species Name                 | SARA / COSEWIC Status         | Critical Habitat   | Brief description of species status, recent trends, importance of focus area to species, potential vulnerability of stock to activities and stressors and data gaps   | References to recent Stock Status Update Report (SSRP) or Science Advisory Report (SAR)   |
|------------------------------|-------------------------------|--|---|---|
| Atlantic White-sided Dolphin | Not at Risk (COSEWIC)         | CH has not been proposed through a CSAS process  | The NL population size is large, but population trend is unknown; they are found throughout NL waters, which serve for migration, socializing, and feeding; Atlantic White-sided dolphins are vulnerable to gear entanglement, and climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey stocks and bioaccumulation of toxins              | National Oceanic and Atmospheric Administration (NOAA). 2022. Atlantic White-Sided Dolphin ( <i>Lagenorhynchus acutus</i> ): Western North Atlantic stock. NOAA Stock Assessment Report. 2022: 90-99.<br><br>Lawson, J.W., and Gosselin, J.-F. 2009. Distribution and preliminary abundance estimates for cetaceans seen during Canada's marine megafauna survey – A component of the 2007 TNASS. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/031. |
| Blue Whale                   | Endangered (COSEWIC and SARA) | CH has been proposed through a CSAS process, but has not yet been formally established by DFO, but would include the new focus areas for the study | The Northwest (NW) Atlantic population has a small size, and low reproductive rate; NL south and southwest coasts are important habitat for blue whales in the winter and spring for feeding; blue whales are vulnerable to vessel strike, gear entanglements, ice entrapment, and climate change if it reduces the amount or changes the distribution of their zooplankton prey; data gaps exist in our knowledge of (1) annual movements and habitat use relative to prey density and (2) regional abundance; displacement by underwater anthropogenic sounds may cumulate with other stressors | DFO. 2018. Identification of habitat important to the Blue Whale in the western North Atlantic. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/003.<br><br>DFO. 2022. Spatial distribution and seasonal occurrence of Minke, Humpback, Fin and Blue Whales in the St. Lawrence estuary. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2022/026.   |

| Species Name     | SARA / COSEWIC Status              | Critical Habitat                                | Brief description of species status, recent trends, importance of focus area to species, potential vulnerability of stock to activities and stressors and data gaps   | References to recent Stock Status Update Report (SSRP) or Science Advisory Report (SAR)   |
|------------------|------------------------------------|---|---|---|
| Common Dolphin   | Not at Risk (COSEWIC)              | CH has not been proposed through a CSAS process | The NL population size is large, but population trend is unknown; they are found throughout NL waters, which serve for migration, socializing, and feeding; common dolphins are vulnerable to gear entanglement, and climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey stocks and bioaccumulation of toxins  | Lawson, J.W., and Gosselin, J.-F. 2009. Distribution and preliminary abundance estimates for cetaceans seen during Canada's marine megafauna survey – A component of the 2007 TNASS. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/031.  |
| Fin Whale        | Special Concern (COSEWIC and SARA) | CH has not been proposed through a CSAS process | The NW Atlantic population appears to be growing; NL south and southwest coasts are important habitat for fin whales in the spring and fall for migration into the Gulf; fin whales are particularly vulnerable to vessel strike, as well as gear entanglements, and climate change if it reduces the amount or changes the distribution of their fish and zooplankton prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for fish stocks such as Capelin and herring | COSEWIC. 2019. COSEWIC assessment and status report on the Fin Whale <i>Balaenoptera physalus</i> , Atlantic population and Pacific population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.<br><br>DFO. 2022. Spatial distribution and seasonal occurrence of Minke, Humpback, Fin and Blue Whales in the St. Lawrence estuary. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2022/026. |
| Harbour Porpoise | Special Concern (COSEWIC)          | CH has not been proposed through a CSAS process | The NL population size is small, but population trend is unknown; they are found throughout NL waters, which serve for migration, socializing, and feeding, although most commonly seen along the south coast of Newfoundland and in the Gulf of St. Lawrence; porpoise are vulnerable to gear entanglement, and climate change if it reduces the amount or changes   | COSEWIC. 2022. COSEWIC assessment and status report on the Harbour Porpoise <i>Phocoena phocoena</i> , Northwest Atlantic population, in Canada. Committee on the Status of   |

| Species Name   | SARA / COSEWIC Status     | Critical Habitat                                | Brief description of species status, recent trends, importance of focus area to species, potential vulnerability of stock to activities and stressors and data gaps  | References to recent Stock Status Update Report (SSRP) or Science Advisory Report (SAR)  |
|----------------|---------------------------|---|--|--|
|                |                           |   | the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; masking of underwater sounds (a form of habitat degradation by noise disturbance (e.g., industrial developments such as offshore wind, tidal, and wave energy, and oil and gas developments)) and displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey stocks and bioaccumulation of toxins   | Endangered Wildlife in Canada. Ottawa.<br><br>COSEWIC. 2022. Response statement – Harbour Porpoise, Northwest Atlantic population. Committee on the Status of Endangered Wildlife in Canada. Ottawa.   |
| Humpback Whale | Not at Risk (COSEWIC)     | CH has not been proposed through a CSAS process | The NW Atlantic population appears to be growing; NL south and southwest coasts are important habitat for humpback whales for migration into the Gulf; humpback whales are particularly vulnerable to vessel strike, as well as gear entanglements, and climate change if it reduces the amount or changes the distribution of their fish and zooplankton prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for fish stocks such as Capelin and herring | COSEWIC. 2022. COSEWIC assessment and status report on the Humpback Whale <i>Megaptera novaeangliae kuzira</i> , North Pacific population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.<br><br>DFO. 2022. Spatial distribution and seasonal occurrence of Minke, Humpback, Fin and Blue Whales in the St. Lawrence estuary. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2022/026. |
| Killer Whale   | Special Concern (COSEWIC) | CH has not been proposed through a CSAS process | The NW Atlantic population size is near 100 whales, although abundance trend is unknown; this species is found throughout NL waters which serve for migration and feeding; killer whales are vulnerable to gear entanglements, and climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of diet, and annual movements and habitat use relative to prey density;   | COSEWIC. 2023. COSEWIC assessment and status report on the Killer Whale <i>Orcinus orca</i> , Northeast Pacific Southern Resident population, Northeast Pacific Northern Resident population, Northeast Pacific Transient Killer Whale   |

| Species Name            | SARA / COSEWIC Status | Critical Habitat                                | Brief description of species status, recent trends, importance of focus area to species, potential vulnerability of stock to activities and stressors and data gaps  | References to recent Stock Status Update Report (SSRP) or Science Advisory Report (SAR)  |
|-------------------------|-----------------------|---|--|--|
|                         |                       |   | displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey fish stocks and bioaccumulation of toxins   | population, Northeast Pacific Offshore population, and Northwest Atlantic/Eastern Arctic population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.                     |
| Long-finned Pilot Whale | Not at Risk (COSEWIC) | CH has not been proposed through a CSAS process | The NW Atlantic population size is large, and likely increasing; while found throughout NL waters, deeper shelf break areas serve for migration and feeding; pilot whales are vulnerable to gear entanglements, and climate change if it reduces the amount or changes the distribution of their squid prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey squid stocks and bioaccumulation of toxins  | National Oceanic and Atmospheric Administration (NOAA). 2022. Long-Finned Pilot Whale ( <i>Globicephala melas melas</i> ): Western North Atlantic stock. NOAA Stock Assessment Report. 2022: 72–80.  |
| Minke Whale             | Not at Risk (COSEWIC) | CH has not been proposed through a CSAS process | The NW Atlantic population trend is unknown; between 2017 and 2023 the U.S. has declared an Unusual Mortality Event along the Atlantic Coast; NL coastal and deeper waters are important habitat for minke whale migration and feeding; minke whales are vulnerable to gear entanglements, and climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for fish stocks such as Capelin and herring | National Oceanic and Atmospheric Administration (NOAA). 2017. Minke Whale ( <i>Balaenoptera acutorostrata acutorostrata</i> ): Canadian East Coast stock. NOAA Stock Assessment Report. 2017: 56–66. |

| Species Name               | SARA / COSEWIC Status   | Critical Habitat                                | Brief description of species status, recent trends, importance of focus area to species, potential vulnerability of stock to activities and stressors and data gaps  | References to recent Stock Status Update Report (SSRP) or Science Advisory Report (SAR)  |
|----------------------------|---|---|--|--|
| North Atlantic Right Whale | Endangered (COSEWIC and SARA)   | CH has not been proposed through a CSAS process | The NW Atlantic population is small and declining in size; NL south and southwest coasts are important habitat for right whales in the winter and spring for migration to the southern Gulf; right whales are vulnerable to vessel strike, gear entanglements, and climate change if it reduces the amount or changes the distribution of their copepod prey; data gaps exist in our knowledge of (1) annual movements and habitat use relative to prey density and (2) potential impacts of climate change  | <p>COSEWIC. 2013. COSEWIC assessment and status report on the North Atlantic Right Whale <i>Eubalaena glacialis</i> in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.</p> <p>DFO. 2020. Updated information on the distribution of North Atlantic Right Whale in Canadian waters. DFO. Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/037.</p>   |
| Northern Bottlenose Whale  | Endangered (SARA - Scotian Shelf population); Special Concern (COSEWIC - Davis Strait-Baffin Bay-Labrador Sea population) | CH has not been proposed through a CSAS process | The Gully population size is small, whereas that of the Davis Strait-Baffin Bay-Labrador Sea is unknown; this species is found in NL waters, where deeper shelf break areas serve for migration and feeding; northern bottlenose whales may be vulnerable to climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey stocks and bioaccumulation of toxins | <p>COSEWIC. 2011. COSEWIC assessment and status report on the Northern Bottlenose Whale <i>Hyperoodon ampullatus</i> in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.</p> <p>DFO. 2020. Assessment of the distribution, movements, and habitat use of the Northern Bottlenose Whales on the Scotian Shelf to support the identification of important habitat. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/008.</p> <p>DFO. 2022. Threat assessment for Northern Bottlenose Whales off eastern Canada. DFO Can.</p> |

| Species Name           | SARA / COSEWIC Status              | Critical Habitat                                | Brief description of species status, recent trends, importance of focus area to species, potential vulnerability of stock to activities and stressors and data gaps  | References to recent Stock Status Update Report (SSRP) or Science Advisory Report (SAR)   |
|------------------------|------------------------------------|---|--|---|
|                        |                                    |   |  | Sci. Advis. Sec. Sci. Advis. Rep. 2022/032.   |
| Sei Whale              | Endangered (COSEWIC)               | CH has not been proposed through a CSAS process | The NW Atlantic population size and trend are unknown; NL coastal and shelf break areas are important habitat for sei whales for migration and feeding; sei whales are vulnerable to gear entanglements, and climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for fish stocks such as Capelin and herring                           | COSEWIC. 2019. COSEWIC assessment and status report on the Sei Whale <i>Balaenoptera borealis</i> , Atlantic population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. |
| Sowerby's Beaked Whale | Special Concern (COSEWIC and SARA) | CH has not been proposed through a CSAS process | The NW Atlantic population size is unknown, as are populations trends; this species is found occasionally in NL waters, where deeper shelf break areas serve for migration and feeding; Sowerby's beaked whales may be vulnerable to climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey stocks and bioaccumulation of toxins | COSEWIC. 2019. COSEWIC assessment and status report on the Sowerby's Beaked Whale <i>Mesoplodon bidens</i> in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.               |
| Sperm Whale            | Not at Risk (COSEWIC)              | CH has not been proposed through a CSAS process | The NW Atlantic population size and trend are unknown; NL shelf and shelf break areas are important habitat for male sperm whales for migration and feeding; sperm whales are vulnerable to vessel strike, gear entanglements, and climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density;   | National Oceanic and Atmospheric Administration (NOAA). 2020. Sperm Whale ( <i>Physester macrocephalus</i> ): North Atlantic Stock. NOAA Stock Assessment Report. 2020: 104–112.                      |

| Species Name         | SARA / COSEWIC Status | Critical Habitat                                | Brief description of species status, recent trends, importance of focus area to species, potential vulnerability of stock to activities and stressors and data gaps  | References to recent Stock Status Update Report (SSRP) or Science Advisory Report (SAR)  |
|----------------------|-----------------------|---|--|--|
|                      |                       |   | displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for squid stocks   |  |
| Risso's Dolphin      | Not at Risk (COSEWIC) | CH has not been proposed through a CSAS process | The NW Atlantic population size is large, and likely increasing; while found occasionally in NL waters, where deeper shelf break areas serve for migration and feeding, this species is more common further south; Risso's dolphins may be vulnerable to climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey stocks and bioaccumulation of toxins | National Oceanic and Atmospheric Administration (NOAA). 2022. Risso's Dolphin ( <i>Grampus griseus</i> ): Western North Atlantic stock. NOAA Stock Assessment Report. 2022: 64–71.   |
| White-beaked Dolphin | Not at Risk (COSEWIC) | CH has not been proposed through a CSAS process | The NL population size is large, and increasing; they are the most ubiquitous dolphin found throughout NL waters, which serve for migration, socializing, and feeding; white-beaked dolphins are vulnerable to gear entanglement, and climate change if it reduces the amount or changes the distribution of their prey; data gaps exist in our knowledge of annual movements and habitat use relative to prey density; displacement by underwater anthropogenic sounds may cumulate with other stressors such as competition with humans for prey stocks and bioaccumulation of toxins                    | National Oceanic and Atmospheric Administration (NOAA). 2020. White-Beaked Dolphin ( <i>Lagenorhynchus albirostris</i> ): Western North Atlantic Stock. NOAA Stock Assessment Report. 2020: 216-219.<br><br>Lawson, J.W., and Gosselin, J.-F. 2009. Distribution and preliminary abundance estimates for cetaceans seen during Canada's marine megafauna survey – A component of the 2007 TNASS. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/031. |

## 7. INVERTEBRATES

*Authors: Kaitlyn Charmley and Hannah Munro*

### Available Information

Bottom trawl data from the DFO multispecies surveys are the main source of data for invertebrate species. These surveys take place in the spring and fall; however NAFO Div. 3P, where the study area is located, is only surveyed in the spring. Relative density layers were created for some commercial species using the catch rates from these surveys from 1996 to 2017 (Wells et al. 2021). For invertebrates, relative density layers exist for Snow Crab and Pandalid shrimp. Data from non-commercial invertebrate species are limited with the exception of corals and sponges, which is covered in Chapter 8: Corals and Sponges. There is also an annual collaborative industry-DFO snow crab trap survey with an allocation since 2018 of 15–28 stations in crab management area (CMA) 11W, which spans most of the study area; however, there has only been participation in this portion of the survey in 2018 and 2019 (Pantin et al. 2024). Additional data for invertebrates may be available from other surveys but have not been analyzed as they do not represent a broad geographic range, are patchy, and are primarily for other purposes. Only high-level summarized data on the fisheries are presented to ensure harvester confidentiality and privacy.

### Snow Crab

The distribution of Snow Crab (*Chionoecetes opilio*) is largely impacted by temperature (Brêthes et al. 1987, Dawe and Colbourne 2002), with Snow Crab in Newfoundland typically inhabiting a narrow temperature range (-1–3°C) (J. Pantin pers. comm.). The most productive and cold conditions on the Newfoundland shelf are generally found at shallow and intermediate depths (Pantin et al. 2024). The most productive Snow Crab fisheries have been associated with intermediate-depth slope edges of offshore banks and inshore bays. Some Snow Crab migrate upslope in winter or summer for mating or molting (Mullowney et al. 2018). The fishery occurs during the spring and summer seasons (Pantin et al. 2024). There are records of low and infrequent catches of Snow Crab in the DFO multispecies survey (Figure 7.1) and negligible catches of Snow Crab in the trap survey in the study area. While the multispecies trawl gear has lower catchability for crab, particularly at smallest sizes (Dawe et al. 2010), agreement between the two surveys highlights that this area is not abundant in Snow Crab.

There is also minimal toad crab (*Hyas* spp.) documented in the area.

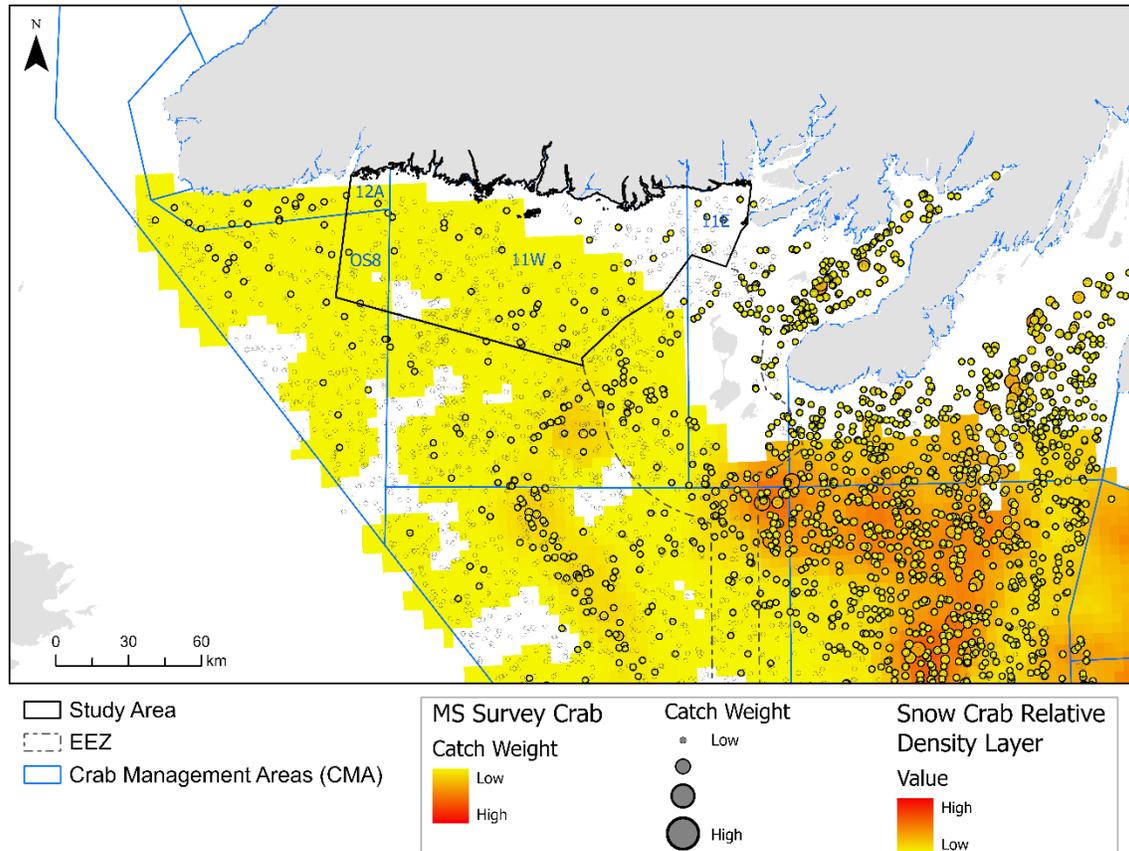


Figure 7.1: A map showing the relative catch rates of Snow Crab from the DFO multispecies surveys (1996–2023) and the relative density layer (1996–2017; Wells et al. 2021) in NAFO Div. 3P. The solid black line denotes the South Coast Fjords study area and the solid blue lines denote the CMAs.

## Shrimp

There are minimal densities of commercial shrimp (Northern shrimp (*Pandalus borealis*) and striped shrimp (*Pandalus montagui*)) documented in the study area. Bottom temperature, phytoplankton bloom dynamics (i.e., food availability), and predation are known drivers of shrimp distributions (Le Corre et al. 2024). The relative density layer for these species together is presented in Figure 7.2 (Wells et al. 2021). There are no shrimp fisheries within or near the study area.

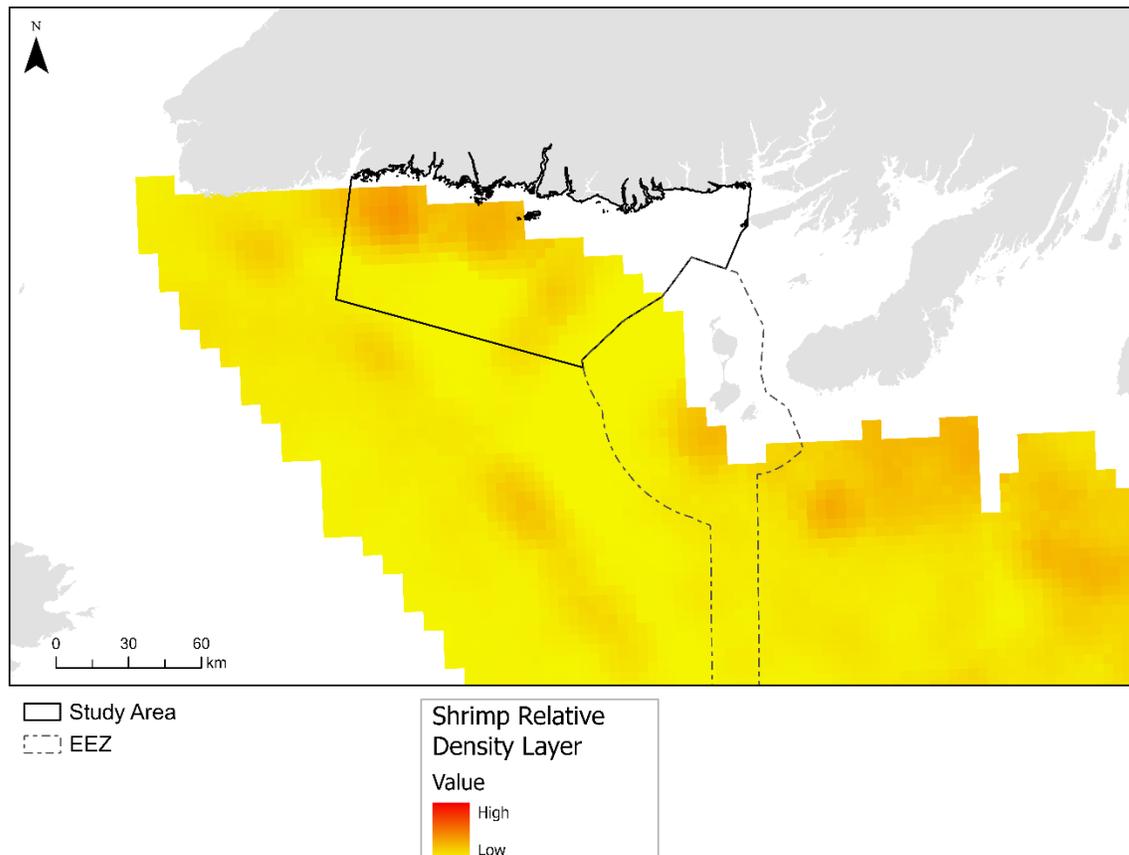


Figure 7.2: A map showing the relative density layer of commercial shrimp (*Pandalus borealis* and *P. montagui*) (1996–2017; Wells et al. 2021) in NAFO Div. 3P. The black line denotes the South Coast Fjords study area.

### American Lobster

Adult American Lobsters (*Homarus americanus*) prefer rocky substrates where they can find refuge, at depths of generally < 50 m (Coughlan et al. 2023b). Temperature is the main driver of lobster distribution. The distribution of juveniles indicates preference for shallower depths than adult lobsters. The lobster fishery occurs close to the shore during the spring season (Coughlan et al. 2023b). Lobsters are very rarely caught in the DFO multispecies survey, likely attributed to their depth range and temperature preferences. There is a lack of monitoring data for lobster within the survey area. However, there has been a DFO lobster survey near the area in Harbour Breton since 2022. To date, there have been no clear population trends reported at this localized scale (Coughlan et al. 2025).

### Scallop

Sea scallops (*Placopecten magellanicus*) are normally found on sandy or rocky substrate at depths of 10–100 m (Coughlan et al. 2023a). There are no documented occurrences of sea scallops in the study area from the DFO multispecies survey, however these surveys rarely fish depths < 60 m (Figure 7.3; Rideout et al. 2022).

Icelandic scallops (*Chlamys islandica*) have the highest distributions on hard substrate consisting of gravel, shell fragments, and stones (Coughlan and Hynick 2022). They are usually found at depths of 50–200 m. There are few documented occurrences of Icelandic scallop in the study area from the DFO multispecies survey (Figure 7.3).

Commercial scallop fisheries occur just outside the study area on the St. Pierre Bank. The Icelandic scallop stock on the St. Pierre Bank has decreased 45% from 2017 to 2023 (DFO 2025a).

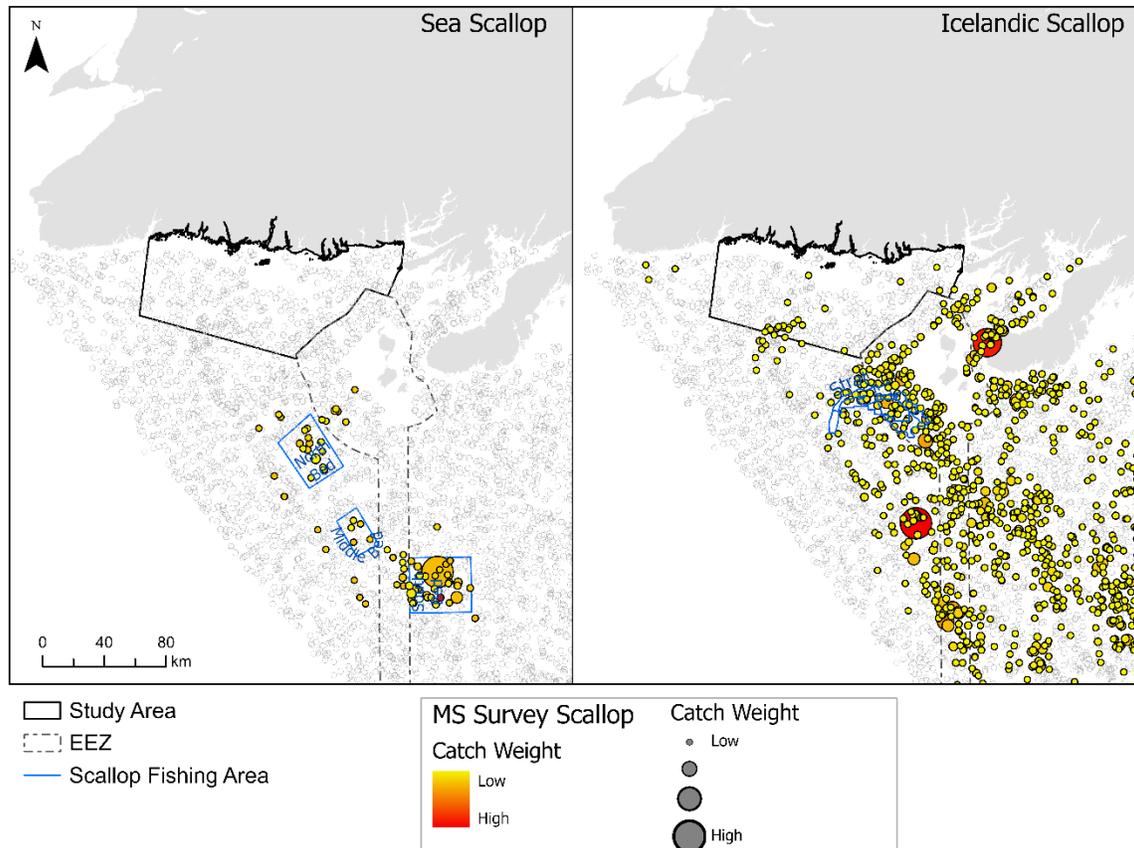


Figure 7.3: A map showing the DFO multispecies relative catch rates of sea scallop (*Placopecten magellanicus*) and Icelandic scallop (*Chlamys islandica*) in NAFO Div. 3P from 1996–2023. The black line denotes the South Coast Fjords study area and the blue lines denote the respective species commercial fishing grounds near the study area.

### Sea Cucumber

Sea cucumbers (*Cucumaria frondosa*) are usually found at depths of 30–70 m on flat, rocky, or shelled substrate (DFO 2024b). Sea cucumbers exhibit a series of migrations as they mature, and adults exhibit a migration downslope in autumn at sexual maturity (Hamel and Mercier 1996). There are few sea cucumbers caught in the DFO multispecies survey in the study area (Figure 7.4), but this gear type is thought to have poor catchability for sea cucumbers. There is a commercial sea cucumber fishery that occurs nearby outside of the bounds of the study area on the St. Pierre Bank.

## Whelk

The waved whelk (*Buccinum undatum*) is found at highest densities on soft bottoms at 15–30 m depth in areas with low water temperatures (DFO 2013c). Waved whelk are predatory and their distribution is influenced by the search for food. There are no documented observations of waved whelk in the study area from the DFO multispecies survey (Figure 7.4). There is a commercial whelk fishery that occurs outside of, but near, the study area; however, harvester participation and landings have been decreasing since 2012.

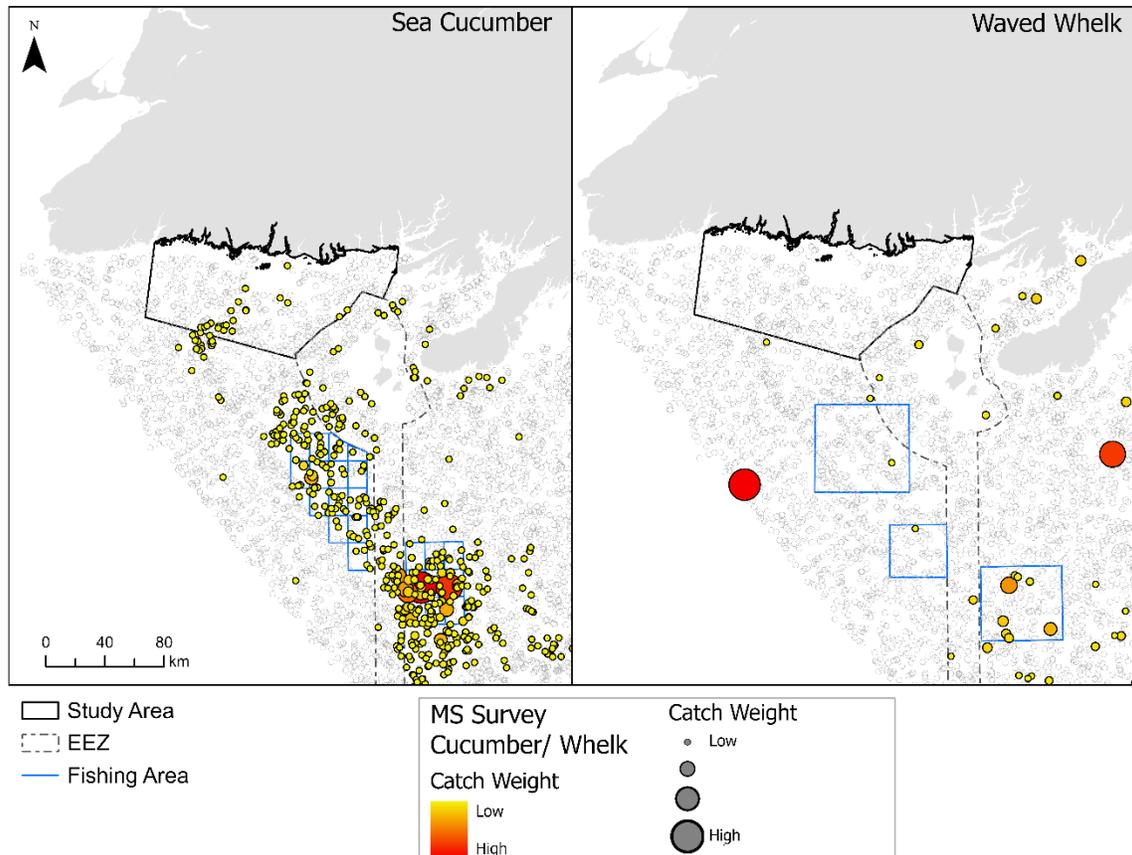


Figure 7.4: A map showing the DFO multispecies relative catch rates of sea cucumber (*Cucumaria frondosa*) and waved whelk (*Buccinum undatum*) in NAFO Subdiv. 3Ps from 1996–2023. The black line denotes the South Coast Fjords study area and the blue lines denote the respective species commercial fishing areas near the study area.

## Shortfin Squid

There are minimal catches of northern shortfin squid (*Illex illecebrosus*) in the DFO multispecies survey in the area; this is thought to be unrepresentative due to the timing of the survey. They reside on sandy or muddy substrates. Northern shortfin squid are highly migratory, which is thought to be driven by mating and environmental factors like temperature, currents, and prey availability (Guerreiro et al. 2023). They move onto the continental shelf and inshore waters during the summer, with shelf populations generally peaking in September (Black et al. 1987).

## Non-Commercial Species

There is limited information on non-commercial invertebrate species in this area. Data are available from the DFO multispecies survey but need to be analyzed at a high taxonomic level, making designation of rare or interesting species limited. Species richness (number of species) and diversity (balance of species, accounted for by biomass using the Shannon-Wiener diversity index) of invertebrates sampled in the DFO multispecies survey is highly variable (Figure 7.5), with no singular areas of high or low diversity. The community structure is variable, but appears to be most similar to the community structure found in the Hermitage and Laurentian Channels (Figure 7.6).

Many phyla are represented in the invertebrates including the Arthropoda (e.g., crustaceans such as shrimp and crab, pycnogonids such as sea spiders), Echinodermata (e.g., sea stars, sea urchins), Cnidaria (e.g., jellyfish, sea anemones, corals), Mollusca (e.g., bivalves such as scallops, gastropods such as whelks, cephalopods such as squid and octopus), Ctenophora (i.e., comb-jellies), and Annelida (e.g., polychaetas). There are some observations of non-commercial shrimp species in the area. There have also been deep-sea shrimp documented in deep fjords within the study area; however, DFO does not survey these areas. It is known that the diversity of invertebrates is much richer than what is surveyed in the DFO multispecies survey, but sampling and data are limited for many benthic species.

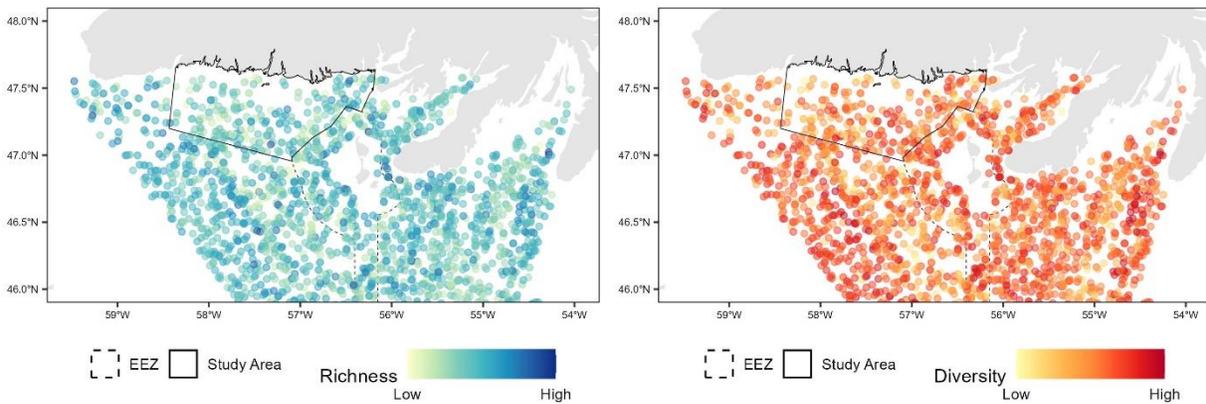
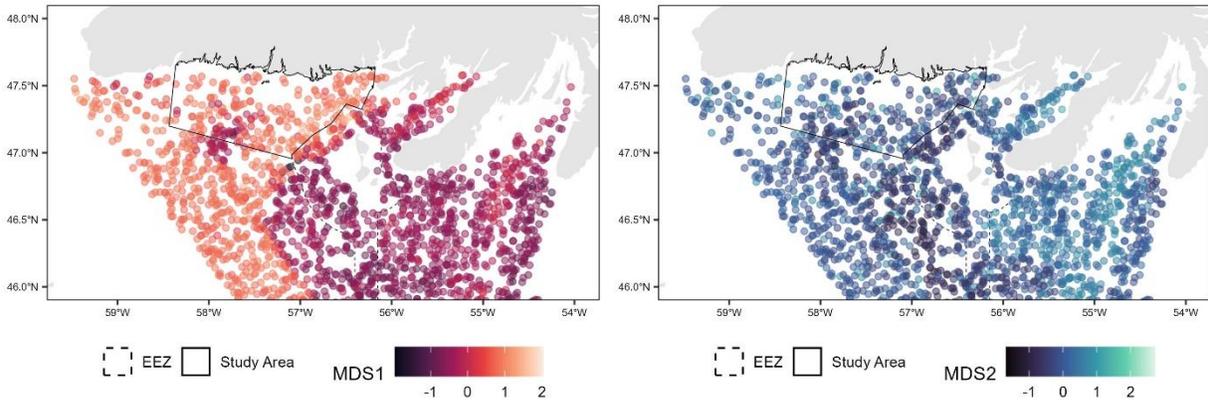


Figure 7.5: A map showing the DFO multispecies invertebrate species richness (left) and Shannon–Wiener diversity index (right; 2005–2023) in NAFO Subdiv. 3P. The black line denotes the South Coast Fjords study area.



*Figure 7.6. Map showing invertebrate community composition along the south coast of Newfoundland based upon catches from the DFO multispecies survey. The two maps show fish community composition based upon the first (left panel) and second (right panel) dimensions of a non-metric multidimensional scaling analysis of species biomass (2005-2023) in NAFO Subdiv. 3P. This analysis reduces the community composition to three dimensions. Areas with similar colours reflect similar species compositions. The black line denotes the South Coast Fjords study area.*

### **Sensitive Species and Habitats**

Commercial and recreational fishing activities occur in the study area. The main invertebrate commercial fisheries that are occurring in this area are American lobster and Snow Crab. This study area falls in Lobster Fishing Area (LFA) 11 and a portion of LFA 12. Reported landings averaged 1,100 t from 2011 to 2015, and then increased to 1,744 t in 2022 (Coughlan et al. 2025), of which LFA 11 accounts for 80–90% (Coughlan et al. 2025). Since 2010, 20% of the lobsters caught in LFA 11 have homeports documented within the study area (Figure 7.7; unpublished data). The study area also overlaps with CMA 12A, OS8 11W, and 11E, but falls predominately in CMA 11W, which historically had the lowest landings and total allowable catches (TAC) in NAFO Subdiv. 3Ps (Figure 7.1; Pantin et al. 2024).

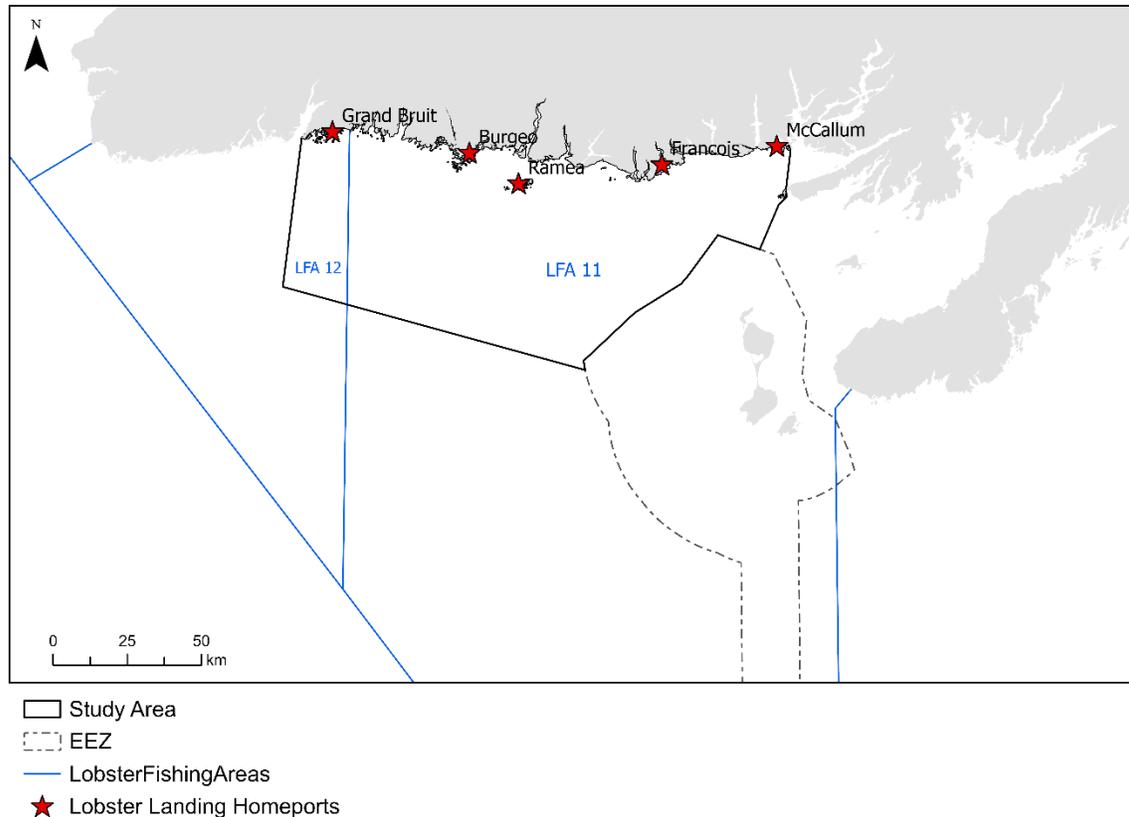


Figure 7.7: A map showing the homeports of commercial lobster landings that fall within the South Coast Fjords study area (2010–2023). The black line denotes the study area and the blue lines denote the LFAs near the study area. LFA 11 and 12 overlap with the study area.

There is anecdotal evidence of recreational scallop and northern shortfin squid fishing in the study area. There are no data collected on these recreational fisheries, so minimal information is available to DFO.

While data are limited for non-commercial species in this region, it is known that benthic species are more sensitive to disturbances. These areas represent unique habitats, and it should be assumed that the invertebrate species associated with them will also be unique and sensitive.

### Data Gaps and Recommendations

There is minimal data on the distributions and abundances available to DFO on invertebrates in the study area, especially non-commercial species. Where data does exist, it primarily comes from the DFO multispecies survey and does not capture the inshore or coastal communities. Also, patchy completion of the survey in this area in recent years (i.e., 2020 and 2023) results in data gaps. Even for species that are caught in the DFO multispecies surveys in the area (i.e., sea cucumber, scallop), true distributions and densities remain uncertain due to the suboptimal survey gear catchability for these species. Therefore, it is difficult to assess the key areas of ecological significance with regard to these species. Also, there is minimal information available on the deep-sea shrimp that have been documented in fjords in the area, a group of species that are known to be of great interest. There is some information for specifically Snow Crab derived from the industry-DFO collaborative post-season trap survey, but this survey has

also suffered from gaps over most of the time series due to low or lacking resource (i.e. Snow Crab), and therefore low participation from industry.

To fill this gap, more surveys and directed survey of the study area are recommended. It is essential that these surveys consider timing, as invertebrates in this region include pelagic and migratory species, and suitable catchability, as not all species are sampled with the same efficiency. For example, there is little known about the infauna in this region which is not sampled using trawl surveys and instead requires box grabs or other benthic sampling.

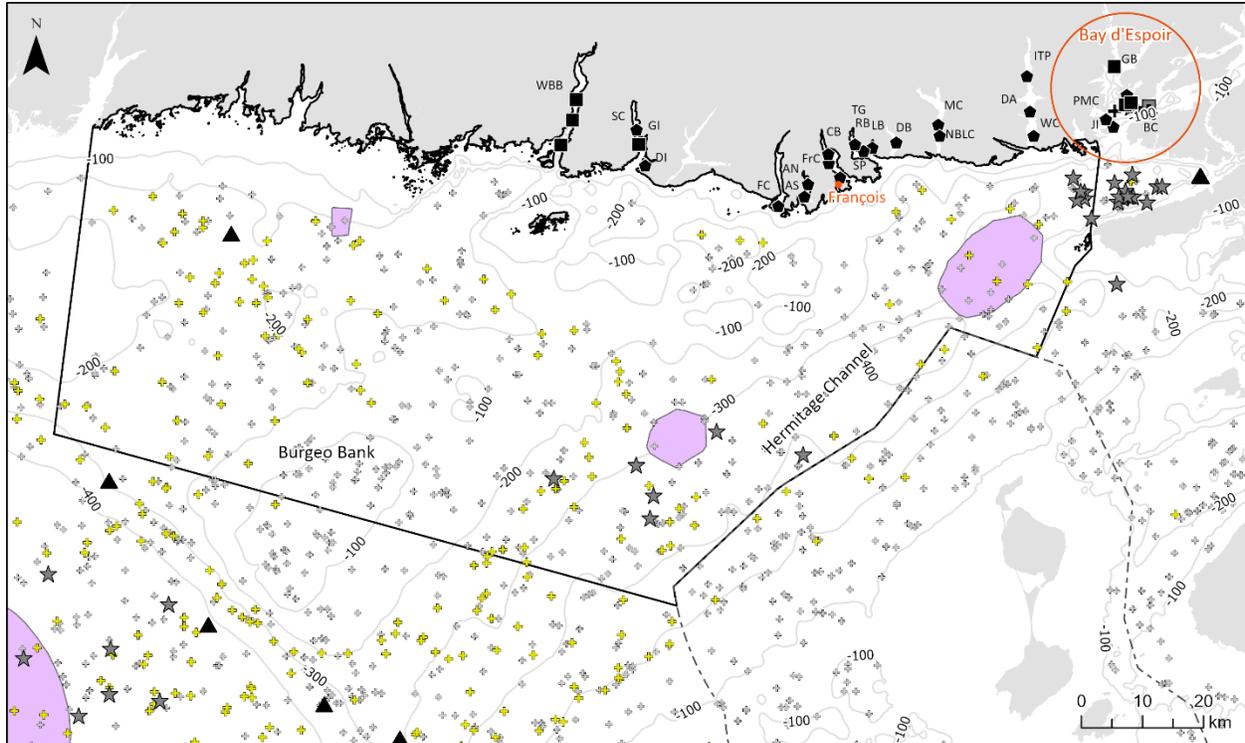
Another component to filling this gap would be to ensure that benthic species that are sampled as part of other projects and programs are integrated into our knowledge of the region. Currently, due to limited resources, they are often unanalyzed or under-analyzed. The non-commercial invertebrates collected as part of the DFO surveys represent one such dataset, and another is sea floor surveys that are conducted for other projects. Providing resources to such projects would allow for efficiency through the utilization of data that is already being collected or can easily be collected.

## **8. CORALS AND SPONGES**

*Authors: Bárbara de Moura Neves and Vonda E. Hayes*

### **Available Information**

Bottom trawl data is one of the main sources of information on the distribution and diversity of corals and sponges in the NL region (Wareham and Edinger 2007). Within the study area boundaries, coral and sponge data consists mostly of DFO multispecies surveys (MSS), with additional data from the redfish survey, Fisheries Observer Program (FOP), historical research fishing data, and seafloor video surveys (Figure 8.1), which are detailed below. These activities have often focused on different areas, depths, and habitats and have used a range of tools and methodologies.



- |                              |                                    |                              |
|------------------------------|------------------------------------|------------------------------|
| □ Study Area                 | ◆ Aquaculture video surveys        | + Haedrich and Gagnon (1991) |
| ⋯ EEZ                        | ★ Historical (1952-1993)           | ■ SIBA Sea pens              |
| — Depth contour (m)          | ▲ FOP (2007, 2010-2011)            |                              |
| ⊕ DFO-NL MSS (2000-2022)     | ■ Drop camera - 2024 Polar Prince  |                              |
| ⊕ Redfish survey (1996-2018) | ■ Drop camera - 2023 Connor Murphy |                              |

*Figure 8.1: Various data sources used to assess coral and sponge information in the study area. Sites from coastal areas are identified as follows: AN: Aviron North, AS: Aviron South, BC: Butter Cove, CB: Chaleur Bay, DA: Dennis Arm, DI: Dennis Island, DB: Devil Bay, FC: Foots Cove, FrC: Friar Cove, GB: Goblin Bay, GI: Gnat Island, ITP: Indian Tea Point, JI: Jervis Island, LB: Little Bay, MC: Mare Cove, NBLC: North Bob Lock Cove, PMC: Pass My Can, RB: Rencontre Bay, SC: Shoal Cove, SP: Shooter Point, TG: The Gorge, WBB: White Bear Bay.*

## Research surveys

### *DFO Multispecies Surveys*

DFO multispecies surveys in NL Region are conducted annually and are based on a stratified random survey design using a modified Campelen 1800 shrimp trawl to a maximum depth of 1500 m (McCallum and Walsh 1996). These surveys are divided into spring and fall, with the coverage of the study area only occurring during the spring survey in NAFO Div. 3P (Figure 8.1). For the purposes of this document, we used 2002–2022 data for corals and 2004–2022 data for sponges. The spatial coverage for the multispecies survey is limited in coastal areas and trawl sets are limited to ‘trawlable’ substrates. The data mainly represents presence/absence (in some cases biomass), but due to low trawl retention or catchability rates for corals and sponges due to fragmentation and/or loss through the net mesh, absence data needs to be considered with caution.

Between 2002 and 2022, a total of 324 sets were conducted within the study area, with 54.6% of sets containing either corals (36.7%, n = 119 sets), sponges (32.1%, n = 104 sets), or both

(14.2%,  $n = 46$  sets). When samples were kept and submitted to DFO Science for analysis, species were identified to the highest confidence level (see below about challenges associated with species identification).

Multispecies survey data (2003–2015) has been used to delineate significant concentrations of corals and sponges as Significant Benthic Areas (SiBA; Kenchington et al. 2016, Guijarro-Sabaniel et al. 2016). An additional seven years of survey data is currently being used to update species distribution models (B. Neves pers. comm.) and coral observations for the NL region (Hayes et al., in prep.<sup>5</sup>).

#### *Redfish bottom trawl surveys*

A comparable bottom trawl survey that takes place in the study area is the redfish survey, which covers NAFO Div. 3P and 4UV, covering the Grand Banks, Laurentian Channel, and Scotian Shelf (Figure 8.1). This survey follows the same stratified random design as the DFO multispecies survey but occurs every second year. This survey commenced in 1973 deploying multiple trawl types over the years (e.g., Engel 145, Yankee 41-5), but in 1996 switched to the same fishing gear as the DFO multispecies survey, except that the trawl does not have a cod-end liner, which will result in even lower retention rates than the multispecies survey. For the purposes of this document, the time series for redfish data was restricted to 1996–2018 (2020–2022 data were not available). Between 1996 and 2018, there were 96 redfish survey sets conducted within the study area at depths of 183–553 m. Of these, 8.3% recorded either corals, sponges, or both. Corals were identified as coral sp. or sea pen, and sponges were only identified at the phylum level.

#### *Fisheries Observer Program*

Fisheries observers are deployed aboard commercial fishing vessels and are responsible for monitoring compliance with fisheries regulations and for the collection of scientific data. Auxiliary data provided to DFO by the FOP covers multiple fisheries using mobile and fixed gear types. However, FOP coverage is primarily directed to large offshore fishing vessels, and as a result there is limited coverage in or near the study area. Data reported here represents presence-only due to non-standardized collections and spatial coverage. In addition, observers are not able to exhaustively inspect the entire catch, especially for high volume fisheries. The FOP data in this chapter covers the years 2007 and 2010–2011.

#### *Historical fishing surveys*

Historical research fishing surveys in the region took place between 1939 and 1995 and included multiyear studies and unique surveys using different gear types and survey designs. Historic data represent presence-only due to non-standardized sampling. Observations within the study area were classified as either coral, sea pen, or sponge. The historical data in this document covers the years 1952–1993.

#### *Seafloor video surveys*

Past and recent expeditions have allowed the collection of seafloor imagery data and have provided more insight into benthic habitats and communities within and adjacent to the study area. Most of the currently available video data for the study area is sparse and probably originates from seafloor video surveys conducted as part of aquaculture industry baseline

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<sup>5</sup> Hayes, V.E., Neves, B.M., Pretty, C., Command, R., and Edinger, E.N. In prep. Updated distribution of deep-sea corals in the Newfoundland Labrador region, Northwest Atlantic Ocean: Expanded insights from enhanced data. Mar. Biodivers.

environmental assessment reports. For instance, in 2019 a DFO CSAS process assessed seafloor video data and reports from 13 sites located in various fjords and bays found within the study area. These include: Indian Tea Point, Dennis Arm, Wild Cove, North Bob Locke Cove, Mare Cove South, Devil Bay, Little Bay, The Gorge, and Rencontre Bay, all located between Bay d'Espoir and François, NL, in addition to four sites in Bay d'Espoir (Butter Cove, Goblin Bay, Pass My Can, and Jervis Island; DFO 2022d). Data from these surveys include unstandardized counts of benthic species, including corals and sponges. While those counts were not available for a quantitative analysis at the time of writing, the presence of corals and sponges is described here based on qualitative observations of unpublished and published data (e.g., DFO 2022d).

In addition to industry data, recent seafloor video surveys have been conducted in White Bear Bay, Gnat Island, and Bay d'Espoir (Broad et al. 2023, V. Hayes pers. comm.). Although Bay d'Espoir is located outside of the study area, we include it in this chapter due to relevance in terms of corals and sponges and meaning for adjacent areas. A submersible video survey was conducted in Bay d'Espoir in 1985 and general findings (e.g., sea pens) are reported by Haedrich and Gagnon (1991).

#### *Challenges with species identification*

Challenges associated with obtaining diversity data on sponges from trawl surveys have been described elsewhere (e.g., Gullage et al. 2022) and thus are not repeated in detail here. In summary, identifying sponges is difficult for many reasons. Samples collected by trawls are almost always fragmented, which makes it difficult to determine species morphology but also increases the risk of cross-contamination of skeletal parts (i.e., spicules), which are critical for species identification. Secondly, sponge taxonomy is time consuming and requires expertise and specialized equipment (e.g., Scanning Electron Microscope), which are not always available. Species identification from seafloor imagery is also challenging and often not possible without access to a physical specimen (e.g., Command et al. 2024).

### **Sensitive Species and Habitats**

Corals and sponges play a significant role in deep-sea habitats (e.g., habitat, nurseries, forage areas) and are key components of sensitive benthic ecosystems. Research shows they are also vulnerable to physical damage (Watling and Norse 1998, Auster and Langton 1999, Hall-Spencer et al. 2002, Anderson and Clark 2003), sediment smothering (Leys 2013, Yahel et al. 2007, Tompkins-MacDonald and Leys 2008, Murray et al. 2023), and can be used as potential proxies for assessing the impacts of climate change (Morato et al. 2020).

#### **Corals**

In the NL Region, corals have been traditionally grouped as large gorgonians, small gorgonians, sea pens, soft corals, stony corals (i.e., solitary cup corals), and black corals (Wareham and Edinger 2007, Gullage et al. 2022). Through assessment of the different data sources described above, large gorgonians, sea pens, soft corals, and cup corals have all been reported within and near the study area, which are detailed below. Small gorgonians and black corals have not been confirmed in the study area.

Based on DFO multispecies survey data, sea pens had by far the largest occurrence rate ( $n = 104$  sets), followed by cup corals ( $n = 17$  sets), soft corals ( $n = 13$  sets), and large gorgonians ( $n = 1$  set). Data from the redfish survey, FOP, and historical surveys do not always specify the coral group and might just be reported as coral sp. Out of the 96 redfish survey sets conducted within the study area between 2009–2018 (no records before 2009), only four contained corals (three sea pens and one large gorgonian, described below). The low

catchability of the redfish surveys might reflect the lack of a cod-liner. Information from seafloor video surveys is provided in the next sections.

### *Sea pens*

Based on DFO multispecies survey data, sea pens were present between mean depths of 66–364 m within the study area (Figure 8.2). Maximum multispecies survey biomass within the area was 3.5 kg/set, with three sets containing > 1.5 kg of sea pens (within each SiBA polygon). Where counts were available, a maximum of 370 individuals were present in a single 15-minute trawl set. Both *Pennatula acuelata* (n = 22 sets) and *Anthoptilum grandiflorum* (n = 3 sets) were identified in the area, although in most cases sea pens were identified at the group level (n = 79 sets). The sea pens *Ptilella grandis* and *Balticina finmarchica* have been observed just south of the study area boundary (Figure 8.2).

Sea pens have also been recorded in the study area as part of the redfish surveys (n = 3 sets, Figure 8.2). Catch weights were relatively high (3–5 kg) within and adjacent to the study area. One set conducted 1 km east outside of the study area boundary in Hermitage Channel had 10 kg of sea pens, while another located 15 km east in Hermitage Bay had 8 kg of sea pens (Figure 8.2). Species were not identified, but based on known distributions from multispecies survey data, catches are most likely comprised of *Pennatula aculata*, a small but often numerous species known to form extensive fields in soft substrates (Figure 8.3). A large single colony of *P. aculeata* (~30 cm) can weigh up to 0.05 kg, while juveniles (< 5 cm) weigh less than 0.001 kg (V. Hayes pers. comm.). Therefore, a 10 kg catch can represent 200 individual sea pens, although this number is expected to be variable depending on size and species. Data from historic fishing surveys documented sea pens (n = 18 sets) in Hermitage Channel and Hermitage Bay (Figure 8.2) and are most likely *P. aculata*, again based on known distributions of this species. Using combined data sources, sea pens were documented in Hermitage Channel within the study area using both DFO multispecies survey data (2002–2006) and FOP data (2004–2006) (Wareham and Edinger 2007).

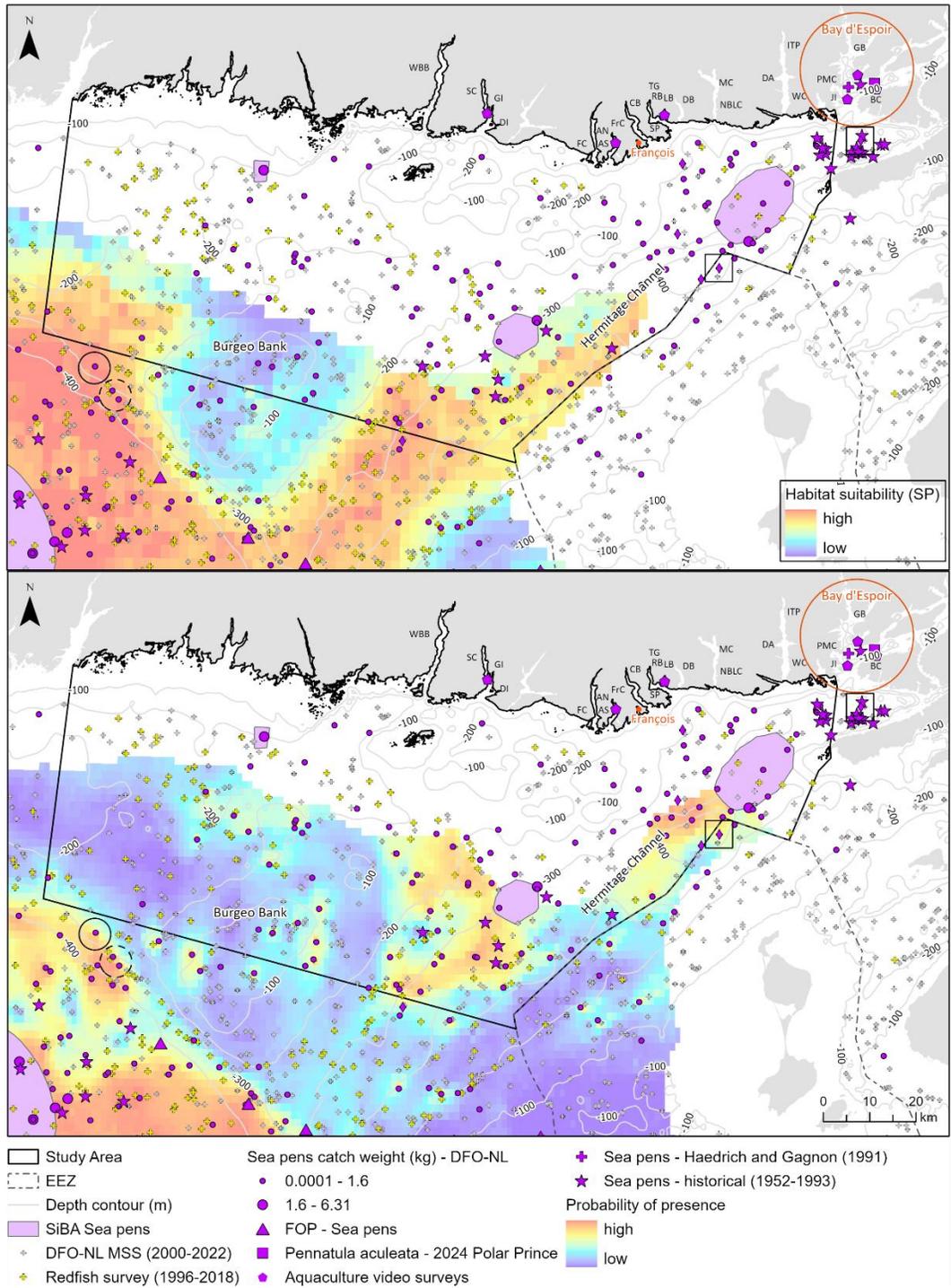


Figure 8.2: Sea pen habitat suitability model from Gullage et al. (2017) (top) and probability of presence model from Guijarro-Sabaniel et al. (2019) (bottom) overlaid with DFO MSS data (2002–2022), redfish survey, 2024 Polar Prince expedition, aquaculture surveys (DFO 2022d), Haedrich and Gagnon (1991), and historic fishing records within and outside of the study area. Black circles represent *Ptillella grandis* (full circle) and *Balticina finmarchica* (dotted circle) and black squares highlight the two high catches from the redfish survey. Acronyms for coastal sites are described in Figure 8.1.

Sea pen fields (*Pennatula aculeata*, Figure 8.3) have been observed *in situ* within the study area as a result of aquaculture industry seafloor video surveys conducted in Little Bay and Wild Cove at depths > 200 m (DFO 2022d), as well as Aviron North and Gnat Island (DFO 2024d) (Figure 8.2). Sea pen fields have also been observed *in situ* at multiple sites near the study area, in Bay d'Espoir, as a result of both industry surveys (DFO 2022d) and targeted research expeditions in 1985 (Haedrich and Gagnon 1991), 2023, and 2024 (Broad et al. 2023, V. Hayes pers. comm.). In Bay d'Espoir, sea pens were identified in Butter Cove, Goblin Bay, Pass My Can, and Jervis Island (DFO 2022d, Figure 8.3).

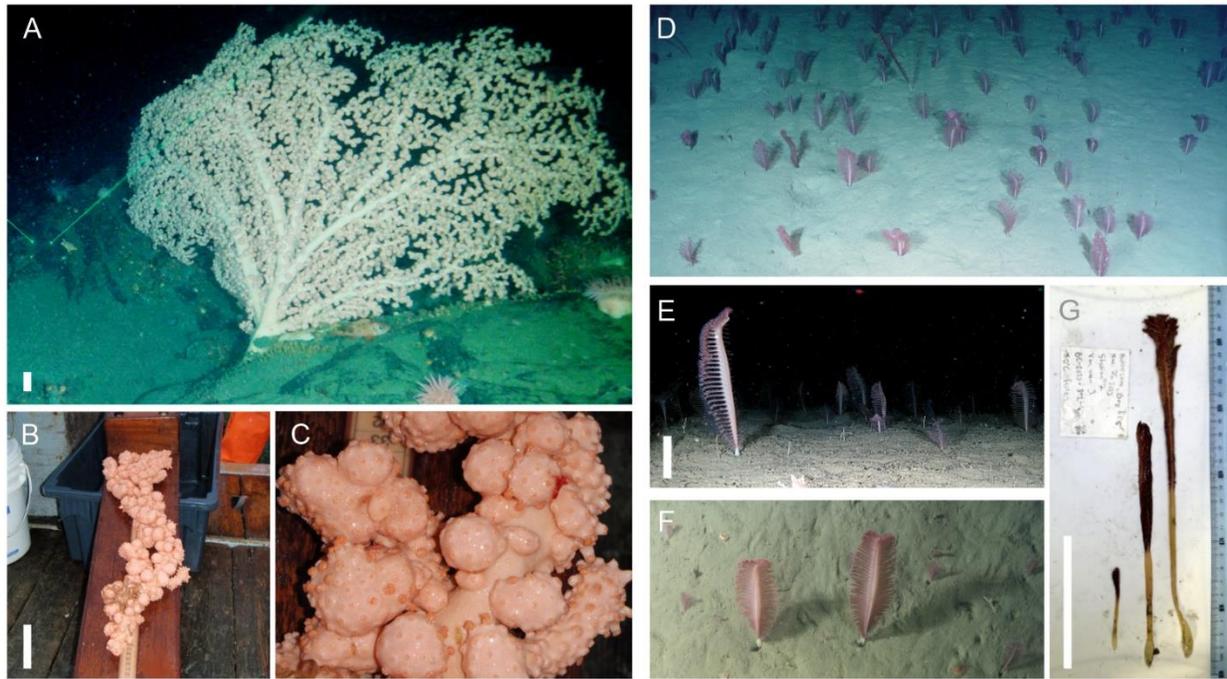


Figure 8.3: The large gorgonian *Paragorgia arborea* (A–C) and the sea pen *Pennatula aculeata* (D–G). A) *Paragorgia arborea* in Bay d'Espoir, estimated to measure ~1.8 m x 2.6 m. B–C) fragment (91 kg) collected from Hermitage Bay as part of a 2010 FOP monitoring. D–F) *Pennatula aculeata* fields in NAFO Div. 3O (D), Bay d'Espoir (E), and Laurentian Channel MPA (F). G) three size classes of *P. aculeata* colonies sampled with a Van Veen grab in Bay d'Espoir (scale = 10 cm). Photo credits: A, E) the 3D Lab (Marine Institute); B–C) FOP; D) DFONL-CSSF, 2007; F) CSSF-CHONe-DFO; G) V. Hayes and K. Murray (DFO-NL).

Three previously delineated sea pen SiBAs are located within the study area, with the largest one located in the eastern side of the study area, north of the Hermitage Channel (Figure 8.2). The sea pen habitat suitability models developed by Gullage et al. (2017) using DFO multispecies survey data predict relatively high suitability for sea pens in the Hermitage Channel area and southwest of the study area (Figure 8.2). Similarly, the model by Guijarro-Sabaniel et al. (2016) also using DFO multispecies survey data indicates a high probability of sea pen presence in the Hermitage Channel area and south of the study area (Figure 8.2). However, both models are limited in their spatial scope (e.g., they exclude coastal areas) and habitat suitability/probability of presence data are not available for most of the study area (Figure 8.2).

#### Cup corals

Information on cup coral presence is only available from DFO multispecies survey data. Cup corals were only found on the east side of the study area, within Hermitage Channel, between depths of 282–357 m (Figure 8.4). Maximum cup coral biomass per set was 0.9 kg. Where

counts were available, a maximum of 13 individuals were present in a single set. Cup corals were identified as *Scleractinia* sp. ( $n = 13$  sets) and *Flabellum (Ulocyathus) alabastrum* ( $n = 4$  sets). The habitat suitability model for *F. alabastrum* (Gullage et al. 2017) is similar to the sea pen model and indicates a relatively high suitability in the Hermitage Channel area and southwest of the study area (Figure 8.4). Both sea pens and *F. alabastrum* cup corals prefer soft sediments.

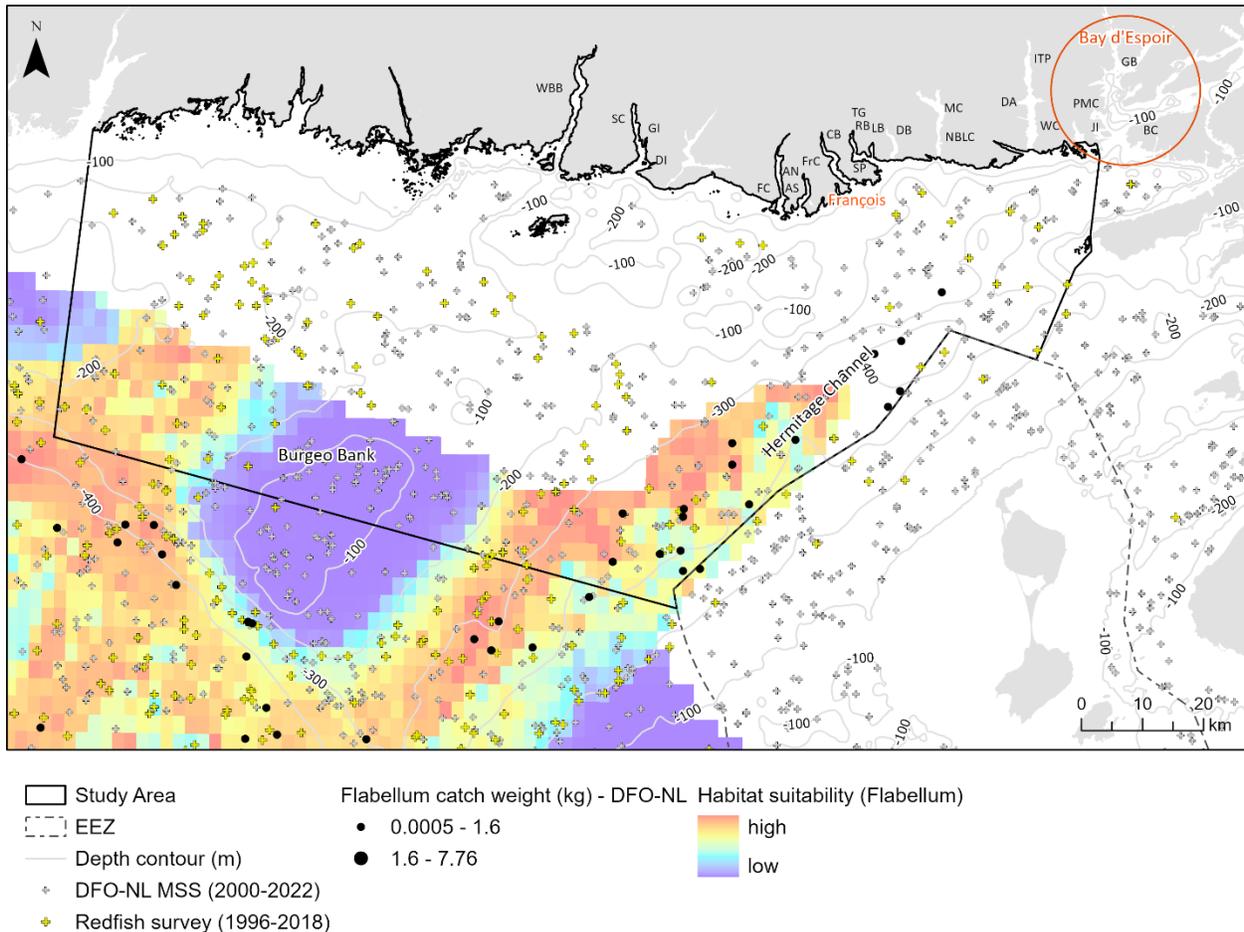


Figure 8.4: *Flabellum (Ulocyathus) alabastrum* habitat suitability model from Gullage et al. (2017) overlaid with DFO trawl data (2002–2022) within and outside of the study area. Acronyms for coastal sites are described in Figure 8.1.

### Soft corals

Information on soft coral presence is available from DFO multispecies survey data, FOP, and coastal video surveys. Based on multispecies survey data, soft corals were present between mean depths of 69–340 m, mostly near the southernmost boundary of the study area (Figure 8.5). Maximum multispecies survey biomass was 0.17 kg. Soft corals were identified as *Octocorallia* soft coral sp. ( $n = 5$  sets), *Duva florida* ( $n = 5$  sets), *Gersemia rubiformis* ( $n = 2$  sets), and *Drifa* sp. ( $n = 1$  set). One soft coral (*Duva florida*) was reported from FOP data within the study area (Figure 8.5).

In coastal areas, soft corals are the most widespread coral group, being reported from every site from where video surveys have been conducted (e.g., DFO 2022d, unpublished aquaculture baseline reports). This group of corals is also common in Bay d’Espoir (DFO 2022d, Broad et

al. 2023, V. Hayes pers. comm.). Soft corals are generally identified as a group due to challenges with species identification from imagery (e.g., Command et al. 2024), but generally belong to the genera *Duva*, *Drifa*, *Gersemia*, and *Pseudodrifa*.

The habitat suitability model for soft corals (referred to as Nephtheidae in Gullage et al. 2017) points to a high habitat suitability in the south of the study area, in the Burgeo Bank area (Figure 8.5). This is contrary to the sea pens and cup coral models, where suitability on the bank is predicted to be low (Figure 8.2, Figure 8.4). Soft corals can be found in shallower waters in comparison to other coral groups in the region, and no models exist for those areas. As reported above, multispecies survey data indicates soft coral records at 69 m as the shallowest depth, and other data indicates coastal areas (including < 69 m) are also home to them (e.g., DFO 2022d). Soft coral gardens (i.e., high coral densities) have been recently identified in the Funk Island Deep marine refuge off northeastern Newfoundland at depths of 50–75 m (E. Broad pers. comm.; Baird 2024). Similar soft coral communities might be present in Burgeo Bank (or other sites in the study area), but video surveys are required to investigate this hypothesis.

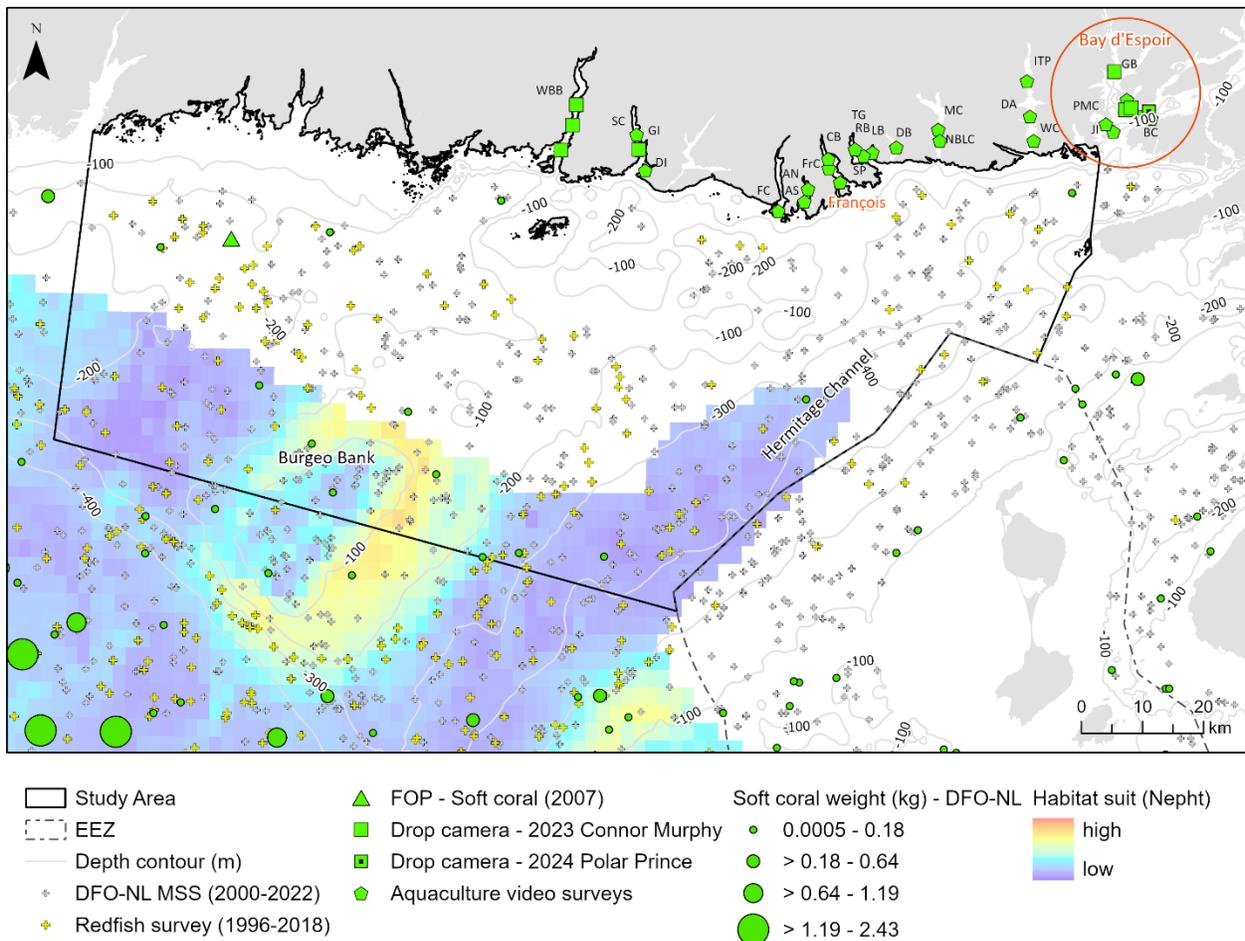


Figure 8.5: Soft coral, referred to as 'Nephtheidae', habitat suitability model from Gullage et al. (2017) overlaid with DFO trawl data (2002–2022), redfish survey, Fisheries Observer Program (FOP), drop camera surveys, and aquaculture surveys (DFO 2022d) within and outside of the study area. Acronyms for coastal sites are described in Figure 8.1.

### *Large gorgonians*

Information on large gorgonian presence is available from DFO multispecies survey data, FOP, redfish, and coastal video surveys. Based on multispecies survey data, the large gorgonian *Paragorgia arborea* (Figure 8.3) was present in one set within the study area, at a mean depth of 249 m (Figure 8.6). This sample was found on the east end of the study area, with another observation near the study area, at ~5 km east of the boundary (Figure 8.6). Near the western boundary of the study area, another large gorgonian species was confirmed, *Paramuricea placomus* (Figure 8.6).

Large gorgonians have also been recorded in the study area as part of a redfish survey set, which yielded a 2 kg catch of *Paragorgia arborea* within the study area, near the eastern boundary (Figure 8.6). *P. arborea* has also been recorded in the region as part of the FOP, which yielded two confirmed observations 1 km apart, at ~200 m depth in Hermitage Bay, east of the study area (Figure 8.3 and Figure 8.6). A total of 91 and 90 kg of *P. arborea* were discarded from these two sets in 2010 and 2011, respectively. Figure 8.3 shows an image of a broken *P. arborea* caught in the 2010 set. In addition to multispecies surveys, FOP, and redfish surveys, data from historical research surveys show a 1988 coral record from Hermitage Bay, classified as a 'red coral', weighing 2.27 kg, which possibly refers to *P. arborea* (V. Hayes pers. comm.), given that it is the only tree-like red coral species known in the area.

*Paragorgia arborea* has also been identified from seafloor imagery at multiple sites in Bay d'Espoir, both as part of aquaculture siting baseline assessments (DFO 2022d, Jervis Island) and targeted research expeditions in 1985 (Haedrich and Gagnon 1991) and 2024 (V. Hayes pers. comm., see Figure 8.3). During the Haedrich and Gagnon (1991) expedition, an attempt was made to sample a large branching coral on a vertical wall near Goblin Head. The sample was lost and never recovered, so there is no mention of it in their publication. However, review of the video revealed that the lost sample was a *P. arborea* colony, further confirming this species in Bay d'Espoir (V. Hayes pers. comm.).

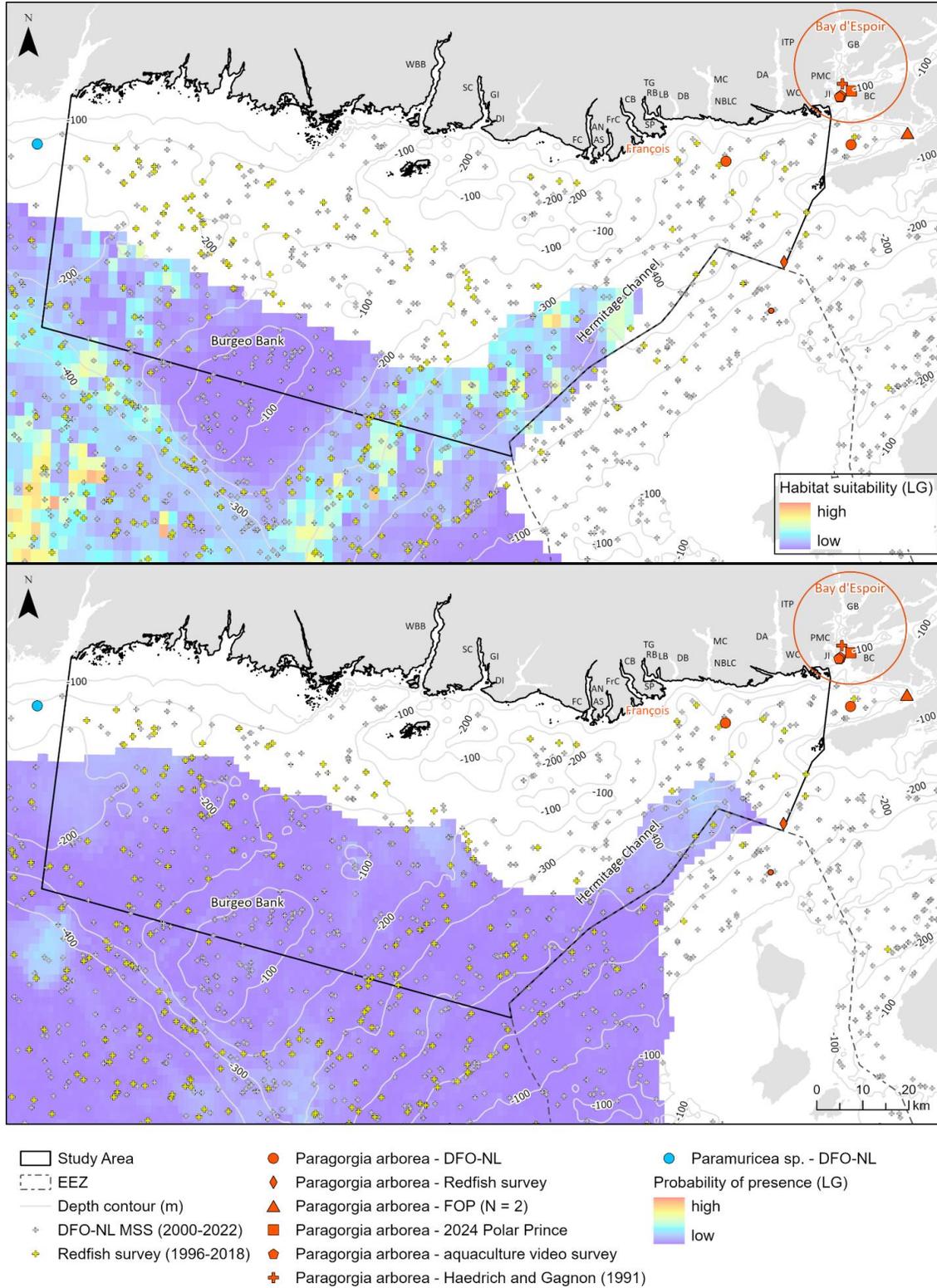


Figure 8.6: Large gorgonian habitat suitability from Gullage et al. (2017) (top) and probability of presence from Guijarro-Sabaniel et al. (2016) (bottom) overlaid with DFO MSS data (2002–2022), redfish survey, FOP, 2024 Polar Prince expedition, aquaculture survey (DFO 2022d), and Haedrich and Gagnon (1991) within and outside of the study area. The two FOP records of *Paragorgia arborea* are only 1 km apart and not distinguishable at the presented scale. Acronyms for coastal sites are described in Figure 8.1.

## Sponges

Information on sponge diversity is largely incomplete for NL Region due to challenges associated with species identification, as detailed earlier. Nevertheless, > 150 species are estimated to exist in the region (V. Hayes pers. comm.), which is likely an underestimation considering that trawl surveys exclude coastal areas and untrawlable substrates such as rock-walls and outcrops, where sponges also thrive. Multiple sponge species caught within the same set cannot be identified at sea due to time constraints and requirements, as stated above. As a result, all sponges collected as part of DFO multispecies surveys are grouped to the phylum level at sea (i.e., Porifera) with one total catch weight recorded per trawl set. In some cases, sponges are further identified to lower taxonomic levels when samples are submitted to DFO-NL. Catch weights have been used as a proxy to identify key areas such as *Geodia* sponge fields (e.g., > 200 kgs/per set) but 'lighter' species that are also relatively large (e.g., *Asconema* glass sponges) are underestimated using this method.

Sponges were present in 32% of the multispecies survey sets located within the study area (2004–2022, n = 104 of 324 sets), between mean depths of 66–338 m, more concentrated towards the western side of the area (Figure 8.7). The maximum sponge catch weight per set was 8.25 kg from a set on Burgeo Bank, near the southernmost boundary (Figure 8.7). This catch is relatively low compared to other areas within the region (> 1000 kgs in some cases) and had no species diversity information associated with it. The second largest catch was 6.7 kg, and included several samples submitted to DFO-NL for identification. Samples included large fan sponges *Mycale (Mycale) lorea* and other unidentified species. Another set recorded 13 species with a much lower total catch weight (0.25 kg), but with higher species diversity, which included large fan sponges *Mycale (Mycale) lorea* and *Mycale (Mycale) lingua*, both identified as nursery for bob-tail squids (*Rossia* sp.), with eggs commonly documented embedded within sponges (Hayes et al. 2017, Aldrich and Lu 1968). Other larger species included *Haliclona* sp., *Hemigellius arcofer*, *Iophon* sp., and *Suberites* sp. However, most sponges were relatively small (< 5 cm) and mostly from the family Polymastiidae (*Polymastia* cf. *andrica*, *Polymastia hemisphaerica*, *Polymastia* cf. *uberrina*, *Polymastia* sp., *Spinularia* cf. *sarsii*, *Trachyteleia hispida*, and *Tentorium semisuberites*). Others included encrusting cushion sponge *Tendania (Tendania) suctoria*, mud-associated *Thenea* sp. sponge, and other species still to be identified (Porifera spp.).

Sponges were also documented as part of the redfish surveys (Figure 8.7). A total of 56 sets in the general region contained sponges (4.2% of 1330 sets), of which 10.4% were found within the study area (n = 10 sets). Similar to multispecies surveys, catch rates were also relatively low (< 10 kg) compared to other areas within the region (e.g., 100s–1000s kg, NAFO Div. 2K and 3L). Data from historic fishing surveys also documented sponges (n = 26 sets) in the Hermitage Channel as well as Burgeo Bank westward throughout the study area. Sponges have not been reported from FOP surveys in the study area.

No sponge SiBA has been identified within the study area (based on 1996–2015 data), but a small SiBA west of the study area exists (Kenchington et al. 2016). Several portions of the study area have a high probability of sponge presence (Guijarro-Sabaniel et al. 2016), mostly on the western side (Figure 8.7).

In coastal areas, sponges have been reported from every site from where video surveys have been conducted within the study area (DFO 2022d) and also nearby areas such as Bay d'Espoir (DFO 2022d; Broad et al. 2023, V. Hayes pers. comm.). Sponges are generally identified as morphotypes due to challenges with species identification from imagery (e.g., Command et al. 2024). Identification of sponges at the species level is often not recommended using imagery alone due to the high level of morphological plasticity shown by this group. However, certain

taxa can be identified to low taxonomic levels with a certain degree with confidence, particularly when they present distinctive characters that can be observed in an image. For instance, in Bay d'Espoir the sponge *Stylocordyla borealis* has a unique “Lollypop” morphology that allows it to be identified from imagery. Caution needs to be taken when using data on sponge diversity from imagery surveys, particularly if samples have not been collected to confirm ID, and if the method and literature utilized to identify the species is not stated. Data on sponge distribution and diversity patterns from the industry video surveys was not available for analysis at the time of writing.

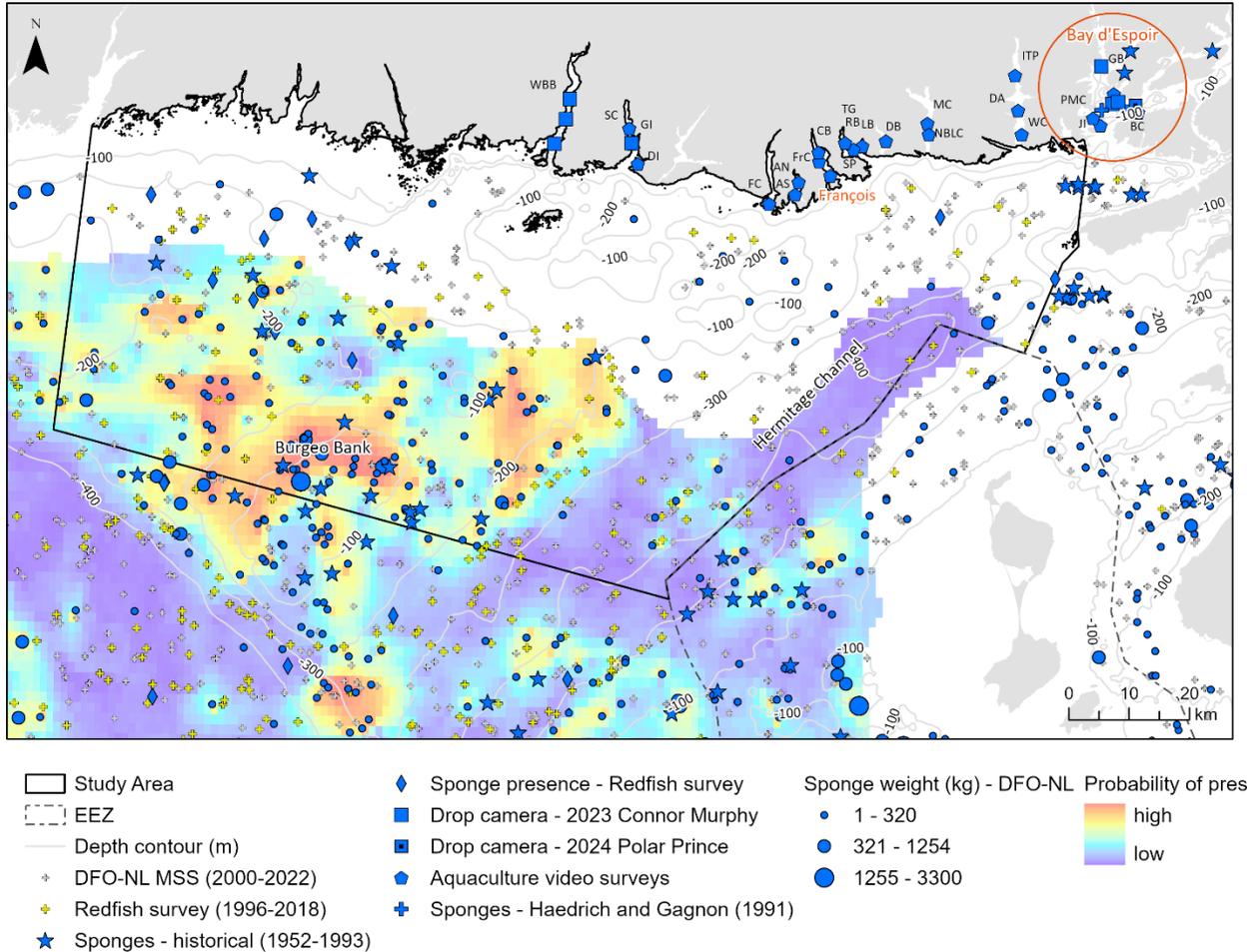


Figure 8.7: Sponges probability of presence model from Guijarro-Sabaniel et al. (2016) overlaid with DFO MSS data (2004–2022), redfish survey, FOP, drop camera surveys, and aquaculture survey (DFO 2022d) within and outside of the study area. Acronyms for coastal sites are described in Figure 8.1.

## Data Gaps and Recommendations

Our data show the presence of widespread corals and sponges within and near the study area, sometimes in significant concentrations (e.g., sea pen SiBAs). Of particular interest is the conspicuous presence of the large gorgonian *Paragorgia arborea* inside of the study area (east side) and adjacent to the study area (Bay d'Espoir and Hermitage Bay). Large gorgonians, particularly *P. arborea*, are slow-growing and long-lived Vulnerable Marine Ecosystem (VME) indicators (Fuller et al. 2008). In fact, one of the colonies observed from video is 1.8 x 2.6 m wide (Figure 8.3A) which could indicate an age of 112–162 years, based on growth rates of

1.6 cm.yr<sup>-1</sup> (Sherwood and Edinger 2009). Additional large colonies (e.g., 0.9 x 1.3 m, ~80 years old) have been identified near Jervis Island (DFO 2022d).

While isolated records of these large gorgonians are also of interest, the combined data from multiple sources highlights a trend of suitable habitat for this species within and adjacent to the study area, and further research is warranted. Although the two models used to identify areas of large gorgonian habitat suitability/probability of presence did not agree on locations, the Gullage et al. (2017) model does indicate areas of high suitability for this group. Furthermore, the lack of model data for most of the study area (including bays and fjords) is a limitation in our understanding of coral distribution therein. In addition, the presence of three sea pen SiBAs and indication of high sea pen habitat suitability/probability of presence models in parts of the study area indicate that sea pen fields are likely to occur elsewhere in the area, similar to those observed in Little Bay (within the study area; DFO 2022d) and Bay d'Espoir. Sea pens are also VME indicators (Fuller et al. 2008, Baco et al. 2023).

Given the widespread and not always concurrent distribution (actual or predicted) of different coral groups and sponges, video surveys targeting specific areas are paramount to better understand coral and sponge distribution, their drivers and significance in the area.

Other data gaps include:

- Data on corals and sponges in coastal areas west of Bay d'Espoir is mostly available from unpublished aquaculture industry baseline environmental assessment reports. Their current fate in areas where aquaculture activities have been initiated is currently unknown. For instance, sea pen fields were identified underneath the proposed cage arrays for Little Bay (DFO 2022d).
- To our knowledge, data on corals and sponges in coastal areas west of White Bear Bay near François are currently not available.
- Sponge diversity information from trawl and seafloor video surveys is limited.
- Large portions of the study area still lack high definition multibeam data, required to better identify areas of high relief or other substrate, and preferred coral habitats (e.g., Cote et al. 2023).
- Coral and sponge habitat suitability models are lacking for most of the study area.

Specific recommendations include:

- To facilitate access to aquaculture industry baseline environmental assessment data on corals and sponges (and other megabenthic fauna). Data is so scarce in the area that in some cases it is possible that industry data is the only available information for the sites (i.e., particularly in deep-water, non-SCUBA diving depths).
- To increase sampling effort in coastal areas, including video surveys and other non-invasive sampling (e.g., ROV), and a strategic sampling design that targets various areas, depths, and habitats.
- To develop seafloor imagery ID guides for the coastal sites in the study area.
- To promote the allocation of funding and human resources (e.g., students) to improve sponge species identification in NL Region.

- To target areas of expected high topography for multibeam sonar surveys, which can assist with the target selection of specific areas for video surveys and identification of coral and sponge potential habitat.
- To ground-truth (using drop camera and/or ROV) high suitability areas for corals and/or sponges identified by Gullage et al. (2017) and Guijarro-Sabaniel et al. (2016), as well as the sea pen SiBAs located within the study area.
- To video-survey locations with bycatch records of the large gorgonian *P. arborea* in the study area.
- To video-survey coastal areas west of White Bear Bay.
- To video-survey coastal areas where aquaculture activities have been active to assess coral and sponge current state (i.e., abundance, distribution).

## 9. AQUATIC INVASIVE SPECIES

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### Available Information

Aquatic invasive species (AIS) are non-native species that pose ecological and/or economic threats to Canada's waters and resources. In response to these threats, DFO established a program in 2006 to detect and track the spread of aquatic invasive species in Canadian waters. In the NL region, these species include biofouling organisms (tunicates, bryozoans, crustaceans, seaweeds), European Green Crab, and recently, several freshwater species. Marine AIS are primarily found in coastal, nearshore areas on, or near, vessels and man-made structures such as floating docks, wharves, and other infrastructure and gear.

DFO NL Science monitors for AIS in partnership with other DFO branches (AIS National Core Program, Aquatic Ecosystems), the Provincial Department of Fisheries, Forestry and Agriculture, the Newfoundland Aquaculture Industry Association (NAIA), Harbour Authorities, Indigenous Groups, ACAP Humber Arm, Memorial University, and community groups for early detection of these species and to determine the range of their distributions within the province. Methods for detecting AIS used by DFO and their partners include the use of settlement plates, traps, seines, eDNA (water samples), qPCR (species confirmation), dive surveys at wharves and on vessels, and video surveys at high-risk harbours. The data collected from DFO's monitoring program and their partners provides an overview of the distribution of AIS in the NL region. Several recent AIS have been found in the South Coast Fjords study area, particularly in the towns of Burgeo and McCallum. Information on the presence, distribution, and method or vector of introduction and spread of AIS can help in the early detection, prevention and control of AIS in NL.

DFO's National Marine Biofouling Monitoring Program conducts annual field surveys to monitor the introduction, establishment, spread, species richness, and relative abundance of native and some non-native species in the NL region since 2006. Standardized monitoring protocols employed by DFO's NL, Maritimes, Gulf, and Quebec regions include biofouling settlement plates deployed from May to October at georeferenced intertidal and shallow subtidal sites, including public docks and public and private marinas and nautical clubs. Initially (2006–2017), the collectors consisted of three 10 cm by 10 cm PVC plates deployed in a vertical array and spaced approximately 40 cm apart, with the shallowest plate suspended at least 1 m below the surface to sample subtidal and shallow intertidal species (McKenzie et al. 2016a). Three

replicate arrays were deployed at least 5 m apart per site. Since 2018, collector networks have been modified to improve statistical replication, including up to 10 individual plates deployed per site at 1 m depth and at least 5 m apart (as above) from May to October. Since 2006, seven invasive biofouling organisms have been detected in Newfoundland and Labrador harbours, marinas, and coastal areas.

## **Tunicates**

### *Golden star tunicate (Botryllus schlosseri) 2006*

Golden star tunicate (DFO 2011c) was the first invasive tunicate detected in NL waters. It was found in 2006 on wharf structures in Argentia, Placentia Bay, during the first AIS survey (Callahan et al. 2010), but was reported once previously in 1945 on the west coast (United States Navy 1951). This colonial tunicate is recognized by its star-shaped grouping of individuals. It is currently found in Placentia Bay, Fortune Bay, St. Mary's Bay, Conception Bay, and the west coast of insular Newfoundland. Figure 9.1 indicates the location of this AIS on the south coast of Newfoundland (yellow circles).

### *Vase tunicate (Ciona intestinalis) 2012*

Vase tunicate (DFO 2013b) is a high-impact invasive solitary tunicate and was first detected by DFO in 2012 on the Burin Peninsula at Ship Cove - Burin, Placentia Bay. Various mitigation measures contained it to a small area for four years (McKenzie et al. 2016b). First detected in Fortune Bay in 2016, increasing reports of Vase tunicate have been made along the south coast as far as Burgeo. It has also been detected on the west coast of insular Newfoundland. Figure 9.1 indicates the location of this AIS on the south coast of Newfoundland (red circles).

### *Violet tunicate (Botrylloides violaceus) 2007*

Violet tunicate (DFO 2011d) was first detected in NL waters in 2007 in Belleoram, Fortune Bay, on wharf structures and vessels (McKenzie et al. 2016b). This colonial tunicate forms irregular-shaped colonies usually of a solid color (orange, purple, yellow, or cream). It is currently found in relatively small colonies in five harbours in NL: Placentia Bay (2 locations), Conception Bay (1 location), and the west coast of insular Newfoundland (2 locations). Figure 9.1 indicates the location of this AIS on the south coast of Newfoundland (violet circles).

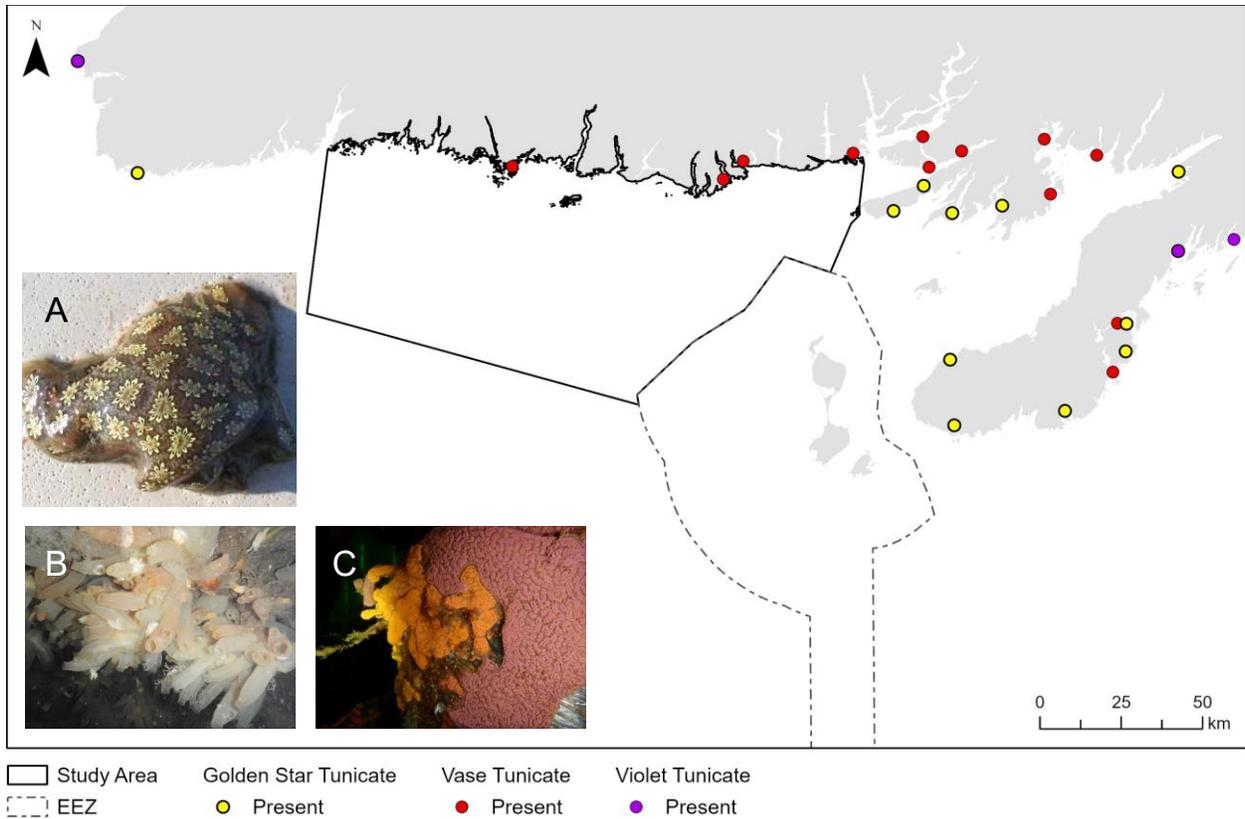


Figure 9.1: Distribution map of invasive tunicate species along the south coast of Newfoundland including within the South Coast Fjords study area. A) Golden star tunicate; B) Vase tunicate; C) Violet tunicate.

## Bryozoans

### *Coffin box bryozoan (Membranipora membranacea) 2002*

Coffin box bryozoan (DFO 2011b) is a filter feeding animal that forms white-colored encrusting colonies, particularly on seaweed, but also on vessels and other surfaces. The individual animals within the colony, called zooids, are rectangular or “coffin box” shaped. It was first detected on the west coast of Newfoundland in 2002 and has since spread throughout insular Newfoundland and parts of southern Labrador. Figure 9.2 indicates the location of this AIS on the south coast of Newfoundland.

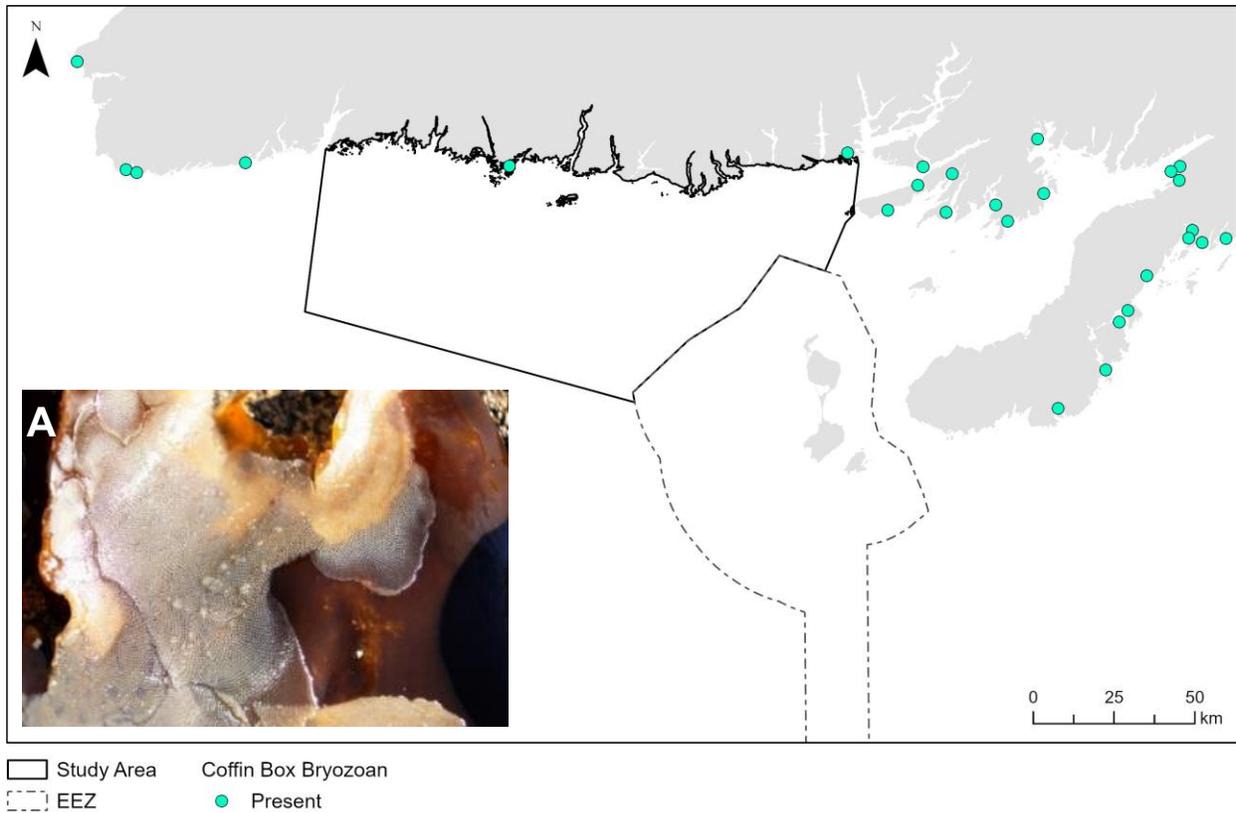


Figure 9.2: Distribution map of Coffin box bryozoan along the south coast of Newfoundland including within the South Coast Fjords study area. A) Coffin box bryozoan.

#### *Orange ripple bryozoan (Schizoporella japonica Ortmann) 2022*

Orange ripple bryozoan is a heavily calcified encrusting species, usually orange in colour, found mainly on man-made structures, rocks, shellfish, and vessels. Initial colonies form flat circular sheets but as it grows it may become bi-layered with the overgrowing layer being flakey with raised edges or lobes. It was first identified in NL in 2022 in Arnold's Cove, Placentia Bay, but has likely been in NL since at least 2018 and has since been detected in several locations in Placentia Bay and Fortune Bay. A 2023 survey of the south coast of Newfoundland found several harbours invaded by this species, including within the South Coast Fjords study area. Figure 9.3 indicates the location of this AIS on the south coast of Newfoundland.

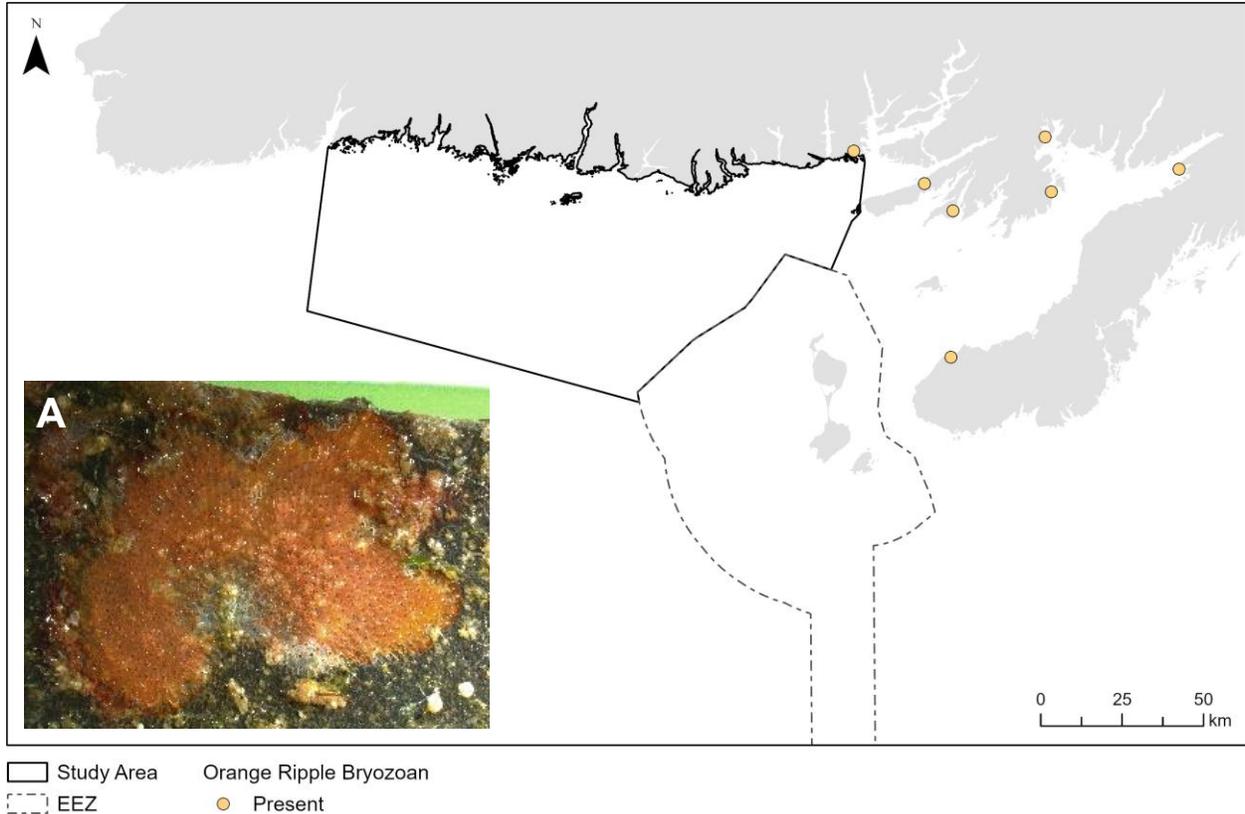


Figure 9.3: Distribution map of Orange ripple bryozoan along the south coast of Newfoundland including within the South Coast Fjords study area. A) Orange ripple bryozoan.

### Crustaceans (Biofouling)

#### *Japanese skeleton shrimp (Caprella mutica) 2006*

Japanese skeleton shrimp is large caprellid amphipod species that was first found on settlement plates in Placentia Bay during the first AIS biofouling survey in 2006. This species is currently found in many places in Placentia Bay and Fortune Bay on the south coast of Newfoundland, as well as two locations in Conception Bay. This species inhabits, sometimes in large numbers (100,000s) ropes, moorings, and docks. Figure 9.4 indicates the location of this AIS on the south coast of Newfoundland.

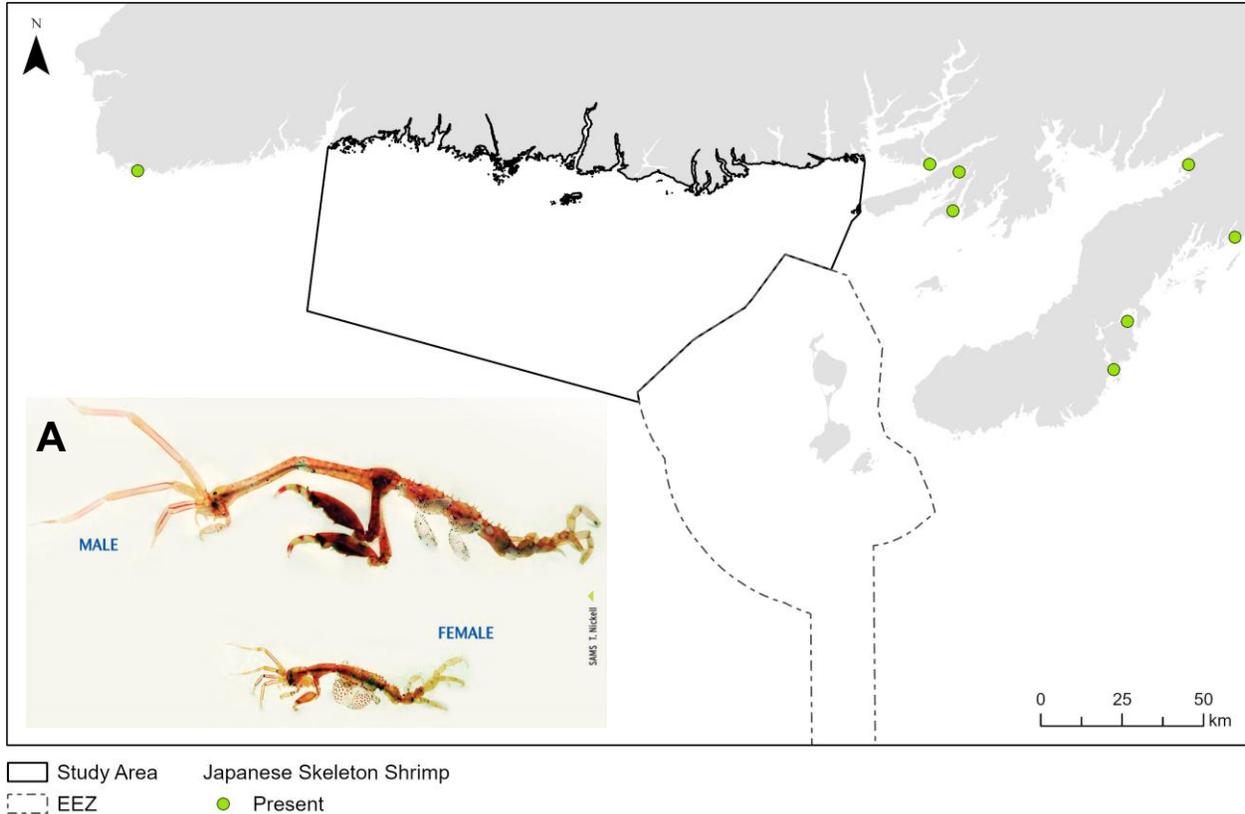


Figure 9.4: Distribution map of Japanese skeleton shrimp along the south coast of Newfoundland including the South Coast Fjords study area. A) Japanese skeleton shrimp.

## Seaweed

### *Oyster thief (Codium fragile) 2012*

Oyster thief (DFO 2013a) is a green seaweed with thick spongy Y-shaped branches that resemble fingers, which is why its alternate common name is dead man's fingers. This invasive species was first found in Placentia Bay in 2012 (Matheson et al. 2014). It is now found in several locations in Placentia Bay and Fortune Bay and also in a small area of Notre Dame Bay on the northeast coast of Newfoundland. It has not been detected in the South Coast Fjords study area (Figure 9.5).

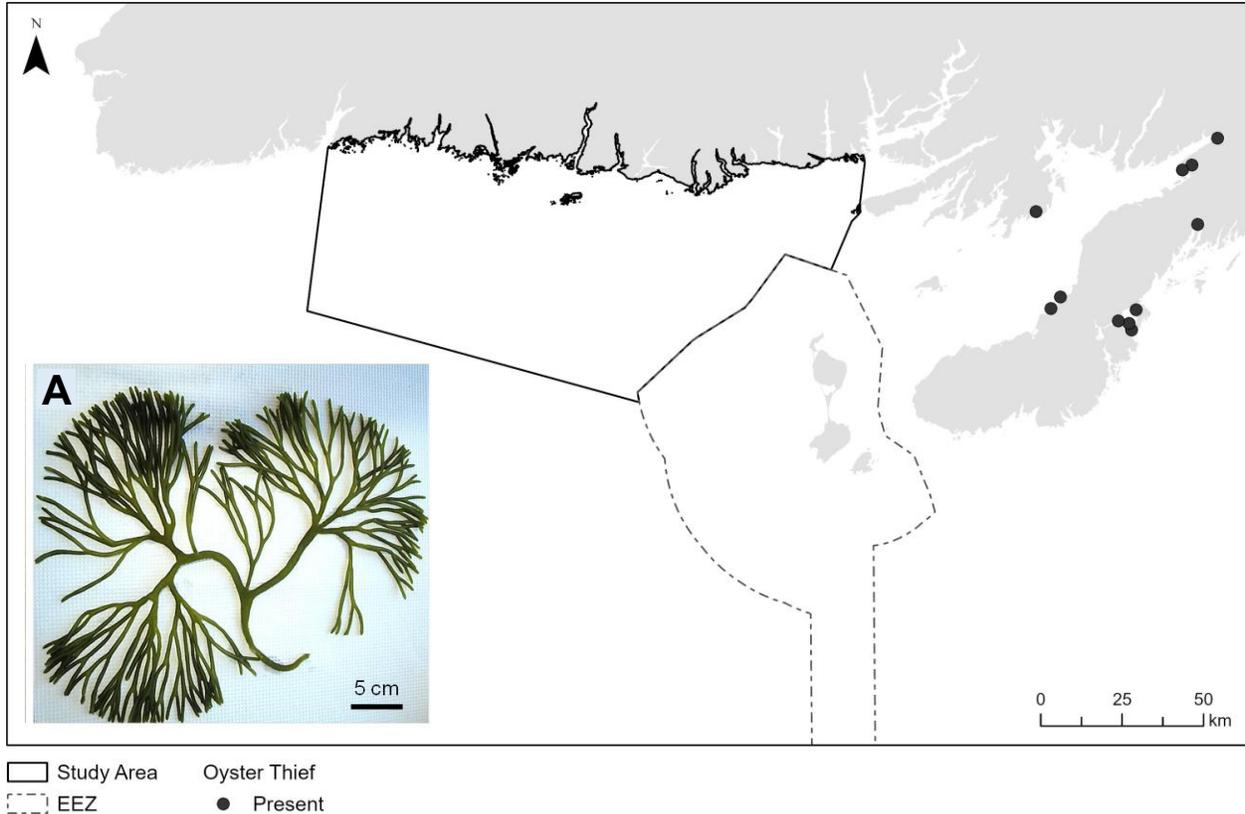


Figure 9.5: Distribution map of Oyster thief along the south coast of Newfoundland including the South Coast Fjords study area. A) Oyster thief.

### Crustaceans (Mobile)

#### *European Green Crab (Carcinus maenas) 2007*

DFO's AIS Science Program has conducted annual field surveys to monitor the introduction, establishment, spread, and relative abundance of the European Green Crab (EGC) in the NL region since 2007. Standardized monitoring and trapping protocols (McKenzie et al. 2022) are used by DFO's NL, Maritimes, Gulf, Quebec, and Pacific regions. The Fukui trap is the most commonly used trap, but other methods are also used including shoreline collection, seining, and dive surveys. Fukui traps have been deployed annually at both new and long-term monitoring locations throughout coastal NL, particularly within Placentia Bay when they were first detected in North Harbour in 2007 (Blakeslee et al. 2010). The EGC has now spread throughout Placentia Bay and into Fortune Bay and St. Mary's Bay. A separate invasion occurred on the west coast of Newfoundland (2009) and is spreading eastward along the south coast. It should be noted that these are two different populations of EGC: a hybridized population in Placentia and Fortune Bays and a cold tolerant population on the west and southwestern coast of Newfoundland (Lehnert et al. 2018). Figure 9.6 indicates the location of this AIS on the south coast of NL and the South Coast Fjords study area.

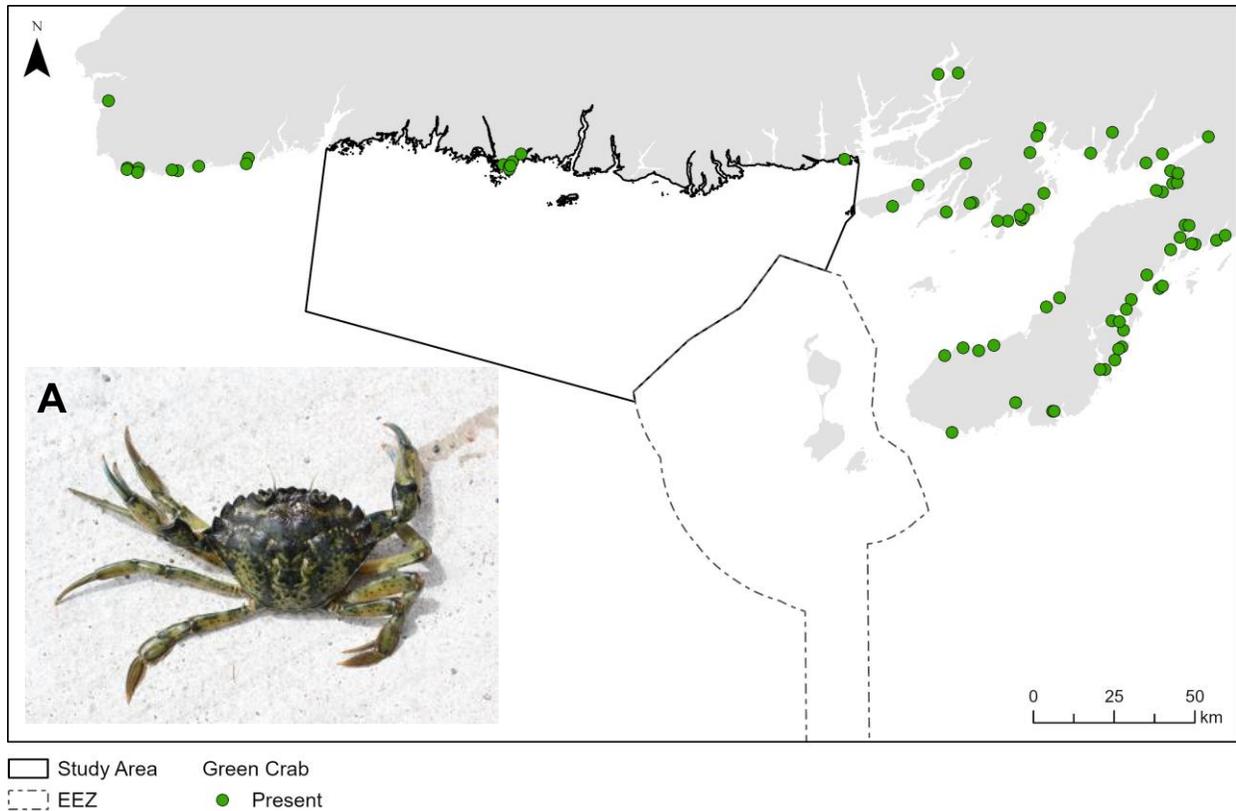


Figure 9.6: Distribution map of European Green Crab along the south coast of Newfoundland including within the South Coast Fjords study area. A) European Green Crab.

### Sensitive Species and Habitats

There are five AIS of concern in the South Coast Fjords study area: Vase tunicate, Golden star tunicate, Coffin box bryozoan, Orange ripple bryozoan, and European green crab. These are all nearshore coastal species.

Vase tunicate is an invasive species that has a high impact on the marine environment and the economy of several industries. It has an elongate, translucent body (often yellow or orange in colour; Figure 9.1B) and can grow up to 15 cm long comprised mostly of water, and as such, adds considerable weight to any structure or gear on which it grows. It grows on most hard surfaces including manmade structures like wharves, floating docks, boat hulls, mussel lines, finfish cage nets and rope mooring lines, but also on natural substrates like kelp and rocks (DFO 2013b). Once established in an area this species often grows in very dense groups covering almost the entire surface (Figure 9.7).

Vase tunicate is believed to have originated from the northeast Atlantic and was first reported in three locations in southwestern Placentia Bay in 2012 (Sargent et al. 2013). Annual surveys for invasive species in Newfoundland suggested vase tunicate had remained contained to that area of Placentia Bay following several mitigation and control measures until 2016 when it was reported at one location in Fortune Bay. Since then, reports have been increasing westward along the south coast of the island and it was even detected on the west coast in St. George's Bay. Many of these reports have come from industry, local harbour authorities, and partners outside of DFO. Reports of this species have been increasing since 2018 as it is rapidly colonizing the south coast of Newfoundland, especially Fortune Bay, where it now ranges from Rencontre East to Burgeo (Figure 9.1). Vase tunicates can reproduce continuously for several

months but their larvae settle out and attach to a substrate in less than a week, and as such, this species can only disperse a short distance on its own. However, it can travel longer distances through the movement of infected vessels or gear. When it arrives in a new area, this species is able to quickly colonize an area outcompeting many native species which makes it a high impact biofouling organism. Vase tunicates also grow on boat hulls which add extra weight and create extra drag on the vessel, increasing fuel and maintenance costs.



Figure 9.7: Vase tunicates growing on kelp and wharf structures.

Golden star tunicate is an invasive colonial tunicate species that is native to the Mediterranean Sea but is now considered cosmopolitan as it has been reported on all continents except Antarctica. Colonies can grow up to 15 cm in diameter. Despite its name, there are many colour variations for this species including yellow, orange, purple, red, brown, or black. It commonly grows in sheltered areas on natural substrates such as kelp, rocks, and shellfish, and on artificial substrates like wharves, floating docks, aquaculture gear, moorings, and boat hulls. This species can reproduce in two ways: sexual reproduction that releases free-swimming larvae; and fragmentation whereby part of the colony breaks off and settles elsewhere. Larvae usually settle out within 48 hours and as such has limited dispersal capability on its own, and most larvae settle within a few metres of the parent colony. Colony fragments however may reproduce for up to 40 days and disperse over greater distances. When water temperatures drop below 6°C, colonies enter a resting state where the colony itself reduces in size or dies back. As with other biofouling invasive species, Golden star can be spread through the movement of infected fishing and aquaculture gear, shellfish, and boats (DFO 2011c).

Tunicates, such as Golden star, are filter feeders and when it occurs in high abundance it can compete with native filter feeding organisms such as mussels and scallops. When established it can grow rapidly over plants and animals depriving them of sunlight and food and may even suffocate some smaller organisms, such as juvenile molluscs. This species can be problematic to shellfish harvesters, aquaculture farmers and native benthic species.

Coffin box bryozoan grow on artificial structures, vessel hulls and on the blade portion of seaweeds, particularly *Laminaria* species of brown seaweeds. As a biofouling organism it is introduced and spread on vessels and gear. It also is distributed naturally through the

movement of currents. This AIS has been found in many areas of NL, particularly on the west coast of Newfoundland. In Nova Scotia, this species has reduced the habitat of kelp forests and led to the replacement of these important habitats with the invasive species, Oyster thief, discussed below. This bryozoan invades and covers the blades of several kelp species and causes the blade to be inflexible and easily broken. Normally, the blade of the seaweed would be flexible and flow with the current. Kelp infested with this bryozoan break off and do not grow back (seaweed grow from the tip of the blade) for the rest of the growing year. This can impact large areas of kelp forests and change the habitat and the species that depend on these habitats (DFO 2011b).

Orange ripple bryozoan is a fast-growing, highly competitive, cold-water bryozoan species that can reproduce into the winter months, as has been observed in Placentia Bay. This species originated from the northwest Pacific from China to Japan. This species is an early colonizer attaching to available open substrates, especially untreated manmade structures like wharves, and vessel hulls where colonies can become extensive and dominate the biofouling assemblage. This species will often outcompete and inhibit the growth of adjacent native species, and if established early, may outcompete some other invasive biofouling species. This species could be a problematic species when fouling harbour structures, vessel hulls, industrial components, or cooling vents. If established on a shellfish aquaculture site, it may reduce the commercial value of the shellfish species and increase processing costs to remove it from the shellfish and aquaculture gear.

European green crab (EGC) is a highly invasive species threatening Canada's Atlantic and Pacific marine and estuarine ecosystems. EGC invasions have potential devastating effects on the environment and local economies. EGC prey on and compete with commercial and recreational shellfish, negatively impact commercial fisheries, and destroy ecologically and biologically significant habitat (e.g., eelgrass) for native species (Matheson and McKenzie 2014, Matheson et al. 2016).

EGC are native to the eastern Atlantic with a broad distribution range extending from northern Europe (Iceland and central Norway) to northern Africa (Morocco and Mauritania). EGC is described as one of the world's 100 worst invasive species and to date there have been no known instances of this species being extirpated after an invasion. This species is highly aggressive, competitive, omnivorous, exhibits wide tolerances for temperature, salinity, and oxygen levels, and can survive out of the water (in a damp environment) for up to three weeks. EGC feeds primarily on shellfish, marine worms, and other small or juvenile crustaceans, but its broad diet may include everything from marine plants to carrion. It also has high reproduction rates and wide larval dispersal, via ocean currents and ship ballast water (DFO 2010).

DFO Science in NL has been trapping EGC for early detection and/or monitoring, and impact research since 2007. The standardized survey and monitoring EGC protocol developed in 2008 uses the Fukui crab trap. This trap has also been used by DFO for mitigation and control studies, but other traps have also been used by DFO and its partners to compare and optimize control and removal.

A review of trapping methods was conducted by DFO in 2022 (McKenzie et al. 2022) and evaluated these protocols and other published studies, and observations from other mitigation trapping activities. Knowledge acquired through these studies includes information on species life history and biology, population dynamics, gear types, and in some cases, catch per unit effort (CPUE) by trapping gear type, bycatch, control measures, and mitigation strategies. This review provided information and advice on EGC trapping for management and mitigation activities including early detection, determining impacts on native species and habitat, and control efforts to prevent ecosystem degradation and commercial fishery loss. The increase in

EGC in the South Coast Fjords area is of great concern to many stakeholders. The specific impacts of EGC on eelgrass, shellfish, native species, and potentially fisheries, including lobster, within the South Coast Fjords are yet to be determined.

### **Prevention and Control**

Preventing the spread of Vase tunicate, Golden star tunicate, Coffin box bryozoan, Orange ripple bryozoan, and European green crab is very important, particularly for vessels and gear, which are the main methods of introduction and spread of these high impact AIS. Clean-Drain-Dry is an awareness campaign promoted by DFO to encourage Canadians to take action to prevent the spread of AIS. This campaign presents a list of best practices to use when moving a vessel, fishing, or aquaculture gear from one area, bay, or cove, to another. These recommendations include:

1. Clean and drain boats, trailer, and other equipment in the same area from which it has been removed;
2. Do not move to another bay to clean your vessel;
3. Try to clean and drain any equipment on land, to prevent any runoff from re-entering the waterway, and clean with freshwater;
4. Dry all equipment before moving it to a new location.

Another way to protect gear and vessels and prevent the spread of Vase tunicate, Orange ripple bryozoan, and other biofouling organisms, is with the use of a copper based antifouling paint. The use of antifouling paints on wharves, docks, and boats will help deter these AIS from attaching to these structures for a period of time, but is most effective if the antifouling coating is reapplied annually.

As this proposed NMCA increases interest for improved data collection and scientific research, etc., in this area, it will be important for all users to adhere to these best practices to prevent the spread of AIS and their impacts throughout the South Coast Fjords study area.

### **Climate Change Considerations**

Many of the AIS found in NL are at the limit of their cold temperature tolerance. As climate change makes southern NL habitat warmer, the risk of invasion and expansion of AIS within the South Coast Fjords area will likely increase. The risk of additional new AIS being able to establish in the warmer climate also increases.

### **Data Gaps and Recommendations**

Although some AIS surveys have been conducted on the south coast, the South Coast Fjords has not been thoroughly investigated due to difficulties in accessing the area. Additional surveys including traditional dive surveys, trapping, sediment plates, as well as newer technologies, such as eDNA, are needed to determine the baseline status of this area. Additional information is needed on the vessel and gear movement that may introduce or spread AIS within the South Coast Fjords. It is important to have baseline information on this issue as discussions continue on the future of this NMCA. In addition, there are knowledge gaps on what impacts AIS are having on the native species and habitats in the South Coast Fjords area.

## 10. SPECIAL AREAS (INCLUDING EBSAS, PROTECTED AREAS, SENSITIVE OR UNIQUE AREAS)

Author: Margaret Warren

### Available Information

#### Ecologically and Biologically Significant Areas

Ecologically and Biologically Significant Areas (EBSAs) are areas that have been scientifically assessed as having a special biological or ecological significance compared to surrounding areas. DFO has developed national guidance for the identification of EBSAs (DFO 2004, 2011a). EBSAs were originally identified for the south coast of Newfoundland in 2007 using a Delphic approach (Templeman 2007) and were subsequently updated in 2017 using a more rigorous, GIS-based approach (DFO 2019a; Wells et al. 2019). During that process, a total of 14 EBSAs were identified in the Placentia Bay-Grand Banks Large Ocean Management Area, with the South Coast (3P) EBSA overlapping partially with the South Coast Fjords study area (Figure 10.1). The EBSA boundary goes from Cape Ray in the west, to just east of Ramea and extends out 35–40 km from the coast. This area is known to be important habitat for the endangered blue whale and other marine mammals. Other key ecological features include important areas for Atlantic Cod, redfish, and shrimp; SiBAs (sea pens, sponges); eelgrass habitat; Important Bird Areas (Grand Bay West to Cheeseman Provincial Park IBA, Big Barasway IBA); fish functional groups (planktivores, piscivores, plank-piscivores); Black Dogfish and Smooth Skate areas; seabird functional groups (surface shallow-diving coastal piscivores, surface shallow-diving piscivores); and seals (grey seals). These features are further described in Wells et al. (2019).

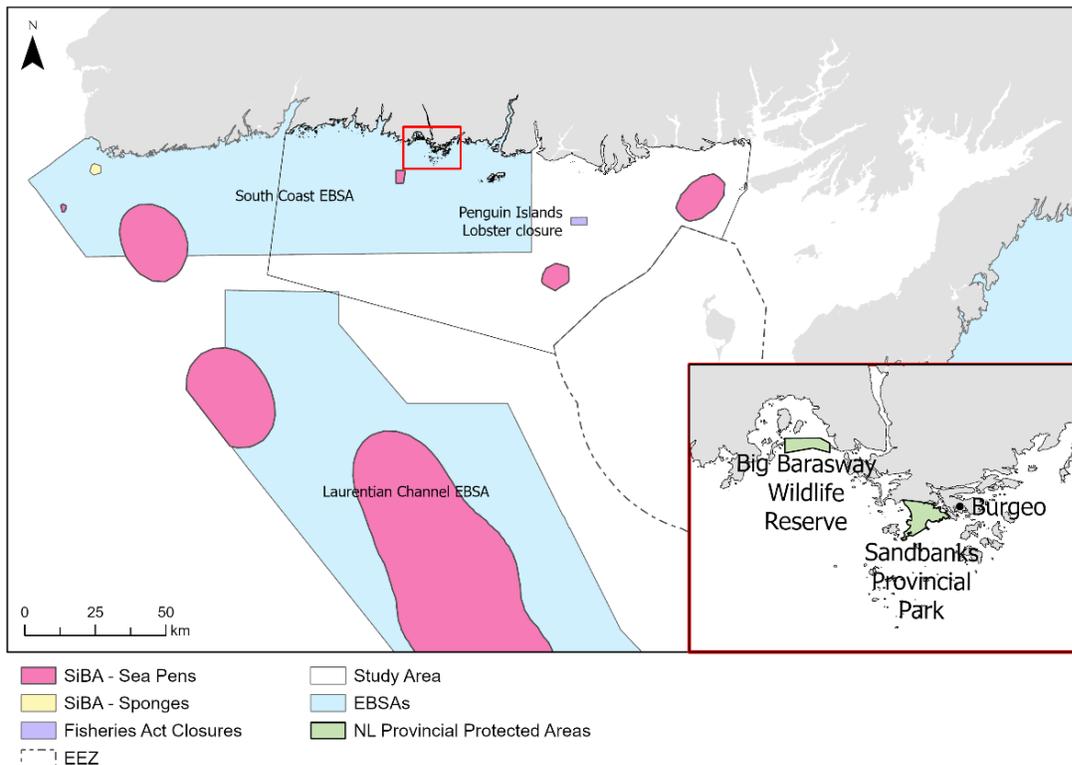


Figure 10.1: EBSAs, SiBAs for sea pens and sponges, and a Fisheries Act Closure located near the study area. Inset map shows the provincial protected areas near Burgeo.

A very small portion of the Laurentian Channel EBSA overlaps with the southwest corner of the study area (Figure 10.1). Since the overlap is minimal, it likely does not reflect the characteristics of the study area as well as the South Coast EBSA; however, the Hermitage Channel, along the eastern side of the study area, has been noted as having a similar community structure for fish and oceanographic conditions as the Laurentian Channel (DFO 2024i). This deeper water channel runs from the Laurentian Channel into Hermitage Bay and creates a unique offshore-like area closer to the coast.

### **Protected Areas**

There is a Fisheries Act closure located within the study area, to the east of the Ramea Islands (Figure 10.1). The Penguin Islands Lobster Closure is one of seven lobster closures around the province put in place to help increase lobster spawning and egg production. All lobster fishing is prohibited in this closure.

Two other areas of importance, although not marine, are the Sandbanks Provincial Park and the Big Barasway Wildlife Reserve, both found to the west of Burgeo (Figure 10.1). Sandbanks Provincial Park has five white sand beaches spanning 7 km along the coast and is relatively unique compared to the rest of the exposed coastal barrens surrounding the area (refer to Chapter 3: Estuarine and Coastal Features). Over 100 islands and complex wave patterns contribute to the formation of the beaches and sand dunes for which the park is named. Also within the park, Heron Pond is able to support salt-tolerant plants as salt water flows up Grepesy Brook to Heron Pond at high tide; at low tide, freshwater flows down the brook to the ocean. The sand deposits, shallow water, and Heron Pond intertidal area make this area and Burgeo more generally an important bird migration route (Parks NL 2024). Big Barasway Wildlife Reserve, located just northwest of Sandbanks Provincial Park, was established in 1992 under the provincial *Wild Life Act* and is also an IBA that aims to protect endangered Piping Plovers and other shore birds nesting along the beaches (Fisheries, Forestry and Agriculture 2024). It is recommended that ECCC's Canadian Wildlife Service is consulted to incorporate further information on marine birds that use this area for foraging and nesting.

### **Sensitive Species and Habitats**

#### **Significant Benthic Areas**

The three sea pen SiBAs that overlap the study area and one sponge SiBA located to the west (Figure 10.1) are described in Chapter 8: Corals and Sponges.

### **Data Gaps and Recommendations**

The South Coast EBSA was delineated as part of a CSAS process in 2017 which used the best available information up to and including 2016 (DFO 2019a). New information, including an additional eight years of DFO's multispecies surveys and benthic surveys related to aquaculture development, have led to the discovery of sea pens in the nearby fjords of Gnat Island, Little Bay, Bay d'Espoir (Goblin Bay, Butter Cove), and Wild Cove. This information could lead to a refinement of the South Coast EBSA boundary if re-assessed. In addition, the level of confidence for coastal EBSA boundaries may be lower due to limited scope and availability of coastal data (Wells et al. 2019). Similarly, the SiBAs were developed in 2016 using available data up to 2015 and could likely change boundaries if re-assessed.

## 11. AQUACULTURE SCIENCE

*Authors: Andry W. Ratsimandresy, Olivia Gibb, and James Meade*

### Available Information

The South Coast Fjords study area includes various fjords with finfish aquaculture licenses (Figure 11.1). Some of these licenses are active or on hold and others have been recently approved. Any information related to aquaculture in this domain has been collected and provided by the proponent to be used during the site license application process and resulting CSAS review process documents (DFO 2022b, 2022d, 2024d, 2024f). These processes are conducted to develop DFO Science advice in relation to DFO's mandate. DFO Science reviews the potential impact of the aquaculture activities on species and habitats in the area. In order to facilitate the review, DFO has developed a consistent and conservative approach based on a simple model, Potential Exposure Zone (PEZ), which provides a spatial scale of exposure zones without quantifying intensity nor duration of exposure. It is a first order estimation of the maximum possible extent of the zone potentially exposed to wastes and chemotherapeutants from aquaculture sites. PEZ does not imply the same potential exposure everywhere within the zone. The intensity of exposure is expected to be highest near the net-pen arrays, decreasing with distance away. Documents provided by the aquaculture industry as part of the license request process following DFO's Aquaculture Activities Regulations have shown that the bulk of waste deposition is generally confined to within the lease area, a few hundred meters around the cage area.

The objective of the PEZ is to provide an area delimitation where waste or therapeutants, released from an aquaculture activity, might reach as a result of waterborne transport. Should species or habitats of concern be identified within that area, it is recommended that further comprehensive studies are carried out to assess the spatial extent, intensity, duration, frequency, and environmental impact of the released wastes or therapeutants in greater detail.

Fish health treatment products may be administered during finfish aquaculture operations to control pests and pathogens. The treatment method can be in-feed or via well-boat or tarp bath treatment (Page et al. 2023). During the feeding process, most feed pellets are ingested by the farmed fish, but some are uneaten and sink to the seafloor. Unabsorbed feed is excreted by the fish and released to the environment via feces. These aquaculture wastes (feces and uneaten feed) are released into the environment, undergo dispersion, sinking, and eventually deposit to the seafloor in the vicinity of the aquaculture farms. This results in a flux of anthropogenic organic matter and medicated waste feed and feces to the seafloor. Tarp bath treatments involve enclosing the salmon net-pens with tarps and adding bath treatment medicine, while the well-boat method is a more contained environment in which fish are pumped into well-boats containing the pesticide (Shen et al. 2019). Both methods disperse pesticides in the environment, producing a patch containing the treatment pesticide, which expands and moves with time until it is diluted. During the dilution period, these chemical products are dispersed and may reach non-targeted species that are present in the area. The process of dispersion, dilution, and sinking of these waste particles depends on the physical, chemical, and biological properties of the waste and of the treatment products as well as on the physical properties of the marine environment (e.g., ocean currents, water density).

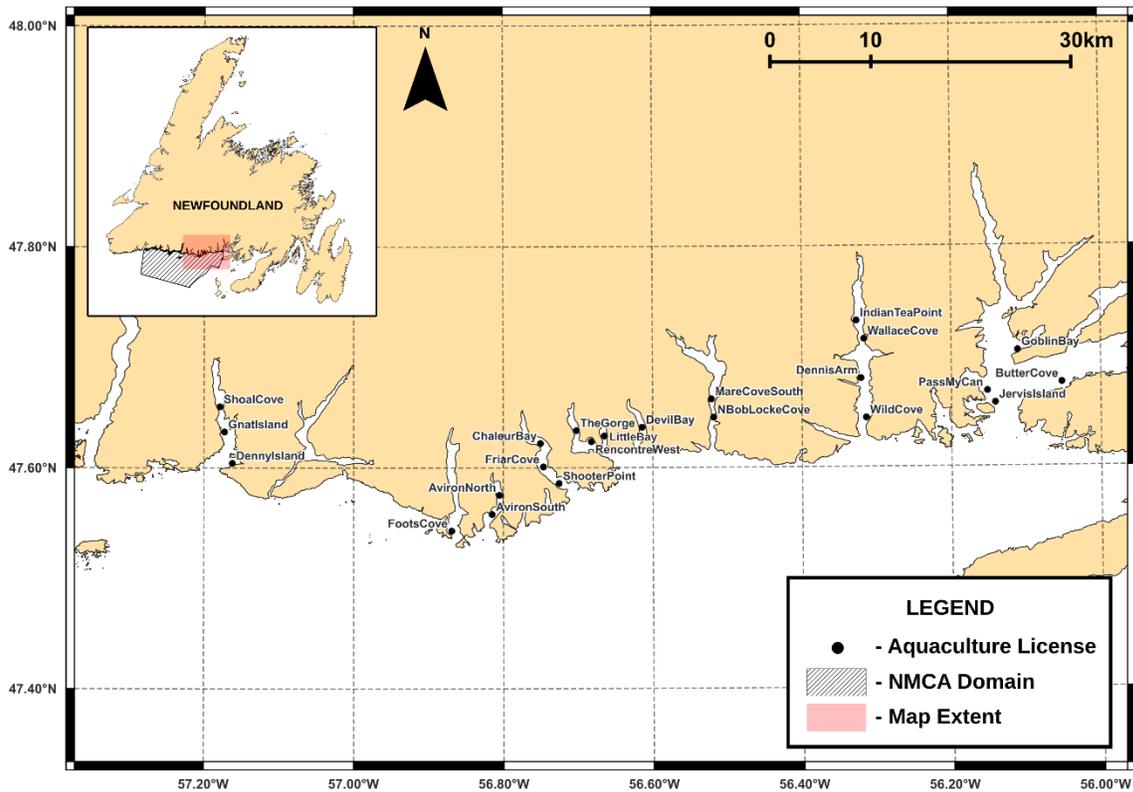


Figure 11.1: Location of the finfish aquaculture licenses within and adjacent to the South Coast Fjords study area (NMCA Domain). Data obtained from DFO 2022b, 2022d, 2024d, 2024f.

Calculation of the PEZ, the area which could potentially be affected by the dispersion and sinking of particles from aquaculture activities, has been carried out during reviews of aquaculture site licensing requests (DFO 2022b, 2022d, 2024d, 2024f). Figure 11.2 illustrates the PEZ of the waste and chemicals that are deposited on the seafloor (benthic PEZ) and Figure 11.3 illustrates the PEZ associated with waste chemicals that can disperse within the water column (pelagic PEZ) as reported in the reviews. The benthic PEZ includes potential zones due to the deposition of feed particles and those due to the deposition of feces particles. The pelagic PEZ includes potential zones due to dispersion of treatment products using the only two approved pesticides for use in Canada: azamethiphos and hydrogen peroxide (PMRA 2014, 2016a, 2016b, 2017). These calculations are based on short-term ocean current data provided by the aquaculture industry proponent (~1 month of current data) which were generally collected between late spring and early fall. The deposition of aquaculture waste to the seafloor (benthic PEZ) is generally expected to occur very close to the site and constrained within the bay where the site is located. For the waste treatment products which can be found in the water column, the pelagic PEZ generally covers the entire bays where farms are located but can also extend outside and into the offshore area. Note that the size of the pelagic PEZ depends on various parameters including the dilution/decay time of the chemicals, used for the treatment, and the choice of horizontal water currents that drive the dispersion of the chemicals. The dilution time has recently been updated (Page et al. 2023, DFO 2024d) leading to changes in the size of the pelagic PEZ (see Figure 11.3 for PEZ calculated with dilution time of 3 h, DFO 2022d, on the eastern side of the south coast and of ~39.5 h on the western side, DFO 2024d). For the ocean

current data used to compute the dispersion, the simple PEZ model assumes that offshore ocean current field is similar to that inside the bays.

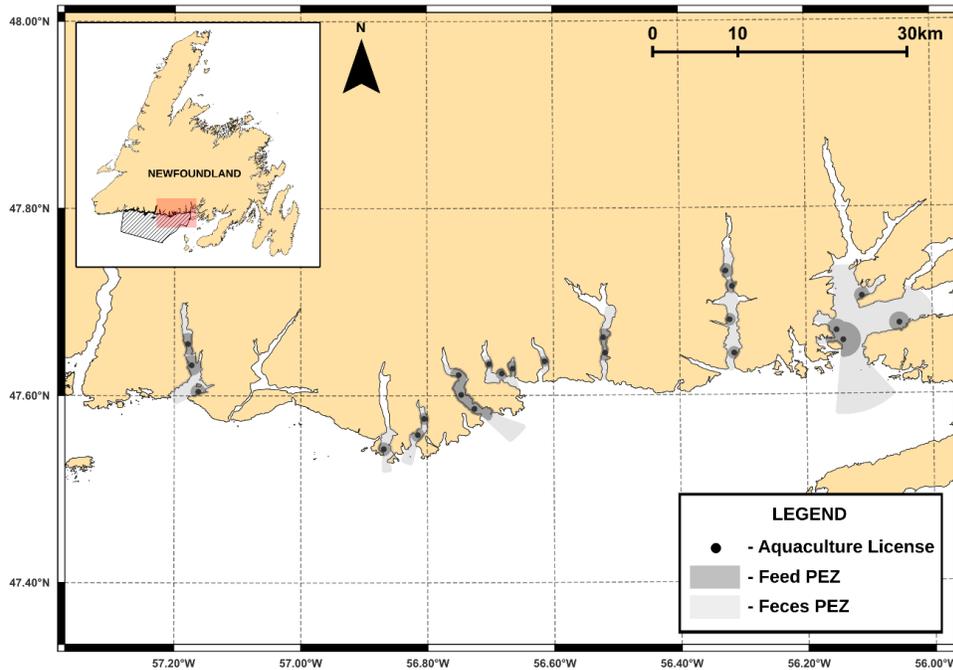


Figure 11.2: Benthic PEZ associated with the waste feed (dark grey) and feces (light grey) within and adjacent to the South Coast Fjords study area (NMCA domain). Data obtained from DFO 2022b, 2022d, 2024d, 2024f.

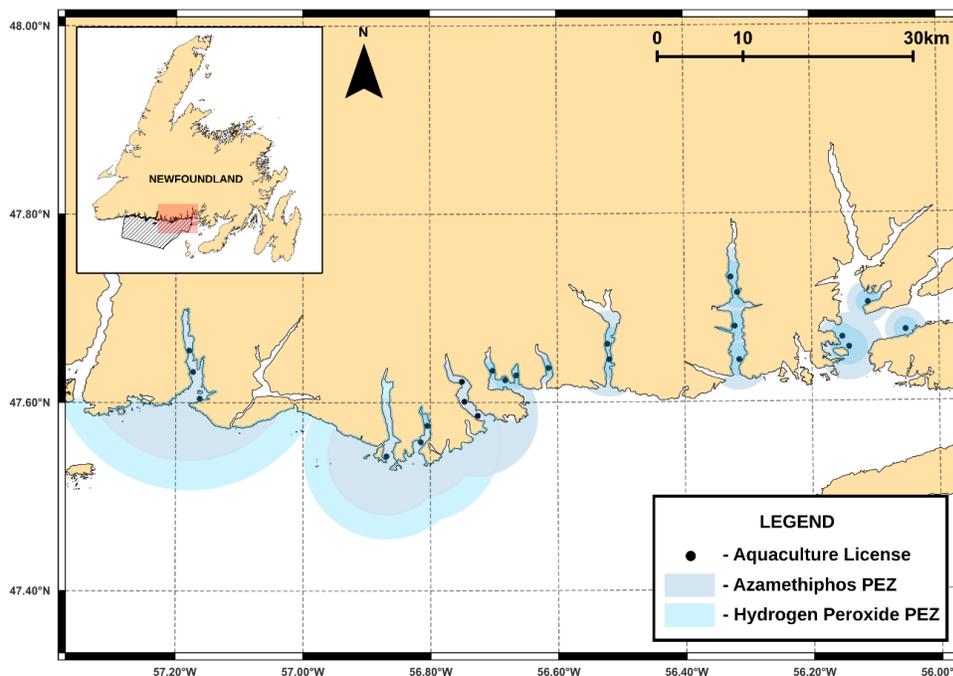


Figure 11.3: Pelagic PEZ associated with the dispersion of waste treatment products: azamethiphos (dark blue) and hydrogen peroxide (light blue), within and adjacent to the South Coast Fjords study area (NMCA domain). Data obtained from DFO 2022b, 2022d, 2024d, 2024f.

## **Sensitive Species and Habitats**

Species sensitive to finfish aquaculture activities have been identified through various site license application review processes (DFO 2022b, 2022d, 2024d, 2024f). The excess feed and feces and treatment products can potentially impact benthic species and habitats, including soft corals and sea pens, as well as pelagic species such as krill and larval stages of crustaceans. The infrastructure associated with net-pen aquaculture has the potential to entangle large marine animals (e.g., sharks, whales, turtles), including species at risk. Salmon escaped from the net-pens may impact the abundance and genetic character of the wild salmon population associated with rivers within the South Coast Fjords study area. Specific species and habitats information can be found within the CSAS documents produced through the review of several site license applications (DFO 2022b, 2022d, 2024d, 2024f).

## **Data Gaps and Recommendations**

PEZ are computed using ocean current data provided by the proponent during the review of site license applications; these data are of low spatial resolution, of short duration, and do not consider spatial and seasonal variability as reported in Ratsimandresy et al. (2019), thus may only provide a limited picture of the zone potentially exposed to wastes from aquaculture activity.

In-depth calculations of where particles released from the aquaculture are dispersed and eventually deposited should be carried out using more ocean current data. These ocean currents can be obtained through collection of more measurements or from the output of circulation models which describe the oceanography in the region. For a circulation model to better simulate the region, it needs to have higher spatial resolution in order to represent and resolve the complex bathymetry and shoreline of the fjords present in the South Coast Fjords study area. In addition, the model should consider updated parameters for dilution time of chemotherapeutants and sinking rates of particles.

As stated previously, the concentration of waste from the aquaculture sites is expected to be highest near the site (the so called near-field region) with the possibility of finding some particles up to several kilometers away as stipulated by PEZ. More advanced calculations and modelling are required to determine the exact distance these particles will travel and may be detected. As per its definition, it is recommended to assess whether there are species or habitats of concern within the PEZ and to carry out the necessary investigations to evaluate how the aquaculture activity in the region might impact the NMCA boundary delineation.

## **12. RESOURCE UTILIZATION AND ANTHROPOGENIC INFLUENCES**

*Author: Mardi Gullage*

### **Available Information**

The south coast of Newfoundland is characterized by a rugged coastline spattered with breathtaking fjords and remote, sparsely populated communities known for their long-standing fishing heritage. With most communities only accessible by boat, this region is one of the more remote areas of the island portion of the province following decades of planned relocations and economic change. The south coast is also the traditional territory of the Miawpukek and Qalipu First Nations, who are active both in natural resource management and economic development in the region.

Overall, the total population on the south coast continues to see a downward trend. Communities are spread out, with the largest populations found where the biggest employers

are located (Figure 12.1). The area's largest employers can be categorized into: health care; agriculture, forestry, fishing, and hunting; and transportation.

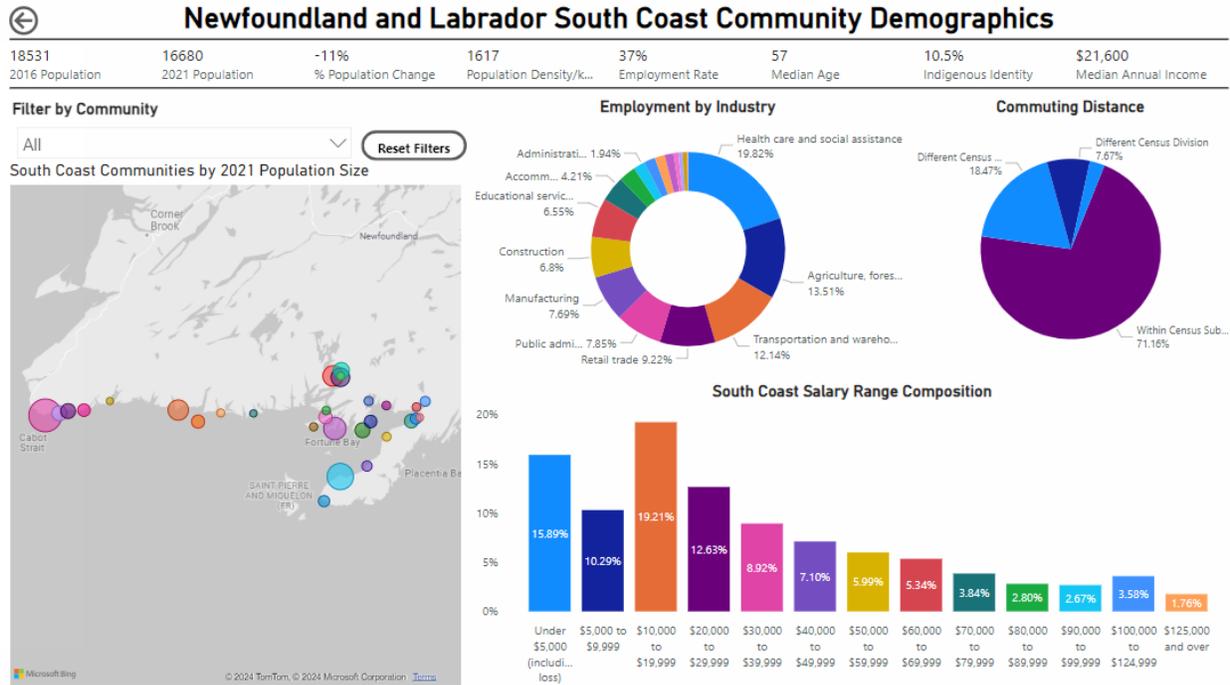
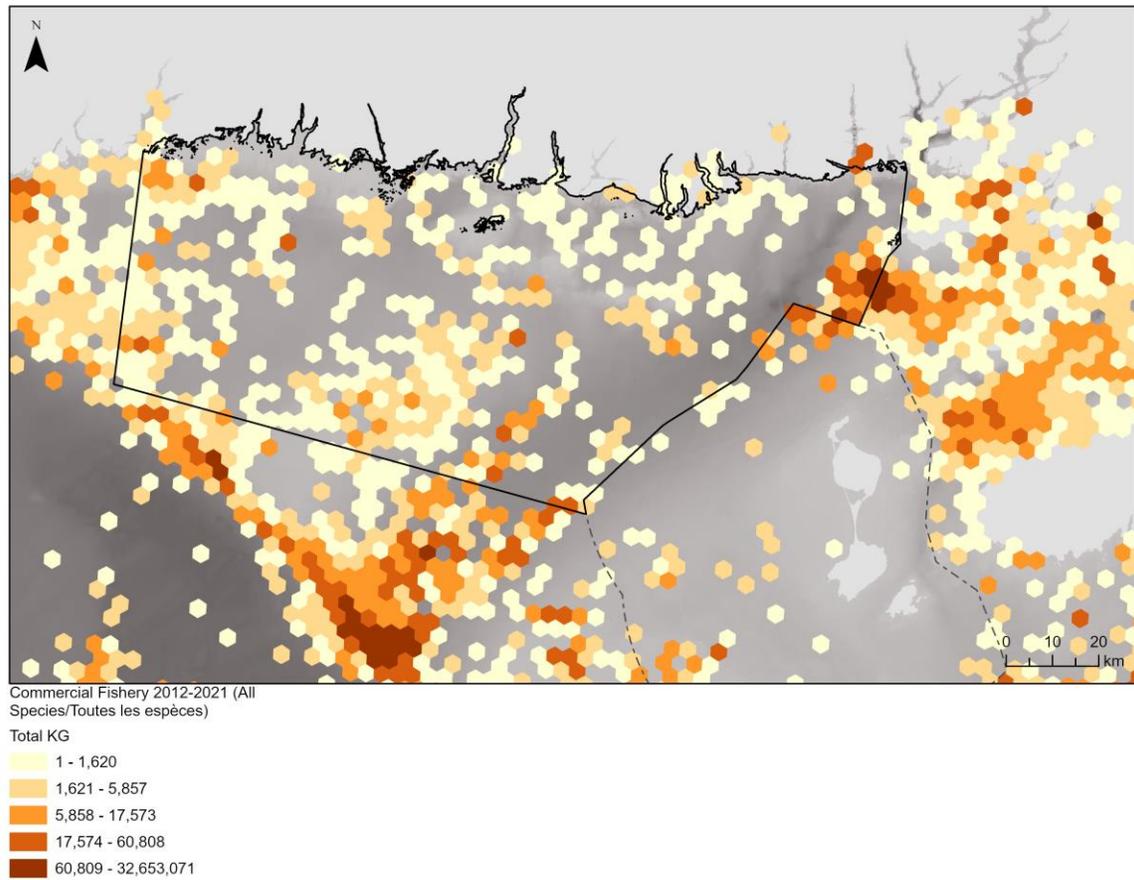


Figure 12.1: Community demographics of Newfoundland’s south coast based on data obtained from Statistics Canada.

**Commercial Fisheries**

The commercial fishery is one of the biggest industries on the south coast and extends across the entire study area (Figure 12.2). Commercial fisheries are mapped by overlaying a 2 minute hexagonal grid (approx. 10 km<sup>2</sup> cell) on species/gear type commercial fisheries point data and summing the total landings by weight reported for each cell over the ten year period (2012–2021). The total value of each grid cell is equal to the total species/gear type landings in kilograms (kg) from 2012 to 2021 for the area and may represent many fishing events from several vessels over the ten-year period. All landings are from Canadian vessels greater than 35-ft and does not include information pertaining to international fishing vessels (i.e., St. Pierre) (Parmenter and Gullage 2024).

There are a number of fisheries taking place in this region, with the largest offshore fisheries being Atlantic Cod, Atlantic Halibut, Snow Crab, and redfish (Figure 12.3). These fisheries are mapped according to Treasury Board’s policy on privacy (known as the “Rule of 5”) (Treasury Board 2017). In those NAFO statistical areas where the total number of records are fewer than five unique vessel IDs, fisher IDs, or licence IDs (Koropatnick and Coffen-Smout 2020), records are removed from the final dataset and are represented in the maps as hatched areas. The patterns of each of these fisheries varies widely, with Atlantic Cod and Snow Crab fished closer to shore, while redfish is generally offshore and mostly outside of the study area. Atlantic Halibut is fished more homogenously across the study area. Fixed gear types, such as pots and longlines, are dominant in the region and particularly in nearshore areas, while mobile gear types, such as bottom otter trawls, are used further offshore and less frequently overall (Figure 12.4).



*Figure 12.2: Generalized picture of fishing on the south coast across all fisheries and gear types. Note that only georeferenced data that has been verified to be in the correct location (e.g., not on land) and that meets the Rule of 5 are included.*

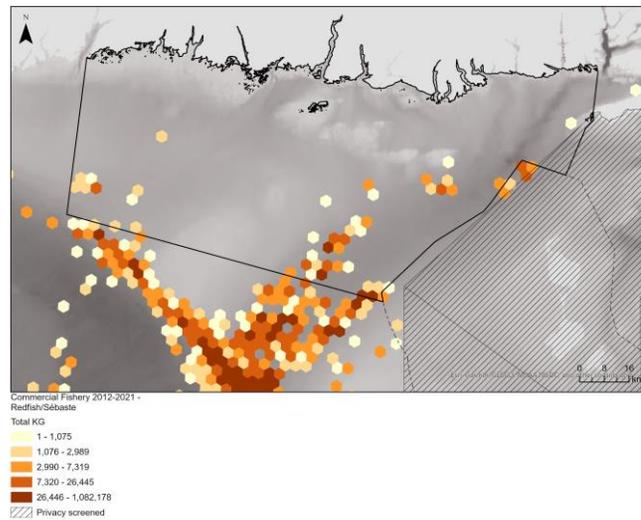
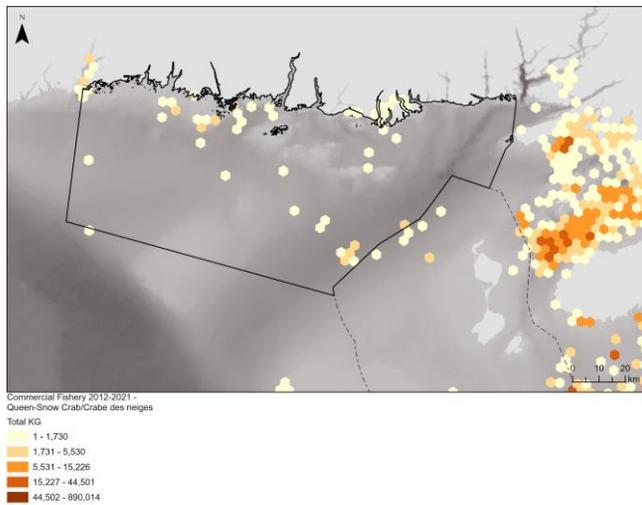
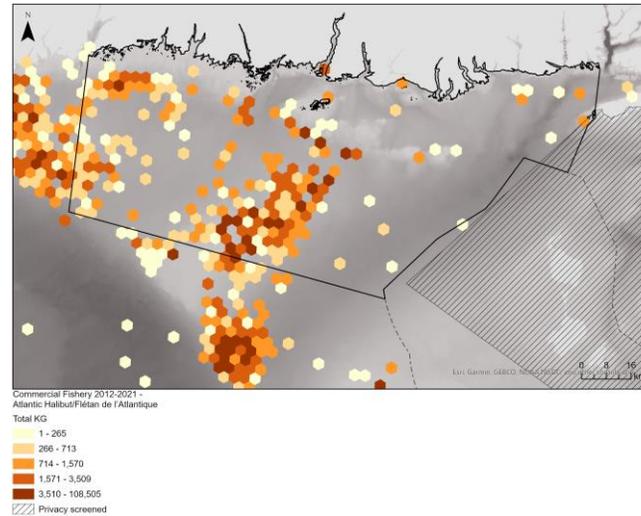
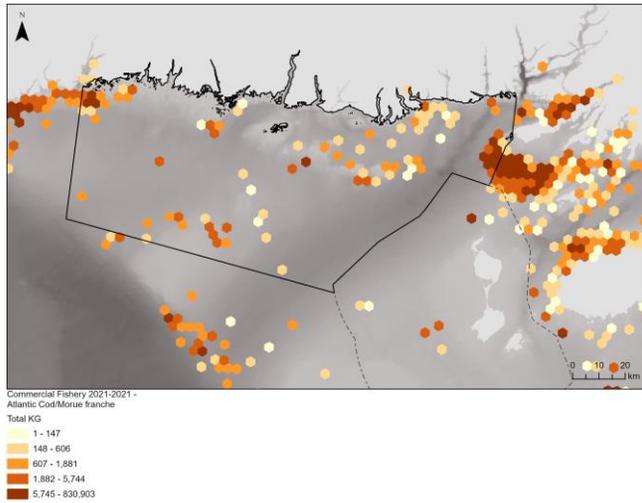
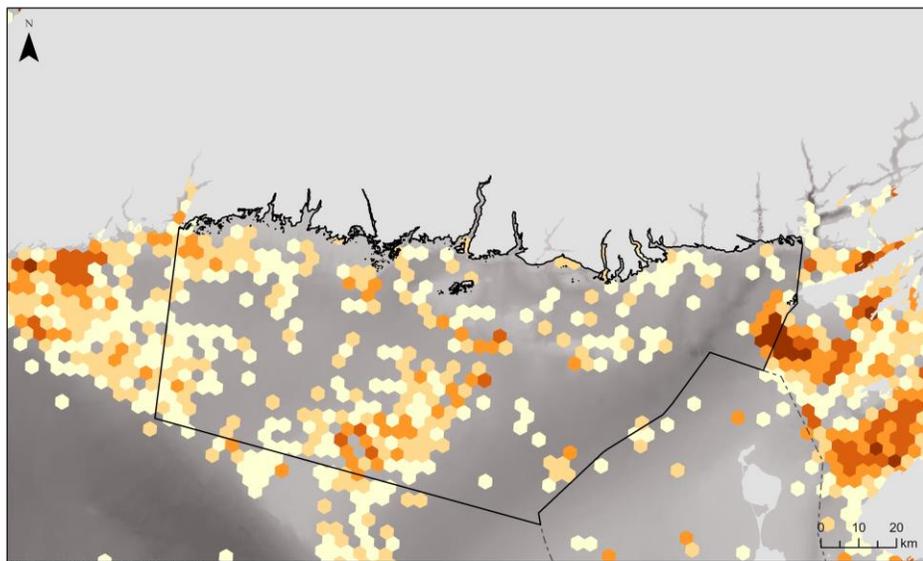
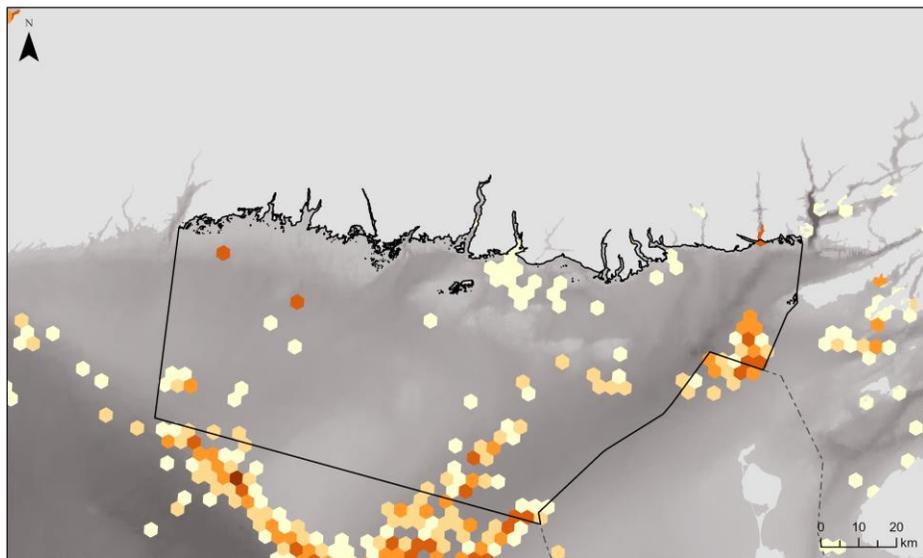


Figure 12.3: Cumulative commercial fishing density of Atlantic Cod (top left), Atlantic Halibut (top right), Queen/Snow Crab (bottom left), and redfish (bottom right) as landed catch weights (kg/10km<sup>2</sup>) from 2012–2021 mapped from logbook data. Note that data are mapped according to Treasury Board policies on privacy (i.e., Rule of 5).



Gear Type Fixed/Type d'engin - fixe  
weight



Gear Type Mobile/Type d'engin mobile

Total KG



Figure 12.4: Cumulative commercial fishing density of fixed (top) and mobile (bottom) gear types around the South Coast Fjords study area.

Many inshore fisheries are poorly georeferenced, so other methods are required to map their distribution. Lobster fishing is one of the largest fisheries in this region and total fishing effort has increased in recent years. In this case, the landing slips were incorporated into a model to create a series of proxy maps to represent lobster fishing activity in NL. This tool takes a number of variables into account, such as distance from homeport, depth, human use, accessibility, traditional ecological knowledge (i.e., CCRI), and a few more, and associates the catch records to hexagons that apply to all variables. Each variable is weighted depending on their influence on the fishery, and the distribution is random within those constraints. The result of this tool is a yearly catch record layer. Figure 12.5 represents the latest year for which data has been mapped according to this method.

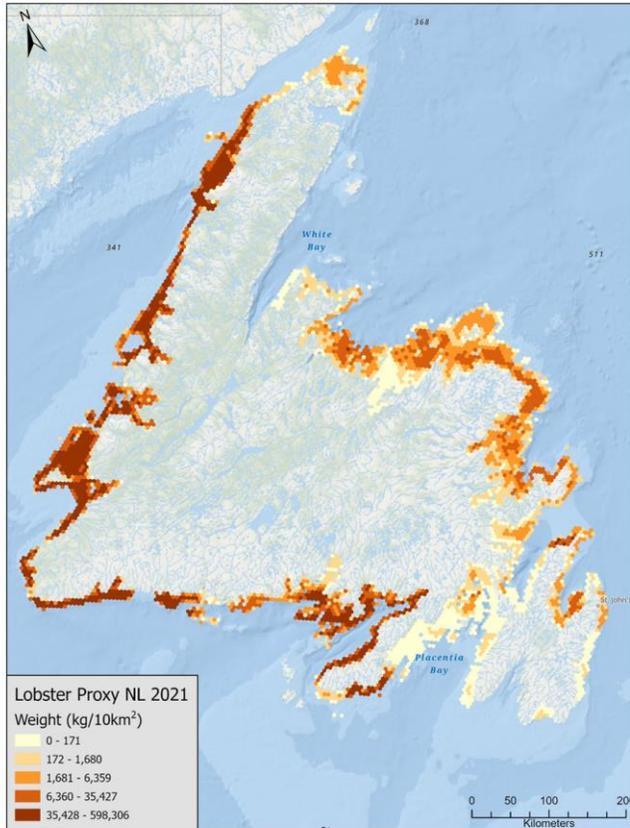


Figure 12.5: Proxy map for the lobster fishery in NL in 2021.

Additional data sources for mapping inshore fisheries include the Community-based Coastal Resource Inventory (CCRI). The CCRI is a traditional knowledge dataset which is comprised of data collected through interviews with fish harvesters and other knowledgeable locals regarding resource use or observations on aquatic species, aquatic plants, marine mammals, marine birds, culture, tourism, recreational use, and infrastructure. The original project ran from 1997 to 2007, and was updated to reflect the current environment between 2021 and 2024. The most recent data shows more than 23 species are fished or observed in the study area, with 17 of those species in the Burgeo area alone (Figure 12.6).

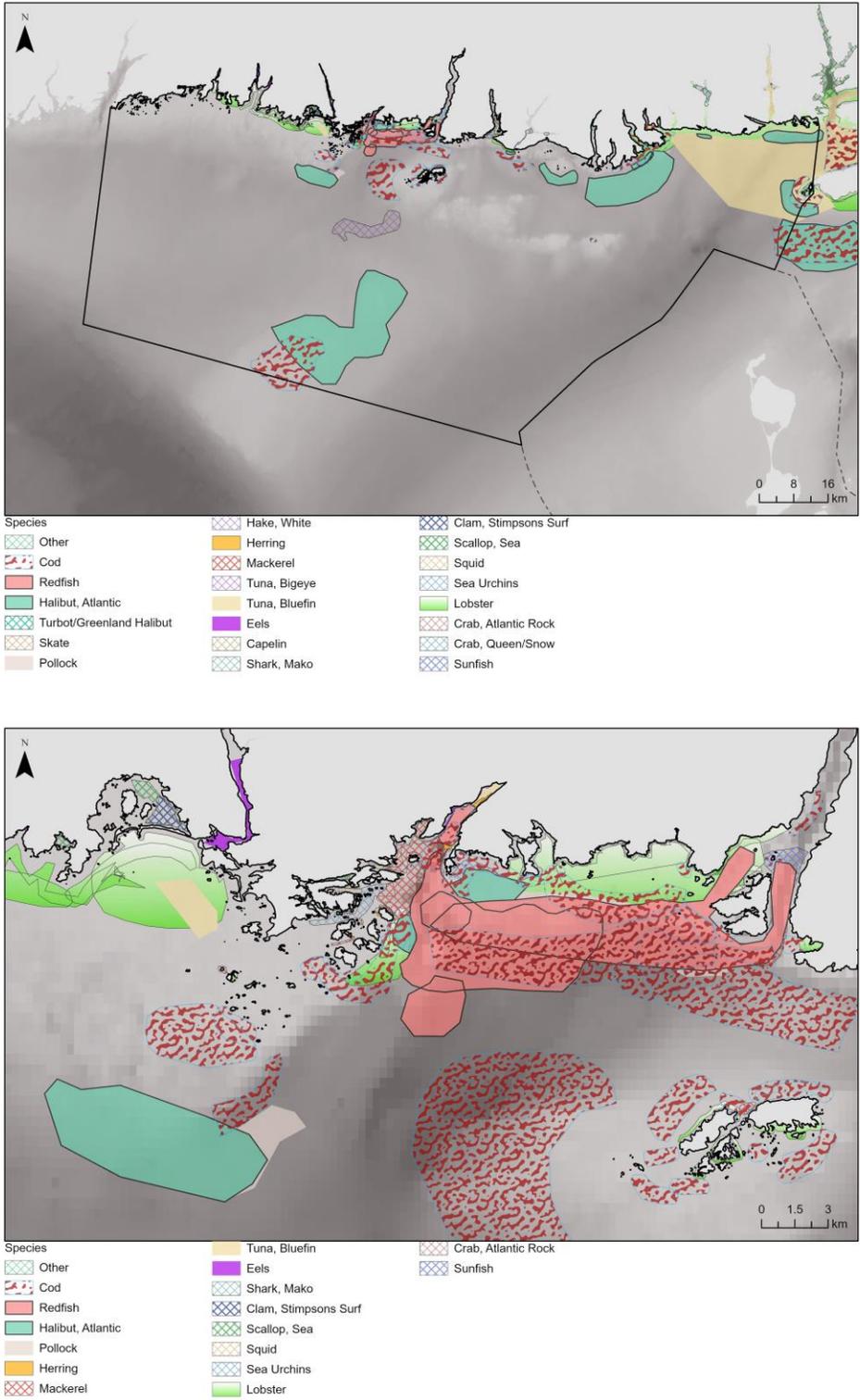
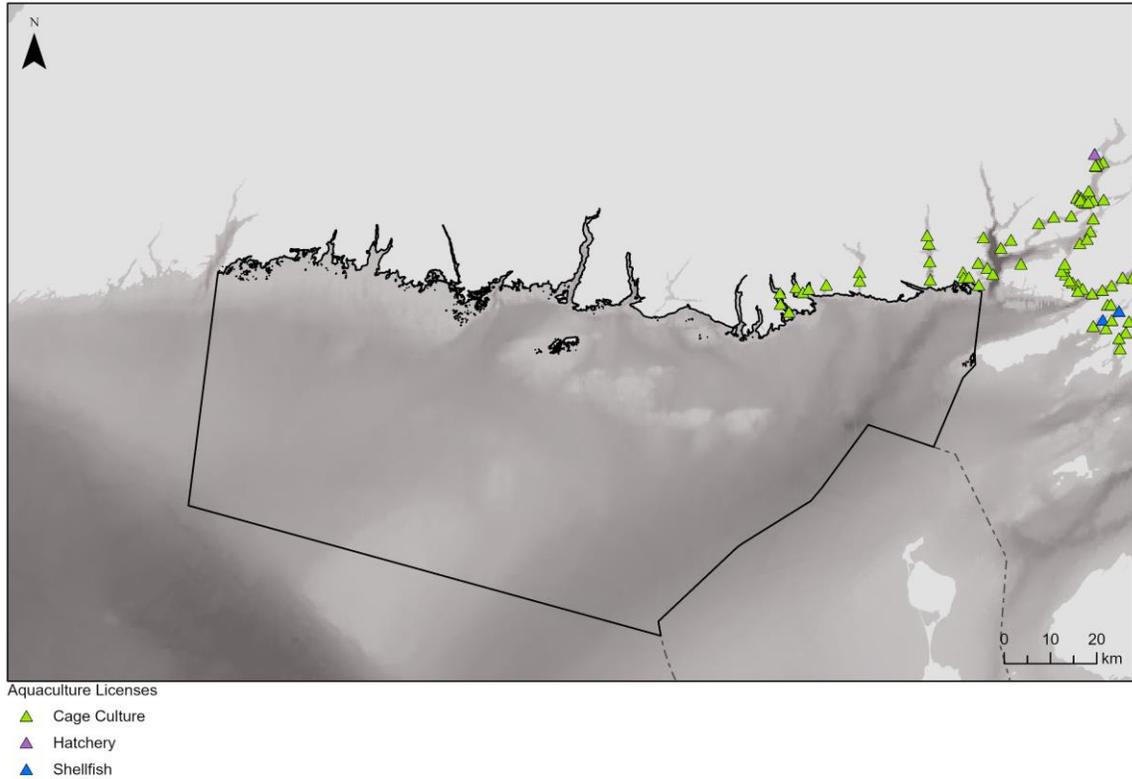


Figure 12.6: Data collected as part of the CCRI from fish harvesters and other knowledgeable individuals in coastal communities show inshore fisheries within the South Coast Fjords study area (top) and surrounding Burgeo (bottom).

## Aquaculture

Marine aquaculture, as previously discussed in previous chapters, has been rapidly expanding across the south coast. With licenses in this region mostly comprising of salmonid cage grow-outs, the majority of existing operations are concentrated around the shores of the Fortune Bay and the Bay D'Espoir areas (Figure 12.7).



*Figure 12.7: Current aquaculture licenses (i.e., existing operations) in and near the South Coast Fjords study area.*

Mowi Canada East has proposed six new finfish aquaculture sites within the study area (DFO 2024d). These sites are located in three separate bays (Figure 12.8). Additionally, Grieg Seafood was the successful proponent for the potential aquaculture industry expansion in Bays West (from Bay D'Espoir west to Burgeo and Port aux Basques) where the production potential has been estimated to be 15,000 to 20,000 MT (Government of NL 2022).

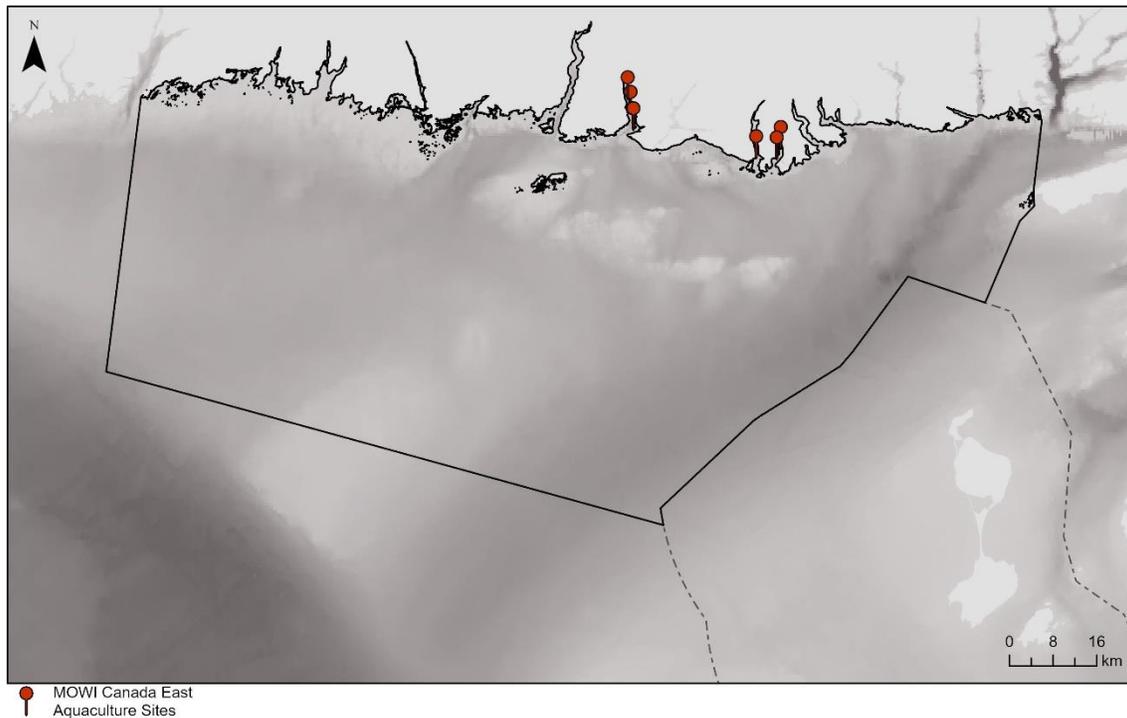


Figure 12.8: Mowi Canada East proposed aquaculture sites in the South Coast Fjords study area.

### Marine Transportation

Marine transport and shipping is a large employer on the south coast. The following maps are based on the Automatic Identification System (AIS), which is a global dataset of satellite-based and terrestrial-based tracking that uses shipborne equipment to remotely track vessel identification and positional information and is typically required on vessels of 300 gross tonnage or more on an international voyage, of 500 gross tonnage or more not on an international voyage, and passenger ships of all sizes (Veinot et al. 2023).

While traffic within the study area is lower than that to the south (Figure 12.9), most communities along the coast are fully dependent on a network of ferries for goods, services, employment, and access (Figure 12.10). Passenger vessels also include cruises and tourism. Additional vessel categories include fishing vessels, tanker vessels, and cargo vessels (Figure 12.10). Passenger vessels and fishing vessels are found within the study area more frequently; tanker vessels pass most frequently just outside of the southern extent of the study area; and large cargo vessels are very infrequently inside of the study area and instead distribute cargo from larger centres like Port aux Basques.

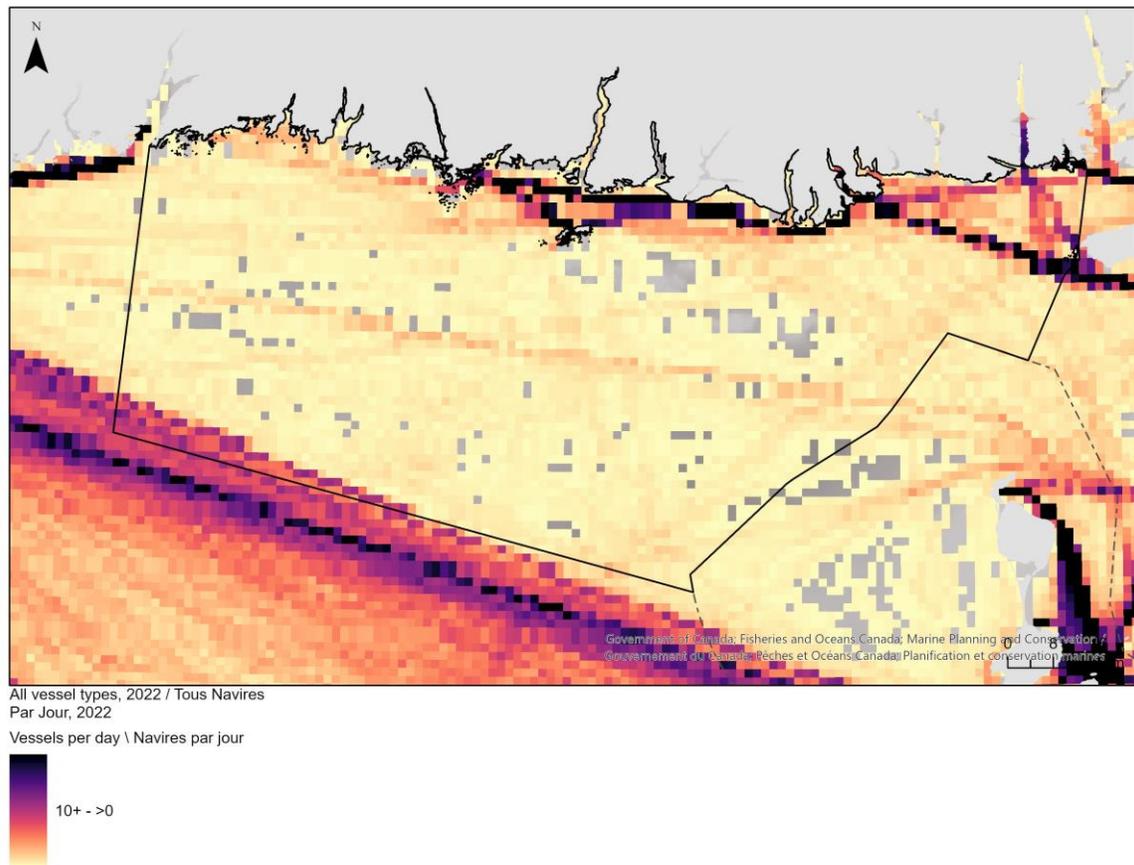


Figure 12.9: Vessel traffic (number of vessels per day) in and around the South Coast Fjords study area for 2022.

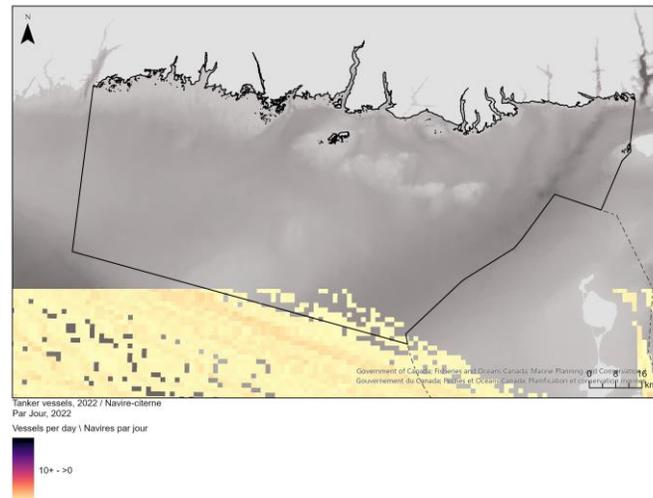
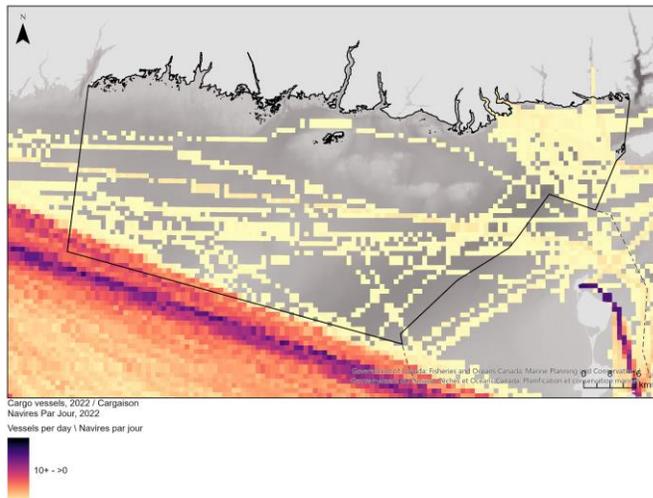
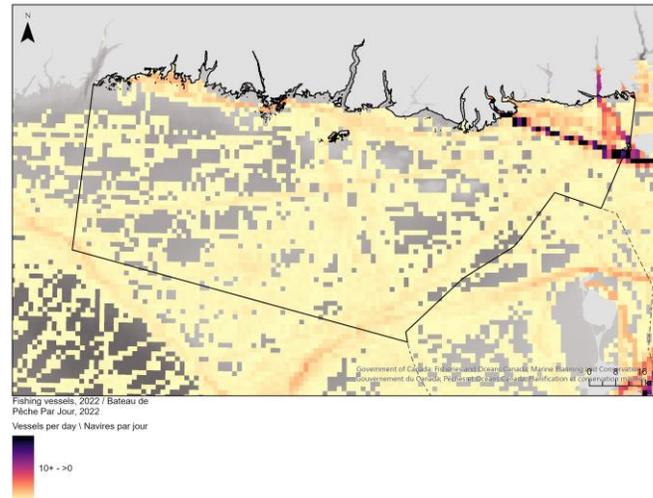
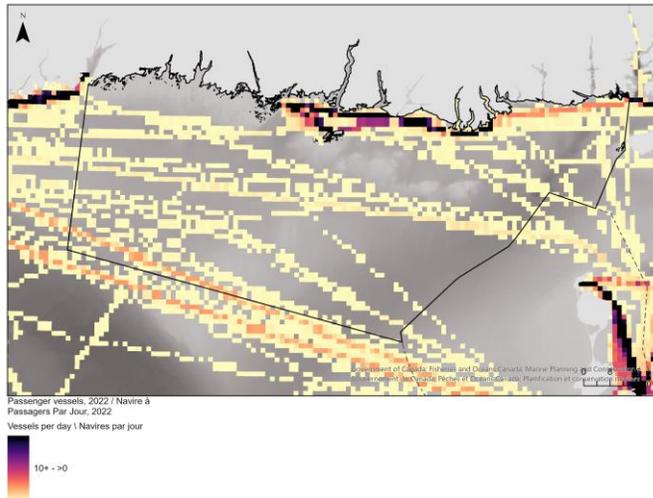


Figure 12.10: Density of passenger vessels (e.g., ferries, cruise ships; top left), fishing vessels (top right), cargo vessels (bottom left), and tanker vessels (bottom right) in 2022, represented as number of vessels per day.

### Small Craft Harbours and Anchorage Areas

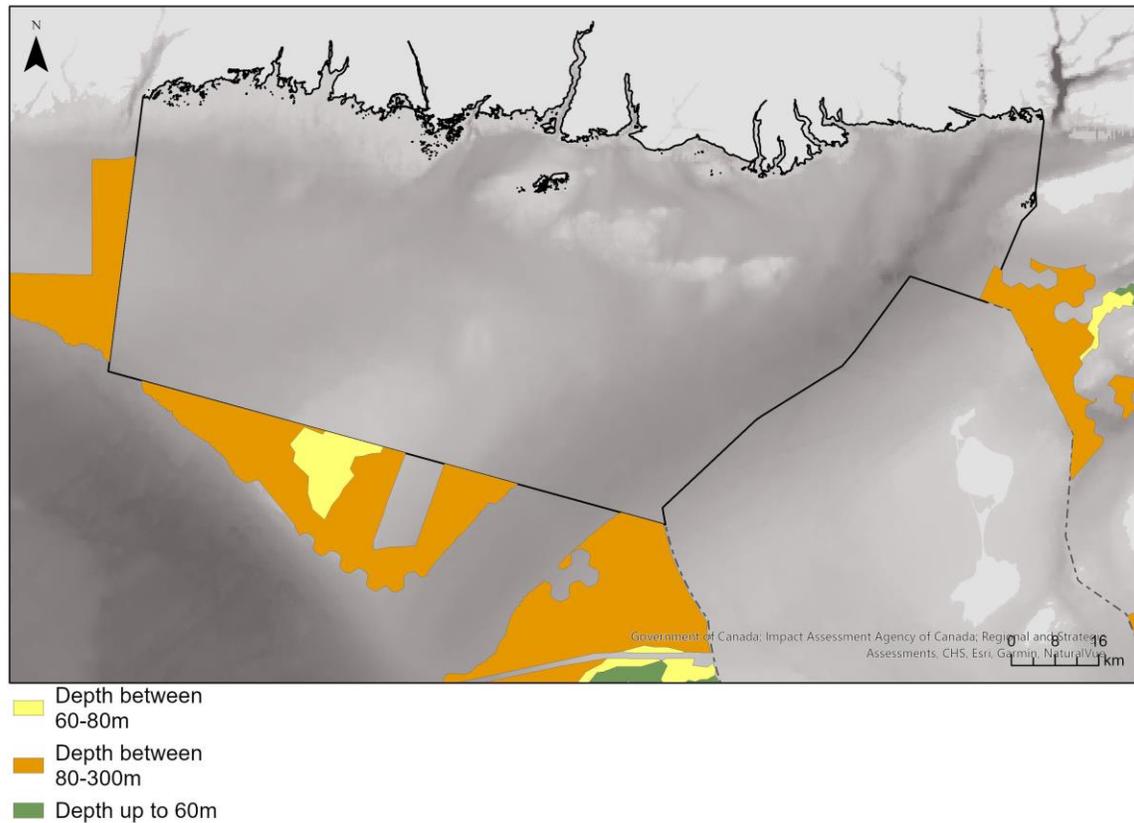
Beyond infrastructure for harvesters and marine industries, small craft harbours and anchorage areas provide indirect employment for residents of communities and a key economic link between the south coast and the rest of the province (Figure 12.11).



*Figure 12.11: Small craft harbours (core fishing and non-core fishing) and anchorage areas within and near the South Coast Fjords study area.*

### Offshore Renewable Energy

In the interim report released by the Committee for the Regional Assessment of Offshore Wind development, it was recommended that the proposed NMCA be removed from consideration until the designation process was complete (Figure 12.12). It is further recommended that licensing areas should avoid the final NMCA area, and any development adjacent to the proposed site prior to designation must consult with Parks Canada regarding the study area and status of the proposed NMCA.



*Figure 12.12: Preliminary licensing areas for offshore wind development by depth, excluding the South Coast Fjords study area, as per the interim report released by the Committee for the Regional Assessment of Offshore Wind.*

### **Marine Tourism**

Tourism on the south coast is largely localized to the Burgeo/Ramea area. Sandbanks Provincial Park near Burgeo is a popular destination for campers and kayakers. Some tours (e.g., cruises) visit the south coast, although in general tourism is more limited in other areas due to accessibility (Figure 12.13).

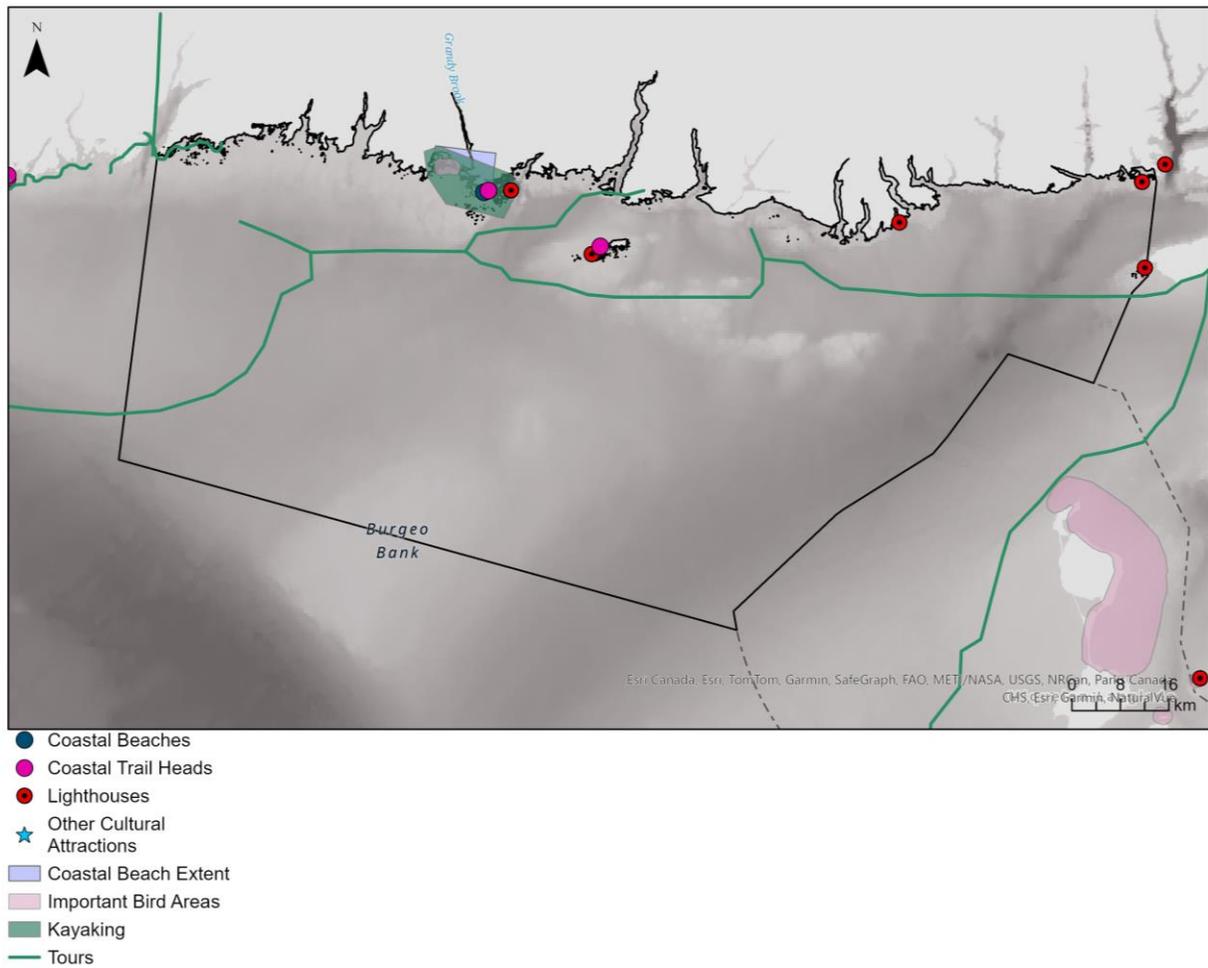


Figure 12.13: Tourism in and around the South Coast Fjords study area includes coastal beaches, trail heads, lighthouses, and other cultural attractions, as well as IBAs, kayaking, and tours/cruises.

### Scientific Research

Due to the ecological significance of this area, it is often an area where research is conducted. In recent years there have been a number of inshore studies for eelgrass, aquatic invasive species (AIS), water quality, and marine debris (Figure 12.14). Offshore, this area is sampled by DFO Science as part of the spring multispecies survey. More information on the multispecies survey methodology and extent can be found in Chapter 5: Marine Fishes.

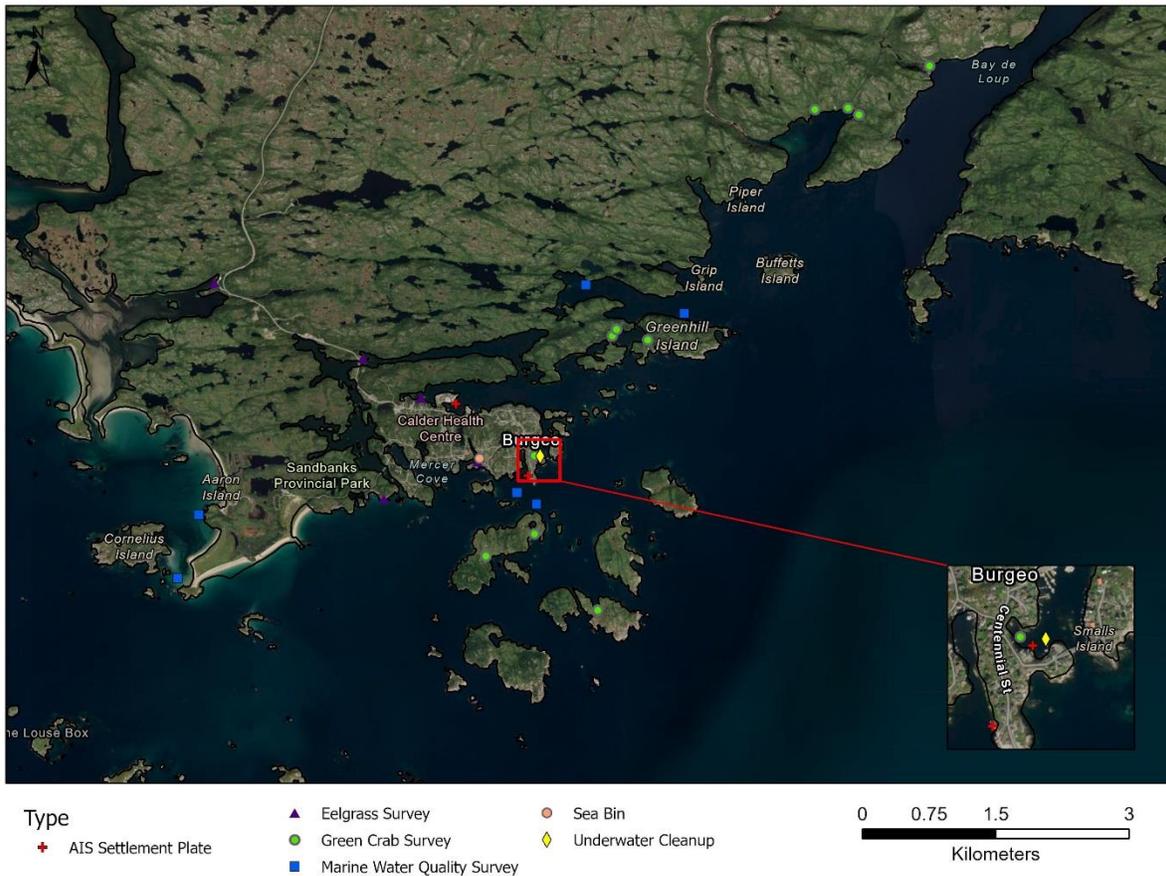


Figure 12.14: Locations of various research undertakings near Burgeo, including European green crab trapping, eelgrass surveys, marine water quality, underwater clean up, sea bin and AIS settlement plates.

### Other Coastal Considerations

In addition to the above activities, there are others that are coastal in nature that may have relevance in NMCA planning processes. These include a number of scheduled salmon rivers along the south coast which have ecological significance and which are used by recreational salmon fishers and Indigenous groups (Figure 12.15). Fish processors (Figure 12.16) and public water supplies (Figure 12.17) are also located within the study area along the coast.

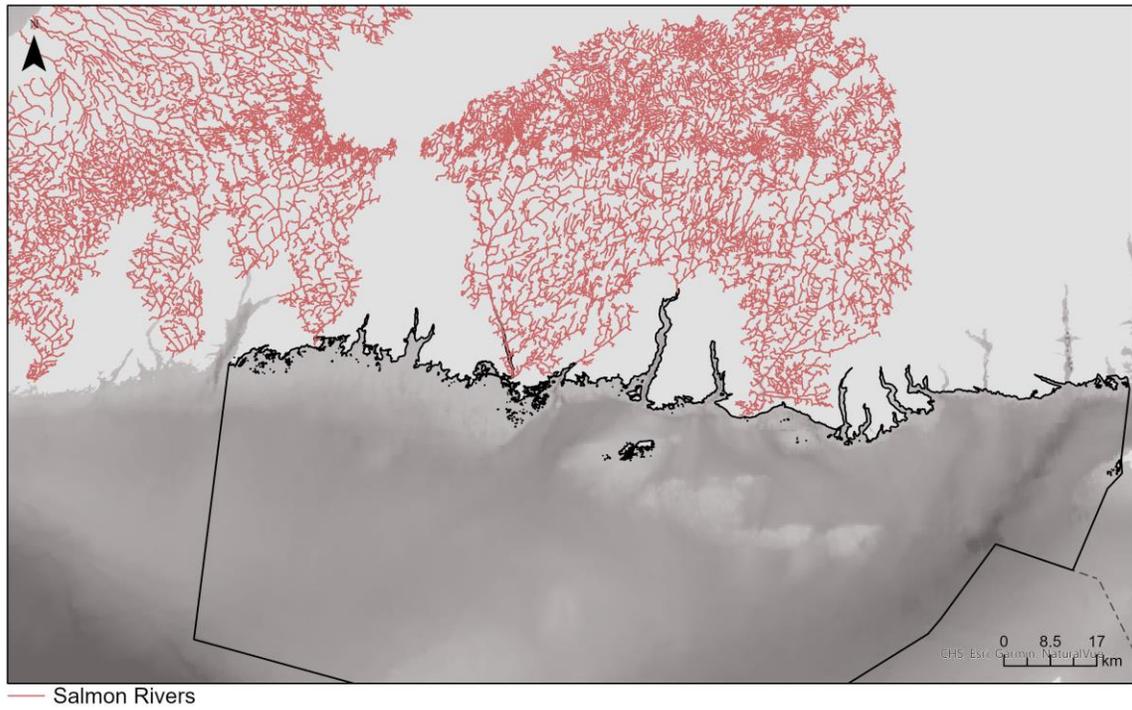


Figure 12.15: Map of salmon rivers within and near the South Coast Fjords study area.

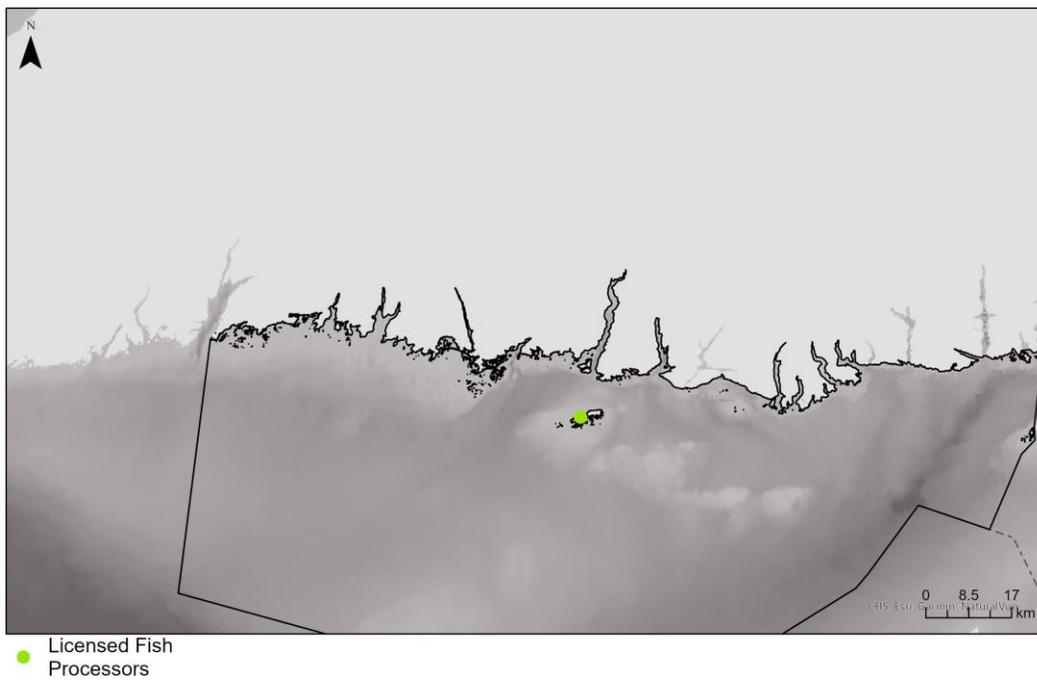


Figure 12.16: Map of licensed fish processors within the South Coast Fjords study area.

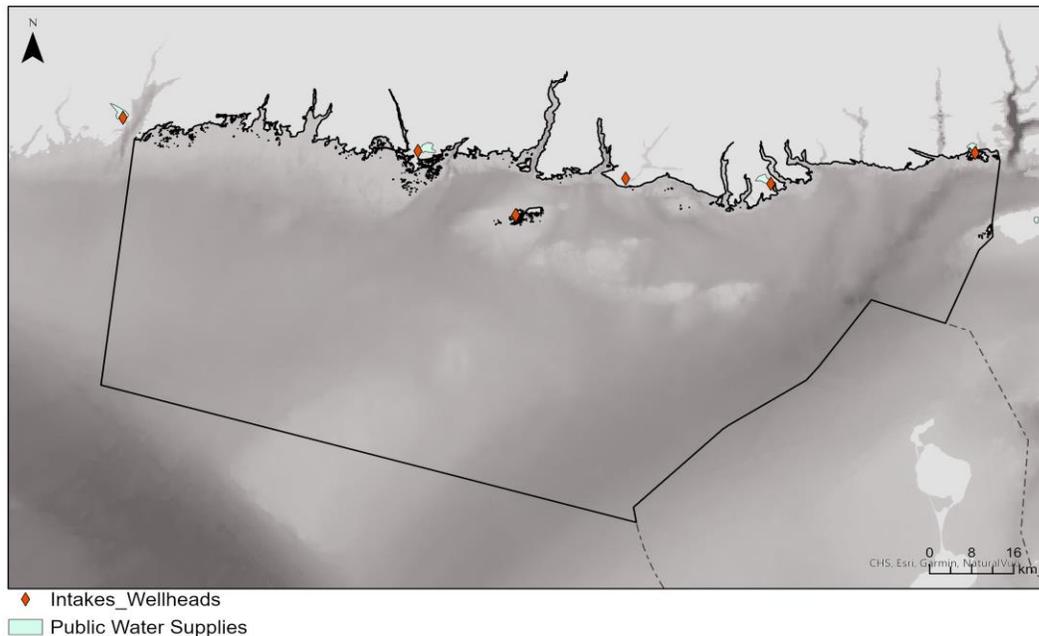


Figure 12.17: Map of wells and public water supplies within and near the South Coast Fjords study area.

## RECOMMENDATIONS AND CONCLUSIONS

This technical report outlines the best available information on the South Coast Fjords study area held by DFO NL Region Science Branch and DFO NL Region Marine Planning and Conservation Program at the time of publication. While this document is comprehensive, it is not exhaustive, and the authors encourage Parks Canada and other interested organizations to include information from other sources, including local or traditional ecological knowledge.

Additionally, early drafts of this document included placeholders for the topics of Geology, Marine Birds, and Macrophytes. DFO NL Region Science is not the authoritative source on Geology or Marine Birds and does not have in-house expertise on Macrophytes, so these chapters were removed from the final document. It is recommended that Parks Canada and other interested organizations reach out to Natural Resources Canada, ECCC's Canadian Wildlife Service, and other DFO Regions (specifically Maritimes, Gulf, and/or Quebec) to help fill these gaps.

Specific data gaps in the South Coast Fjords study area are detailed in the above chapters. In general, these gaps include:

- Poor data coverage in the fjords, coastal, and nearshore areas;
- Out-of-date data requiring updating, especially given the rapidly changing ecosystem;
- Lack of information on species characteristics (e.g., ecology, behaviour) specific to this area;
- Absence of data on spawning areas, foraging areas, and other ecologically important areas;

- Limited consideration of seasonality in existing data (e.g., DFO multispecies survey in this area is spring-only);
- Patchy data coverage of existing surveys in more recent years; and
- Uncertainty of climate change impacts and their implications on species in the area.

Similarly, specific recommendations for taxonomic groups and other features are given in each of the above chapters. Key overall recommendations include:

- Additional surveys and/or increased survey coverage for species and other features of interest, particularly in areas where there are data gaps;
- Further in-depth analysis of existing data, including verification and/or ground truthing;
- Increased research and knowledge gathering of information specific to the populations and/or dynamics of the study area;
- Exploring alternate technologies and/or methods for data collection;
- Increasing the availability and/or accessibility of existing data (e.g., aquaculture industry baseline environmental assessment data);
- Greater consideration of seasonality in data collection efforts; and
- Increased collaboration both within DFO and with external partners.

Although relatively data-poor compared to other areas in NL Region, this document shows that the South Coast Fjords study area on the south coast of Newfoundland contains multiple biophysical and ecological features, species, and processes of interest. While further research in this area is recommended to fill existing data gaps, the authors hope that this document can be a useful baseline of existing western science information in the area for the NMCA feasibility assessment and other planning and decision-making processes.

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