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RE-EVALUATION OF THE PLACENTIA BAY-GRAND BANKS AREA TO IDENTIFY ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS

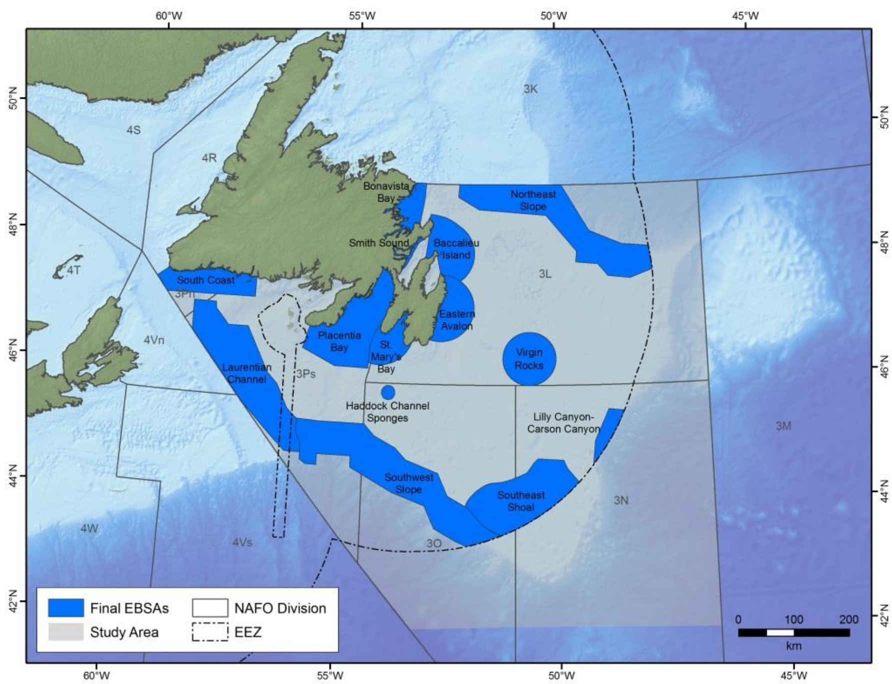

Figure 1. Ecologically and Biologically Significant Areas in the Placentia Bay Grand Banks study area.

Context:

Fisheries and Oceans Canada (DFO) has developed guidance for the identification of Ecologically and Biologically Significant Areas (EBSAs) (DFO 2004) and has endorsed the scientific criteria of the Convention on Biological Diversity (CBD) for identifying ecologically or biologically significant marine areas as defined in Annex I of Decision IX/20 of its 9th Conference of Parties. A DFO National Advisory Process was also held to examine the lessons learned with the previous application of national guidelines to identify EBSAs within the Department's Bioregions (DFO 2011).

In support of domestic integrated management efforts, EBSAs have been identified in each of DFO's five Large Ocean Management Areas (LOMA), as well as areas outside the LOMA in the Newfoundland and Labrador (NL) Shelves Bioregion (DFO 2013). EBSAs were identified in the Placentia Bay-Grand Banks (PBGB) LOMA in 2007 (Templeman 2007) but new guidance followed after this advice (DFO 2011). An update on the science advice regarding EBSAs identification in the PBGB LOMA has been requested by the Oceans Program, NL Region. Thus the main objective of this meeting was to provide an update to the Research Document 2007/052 by re-evaluating the PBGB LOMA to identify EBSAs using the most recent and relevant data available, consistent with methods used in the Science Advisory Report (SAR) 2013/048 and based on advice provided in the SAR 2011/049.

Canada

This Science Advisory Report is from the January 17-18, 2017 Re-evaluation of the Placentia Bay-Grand Banks Large Ocean Management Area to identify Ecologically and Biologically Significant Areas. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule](#) as they become available.

SUMMARY

- 14 EBSAs were identified, delineated and described within the Placentia Bay Grand Banks study area. These EBSAs represent approximately 35% of the total area examined.
- Seven of the EBSAs are in coastal areas (Bonavista Bay, Smith Sound, Baccalieu Island, Eastern Avalon, St. Mary's Bay, Placentia Bay and South Coast) and seven EBSAs are in offshore areas (Northeast Slope, Virgin Rocks, Haddock Channel Sponges, Lilly Canyon-Carson Canyon, Southeast Shoal, Southwest Slope and Laurentian Channel).
- Most of the EBSAs are associated with areas of relief/shelf break/slopes with several areas adjacent to one another on slope edges (e.g. SW shoal, Laurentian Channel). Each EBSA was identified based on features important to that area and sometimes bathymetry or other physical features were used to delineate boundaries.
- A number of sources of information, including research survey data, published and unpublished studies, local and traditional ecological knowledge (LEK/TEK), and expert knowledge were considered for the identification of EBSAs in the study area. However, it is recognized that additional information may exist, or become available, that could potentially identify more specific areas of significance within each of the EBSAs, refine the boundaries of the EBSAs, or result in the identification of additional EBSAs.
- The 2007 EBSAs were not taken into consideration when identifying or delineating these new EBSAs. This process started anew and was data intensive. Comparisons were made with previous EBSAs post-hoc.
- Dealing with information and data originating from multiple sources and various collection methods presents a challenge in combining the available material into metrics that can then be compared. To address this, coastal and offshore components of the study area were assessed separately.
- A total of 272 biological and geomorphological layers of data were examined to complete the analyses required to identify EBSAs in the study area. 123 offshore biological layers were resampled using a 20 km x 20 km grid and 113 coastal layers were reviewed at the scale at which the data were available. Of these, 77 coastal layers were based on Community-based Coastal Resource Inventory (CCRI) data.
- Most EBSAs were identified based on the aggregation of several taxa in an area because few available data sets allowed for the assessment of life history events being undertaken by a species in a given area. Published literature was often used to determine areas of fitness consequences, especially for fish species. All identified EBSAs had at least one unique feature with the exception of the Baccalieu Island EBSA.
- The approach with coastal EBSAs should be viewed as precautionary as many of the data were not available at the appropriate scale to delineate boundaries effectively. In the absence of fish data, seabirds were used as indicator species and foraging ranges were sometimes used to delineate seaward boundaries.

- Many of the habitat features that underlie significant ecological and biological processes in the coastal zone were poorly resolved for this process. Such features include areas of high primary productivity such as kelp forests and upwelling sites.
- The majority of data for fish was based on DFO Research Vessel (RV) survey data which were seasonal surveys – spring and fall. There were limitations with these data, for example, recruitment information was not incorporated and substrates were not sampled.
- Deep waters, i.e., those waters off the continental shelf and slope, represent portions of the study area that remain relatively understudied and therefore undefined. Therefore, the distribution and diversity of deep-water habitats and the biota they support were poorly described in this study. Some major ecosystem features were not included (e.g. phyto- and zooplankton, seafloor habitat types).
- Given the limitations of some of the available data in the study area, as well as changes in environmental and community structure observed in the ecosystem in recent times, it is important to revisit EBSA delineations periodically (5-10 years) as more information becomes available from scientific research, monitoring and LEK/TEK.
- EBSAs were identified based on scales relevant to ecological processes and therefore extensions of some areas were drawn beyond the boundaries of the Exclusive Economic Zone (EEZ).
- A full bioregion analysis is recommended for the re-evaluation of future EBSAs (as some EBSA boundaries are likely artifacts of the study areas that were considered). When determining management measures, the rationale provided for each EBSA should be carefully considered. Underlying ecological properties within each EBSA need to be clearly defined with respect to the temporal and spatial extent of the layers, as well as the associated uncertainties of each.
- In general, this version of EBSAs in the PBGB study area were similar to the previously identified set of EBSAs, even though both sets were identified using different approaches. The EBSAs described in this document should be considered as the current set for the PBGB study area because this process used the most recent available data.
- The secondary EBSA criteria of naturalness and resilience were not used to identify EBSAs. These factors could be assessed to prioritize sites for protection.
- More than 80% of offshore data layers were based on DFO RV survey data. Although this is a multispecies survey, some species groups and sizes are under sampled (icthyoplankton, juveniles, small-sized taxonomic groups, pelagic fish, benthic infauna, and some species of corals and sponges).
- Migratory pathways for most species were not identified due to the seasonality of available data. In some cases, migratory pathways could be inferred but generally this was not a defining factor for most EBSAs.
- The resolution of the data used to identify EBSAs, in particular those in the offshore, had some effect on the size and shape of the areas that were described. The issue of having many small areas versus fewer large areas was discussed and generally, it was agreed that our understanding of the ecosystem exists at coarse scales and it is difficult to identify and describe relatively small EBSAs.

INTRODUCTION

Under Canada's Oceans Act (1997), "conservation, based on an ecosystem approach, is of fundamental importance to maintaining biological diversity and productivity in the marine environment". This Act provides the legislative framework for an integrated ecosystem-approach to management in Canadian oceans, particularly in areas considered ecologically or biologically significant.

Fisheries and Oceans Canada (DFO) Science has developed guidance on the identification of Ecologically or Biologically Significant Areas (EBSAs) (DFO 2004) and has endorsed the scientific criteria of the Convention on Biological Diversity (CBD) for identifying ecologically or biologically significant marine areas as defined in Annex I of Decision IX/20 of its 9th Conference of Parties. In 2011 a DFO National Advisory Process was held to examine the lessons learned in previous applications of the national guidelines to identify EBSAs within the Department's five national Large Ocean Management Areas (LOMAs). This additional guidance (DFO 2011) was intended to address potential issues that may arise while moving forward with the identification of additional EBSAs outside the LOMAs.

In 2007, DFO Science, NL Region provided advice to Oceans Division on EBSAs within the PBGB LOMA (hereafter referred to as the "PBGB area" or "study area") using a Delphic approach. Information from documents detailing ecosystem overview and status, fish distribution and spawning, and single species assessments were compiled along with expert knowledge from NL scientists. The result of this exercise was the identification of 11 EBSAs and their significant features, along with a corresponding map, provided to the client via a CSAS Research Document (Templeman 2007).

In 2012, a process was undertaken to identify additional EBSAs north of the PBGB area (DFO 2013), hereafter referred to as the "2013 EBSA process". A steering committee was formed to provide guidance on data identification, collection, processing and analysis and to delineate candidate EBSAs. This analysis relied on the use of a Geographic Information System (GIS) to process all relevant data into spatially referenced data layers for use in the identification and delineation of candidate EBSAs (Ollerhead et al. 2017). A CSAS meeting was held to peer review the candidate EBSAs and all relevant data, leading to the acceptance or rejection of each candidate EBSA, as well as the identification of additional EBSAs based on expert scientific knowledge (Wells et al. 2017).

In 2015, Oceans Division requested that Science provide additional information on the geospatial information that led to the delineation of the PBGB area EBSAs. During the Science Response advisory process (DFO 2016), it became clear that the amount of geospatial information available for EBSAs in the PBGB area was not as complete or consistent with the data available for EBSAs north of that area. This led to a 2016 request by Oceans Division for Science to replicate the 2013 EBSA identification process for the PBGB area. A steering committee was formed and the data collection process began. The EBSA criteria of aggregation, fitness consequences and uniqueness, as well as previous CSAS guidance documents (DFO 2004; 2011), were used to guide the process of data identification, collection, processing and analysis. All information was compiled in a GIS and candidate EBSAs were proposed for consideration at a CSAS peer review meeting on January 17-18, 2017. This research document discusses the methods used to identify and delineate the EBSAs and describes the final EBSAs based on feedback obtained at the CSAS meeting.

Advice on the identification of EBSAs, based on methods consistent with those used for other EBSA identification processes, will serve as a key component of the knowledge and advice for developing Canada's network of MPAs to meet the domestic and international commitments noted above. In addition, this information will be of direct use to other federal Departments, as well as the Government of Newfoundland and Labrador and other organizations, who are responsible for the management of activities in the NL Shelves Bioregion within their mandate (e.g. resource extraction, marine shipping, ocean dumping, spill response, cable laying, land use planning, etc.).

ANALYSIS

The PBGB study area is set off the east (49.26 N, 53.47 W) and south (47.62 N, 59.31 W) coasts of the island of Newfoundland from the shoreline to Canada's Exclusive Economic Zone (EEZ) boundary. The northern boundary of the study area is the border between Northwest Atlantic Fisheries Organization (NAFO) Divisions 3K and 3L; the western boundary is the border between NAFO Divisions 4R and 3Pn; and the southern boundary is the border between NAFO Divisions 3P and 4V. The study area is inclusive of NAFO Divisions 3LNOP and is ~575,000 km^2 (Figure 1).

All data layers except those for pelagic seabirds included data that were outside the EEZ. This was done to ensure that ecological processes occurring along the shelf break were captured in a consistent manner. Interpolations were made using data that fell both outside and within the boundaries of study area. This was done to prevent edge effects in data analyses from having any impact on the study area. Interpolated data that fell outside of the study area boundaries were subsequently clipped from the data layer and excluded from the quantile classification and further analyses.

ArcGIS v10.2.2 (ESRI Inc. 2010) was used to create, store, analyze and display all spatially-referenced data used in the delineation of candidate and final EBSAs. For additional information pertaining to the software packages used in the preparation, management and processing of data, see Wells et al. 2019.

Methods for processing and analyzing spatial data were similar to those used in the 2013 EBSA identification process (see Wells et al. 2019). These included spatial interpolation techniques such as Kernel Density (KD), the upper 10^{th} percentile rule to find important areas (IAs) and cell statistics analysis of offshore data using a 20 km x 20 km grid cell size. KD analysis was the primary method used in the 2013 EBSA identification process, therefore, this method was chosen over Inverse Distance Weighted analyses (IDW) to remain consistent with the previous approach. A PCA was not done for this study area because, while this task was found to be useful for finding and describing large scale patterns within the study area for a previous EBSA identification exercise (Wells et al. 2017), it was not particularly helpful for finding ecologically important areas.

Data representing 272 layers of biological and geophysical features were collected from a variety of sources, with the majority coming from DFO and Environment and Climate Change Canada, Canadian Wildlife Service (ECCC, CWS). Online data repositories and published literature were also mined for relevant information. For some species, there were multiple sources of information and the layers developed from these sources often applied to different EBSA criteria, therefore they were reviewed and treated separately during the EBSA identification process. For more information on the data sets included (and not included) in the analysis, see Wells et al. 2019.

At-risk species were recognized based on Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designations and were treated separately (i.e. not combined with functional groups). A subset of these species is protected legally under the *Species at Risk Act* (SARA). Unfortunately, data layers could not be created for all at-risk species due to limited availability of data. However, literature searches were conducted for all data-poor species and relevant geospatial information was taken into account as part of the EBSA identification process.

In 2016, a Science Response process (hereafter referred to as the EBSA refinement process) was conducted in response to an Oceans Division request to provide geospatial information on EBSAs previously identified in the PBGB area (Templeman 2007). A Delphic approach was taken to re-collect information provided in Table 1 of Templeman 2007 by consulting with DFO Science and reviewing the original data sources for the 2007 process. This information was geospatially referenced where possible and compiled in a Geographic Information System (GIS) atlas (DFO 2016). These data layers (see Table 5 of Wells et al. 2019) were included in this process as overlays for delineated EBSAs and in the descriptions for the EBSAs, but were not included in the cell statistics process, because the methods used to create each of those data layers differed from the methods used here.

EBSA Identification

EBSAs were identified using calculations based on relative measures to determine areas of high concentrations, which are assumed to be areas of higher biological importance. Some offshore data layers were not included in composite layers if they were redundant, if they were based on polygons that were digitized for the 2016 EBSA refinement process, or if they were acquired once all analyses were complete. All of these data layers were reviewed as overlays on the final EBSAs to determine the amount of overlap and to determine how much of each feature was captured by specific EBSAs.

The composite layers were used as a starting point for the identification of EBSAs in the offshore. The 60% value threshold was deemed to be the best fit as a cut-off point (see Wells et al. 2019). This use of the composite layers enabled the identification of areas that were important to a number of species or functional groups and potentially met several EBSA criteria. However, an iterative process was used to identify EBSAs and refine boundaries at different data resolutions:

- Step 1 – identify EBSAs using the 60% threshold on composite layers. These EBSAs are effectively areas of high biomass (indicator for the aggregation criterion) for several species or species groups.
- Step 2 – review cell statistics layers for each data group (logical groupings based on common taxa or characteristics) to identify EBSAs or refine boundaries of EBSAs identified during Step 1. This allowed for the identification of important areas at higher taxonomic levels (e.g. for all cetaceans, all at-risk species, etc.).
- Step 3 – review all individual data layers to identify EBSAs or refine boundaries of EBSAs identified during Steps 1 and 2. This final step ensured IAs for uniqueness or fitness consequences were identified.

Data in coastal areas (areas in the nearshore falling outside the footprint of the DFO RV survey) were treated separately and not included in the composite layers due to differences in scale. The identification of EBSAs in coastal areas involved reviewing all coastal layers simultaneously to determine if certain areas visually emerged as ‘hotspots’ (i.e. areas occupied by multiple species or species groups). Data layers were also reviewed to determine if there were unique features in the coastal zone. Scientific data layers were reviewed initially and Community Based Coastal Resource Inventory (CCRI) data were then used to validate areas of importance.

Once EBSA boundaries were delineated, the individual data layers that were found within each EBSA were identified and described using relative descriptors that helped determine the size and number of features within an area; this aided in the application of the uniqueness criterion. The key features used to identify each EBSA are described below.

Most EBSAs were identified based on the aggregation criterion because of the nature of the available data and the methods used to analyze them. Datasets available for the PBGB area that enabled the identification of areas with specific fitness consequences for species or species groups included capelin spawning areas, seabird colonies and associated seaward foraging areas, and high concentration areas for at-risk species. Given the methodology used to identify IAs during this analysis, any areas identified based on the fitness consequences criterion are also assumed to be important aggregation areas for that species. Application of all criteria followed that of Wells et al. (2017). However, in this study, additional peer reviewed data layers were used to identify some features under the aggregation or fitness consequences criteria. With the exception of the Blue Whale and Leatherback Turtle important habitat layers, the uniqueness criterion was not applied to these layers. Some of the studies from which these data layers resulted were based on localized studies that may not have taken the full study area into account when identifying these features. Also, the polygons may have represented the full distribution for a species rather than the most important areas (i.e. the upper 10^{th} percentile). For species that were kept separate from functional groups in this analysis (e.g. core species, at-risk species) and were represented on their own data layers, the IAs found on data layers that were developed took priority over the peer reviewed polygons. In these cases, the peer reviewed polygons were used to validate the presence of a species in a given area. For species that were grouped with functional groups, RV survey point data were reviewed for the studied species to determine general patterns at the extent of the study area. However, a full analysis was not done for these species.

When EBSAs were identified in the area north of the PBGB study area (DFO 2013), key features were identified for each EBSA based on whether or not they were one of the main reasons why the EBSA was identified. Decisions regarding key features were made by experts during the peer review process. In order to make this process more objective, key features of EBSAs in the PBGB study area were identified based on the following criteria:

- the feature was described as moderate or above relative to the EBSA size;
- or, the number of polygons in the EBSA compared to the entire study area was greater than 50%, regardless of size;
- or, the only IA found within the study area was found within the EBSA, regardless of size.

Exceptions to the above criteria were made for some ecosystem features. The list of features that were exempted and the rationale for these exceptions are found in Table 6 of Wells et al. (2019).

Coastal EBSAs

Seven EBSAs were identified in coastal areas (Figure 1). The primary data layers that were used to delineate these areas included Eelgrass habitat, Salmon, Capelin spawning areas, seabird colonies and waterfowl areas. Maps indicating the presence of these features in each

EBSA are available in Wells et al. (2019). Data for the entire coast of Newfoundland are unavailable for many ecosystem features, particularly fish species. This is particularly true when considering the variability and scale of local ecological dynamics occurring in nearshore environments.

The distribution and abundance of breeding and foraging seabirds usually reflects the availability of prey in the marine ecosystems on which the birds depend (Birkhead and Furness 1985, Hunt 1991). Clearly, globally significant and persistent seabird colonies found on the east coast of Newfoundland are sustained by persistently highly productive waters nearby. The breeding season foraging ranges of piscivorous colonial seabirds were used as a proxy to indicate areas where a high abundance of forage species for these birds is likely to occur. In the absence of long-term tracking studies at individual colonies, use of mean maximum foraging range provides the most appropriate prediction of spatial use during breeding (Soanes et al. 2016; Bogdanova et al. 2014; Thaxter et al. 2012; Cairns et al.1987). More information on the main prey types for these species can be found in Wells et al. 2019. These foraging buffers were used to delineate the seaward extension of some coastal EBSAs, and in most cases this meant that IAs identified in offshore data layers were captured by the EBSA boundaries. Therefore, all offshore data layers were also reviewed within the boundaries of each coastal EBSA and key ecosystem features were identified based on the criteria described above. Important Bird Areas (IBAs)were reviewed and descriptions were incorporated into identified EBSAs. Though they were not used in the analyses, IBAs were used as a confirmatory step in the EBSA identification process. CCRI data were also reviewed to determine what species were present in each EBSA, but these data were also not used in the identification of EBSAs.

Bonavista Bay (3L)

The Bonavista Bay EBSA consists of the entire Bonavista Bay area from Cape Freels North to the headland just east of King's Cove. This area originally included two EBSAs and it was determined that the spatial resolution of the coastal datasets were not conducive to the delimitation of nearshore processes at the scale at which they likely occur. Therefore, it was determined that it would be more appropriate to combine the two areas, expand the boundary to the bay scale and describe the key features within the single resulting area as best as possible.

The northern boundary extends seaward along the northern edge of the study area adjacent to the Fogo Shelf EBSA, which was identified during the 2013 EBSA process. The seaward extension in the north end of the Bonavista Bay EBSA was delineated based on the pelagic seabird layer group, which indicated that IAs for 4 of the 7 pelagic seabird functional groups are found in this area. The EBSA boundary was extended southward nearly perpendicular to the study area boundary to meet the headland just east of King's Cove. While the foraging buffer for terns (20 km) was not used to delineate this boundary, this EBSA does capture most of the area that would have been delineated using that approach. This EBSA was delineated based on the size, number and diversity of seabird colonies in the area, as well as eelgrass habitat, capelin spawning beaches and important salmon areas.

During the 2013 EBSA process, it was suggested that the ecological importance of the Fogo Shelf EBSA likely extends south of the study area boundary into NAFO Division 3L. This was mostly because the Cape Freels Coastline and Cabot Island IBA occurs there and contains one of the largest concentrations of wintering Common Eiders in Newfoundland (Website). This was confirmed by the presence of a Common Eider IA south of Cape Freels North. Other features of the Fogo Shelf EBSA are also found in the Bonavista Bay area such as Capelin spawning, Salmon, Cetaceans, Seals, Sea Ducks and numerous seabird colonies representing multiple species.

Capelin spawning occurs on many beaches throughout this EBSA. Small pockets of eelgrass habitat are also found throughout the coastal areas of this EBSA. A large area of eelgrass is found approximately halfway between Cape Freels North and New-Wes-Valley. Several other eelgrass beds are found in pockets between Newman Sound and Southern Bay, mainly at the heads of bays and coves. Newman Sound is an important nursery area for demersal fishes (Gregory et al. 2016 and references within).

Important areas for Sea Ducks and most half of all Tern species colonies are found in this EBSA. Given their relatively short foraging ranges, terns depend on the highly productive waters in this area for prey items such as Capelin, Sand Lance, White Hake and more.

The boundary of Terra Nova National Park is found within this EBSA, as are the Eastport MPAs. The Terra Nova Migratory Bird Sanctuary, which is also found within this EBSA, consists of the upper portions of two tidal inlets that are nearly totally enclosed by lands within the Terra Nova National Park. The northern portion consists of Broad Cove and Southwest Arm. The other section is the most westerly portion of Newman Sound (Website). Terra Nova River is an important salmon river found within this EBSA. It is also the only river in Atlantic Canada where spawning populations of sea lamprey have been found (Dempson and Porter 1993, Bradbury et al. 1999).

Killer whales, Mysticetes (primarily Humpback and Minke Whales) and Harbour Seal IAs are also found in this area. They likely use this area for feeding during summer and fall months.

Smith Sound (3L)

The Smith Sound EBSA extends from the headland east of Port Rexton south to the headland east of Shoal Bay and includes Smith Sound and the Southwest Arm of Random Sound. This EBSA was delineated based on the numerous capelin spawning beaches, eelgrass beds, seabirds and marine mammals in the area.

Smith Sound is a long continuous channel that encircles Random Island and is known to have one of the most extensive beds of eelgrass habitat on the island of Newfoundland (R. Gregory, pers. comm.). The Smith Sound area was identified as an EBSA by Templeman (2007), mainly based on the fact that it was the largest known spawning area for northern cod at that time. The spawning population of northern cod has since dispersed from this area and has not been observed there since 2009 (Rose et al. 2011).

Capelin are known to spawn throughout large portions of Smith Sound, including Northwest Arm and Southwest Arm, and south to Big Island which is just north of Shoal Bay. The foraging ranges of several piscivorous seabird species (Atlantic Puffin, Black-legged Kittiwake and terns) overlap with this area. IAs for Killer Whale and Mysticetes were also found outside the Sound in Trinity Bay.

Baccalieu Island (3L)

The Baccalieu Island EBSA is centered on the island itself and extends north to Bonavista and south to Pouch Cove. This EBSA was identified because of important seabird colonies that are found on the Island. The foraging range of Atlantic Puffin, Black-legged Kittiwake and Common Murre (60 km) was used to delineate the seaward boundary. There are also several other key features in surrounding waters including IAs for Capelin, shrimp, plank-piscivorous fish, Spotted Wolffish and marine mammals.

Baccalieu Island is recognized as an IBA as it hosts the world's largest known nesting colony of Leach's Storm-Petrel. (Website).The island also supports continentally and globally significant populations of Atlantic Puffin, Black-legged Kittiwake, and Northern Gannet. The island has the greatest abundance and species diversity of seabirds in eastern North America. Other seabirds nesting on the island include Common Murre, Thick-billed Murre, Razorbill, Black Guillemot, Northern Fulmar, Herring Gull and Great Black-backed Gull (Website). The enduring presence of such significant populations of mostly piscivorous seabirds is a strong indicator that surrounding waters are persistently highly productive and provide ample food for these colonies to thrive. This is confirmed by the presence of Capelin spawning areas at each of the three headlands captured within the boundaries of this EBSA. Also, Capelin and shrimp IAs are found within the foraging range of these seabirds. Plank-piscivore and Spotted Wolffish IAs are also found in this EBSA. All fish and shrimp IAs are located near the seaward boundary of the EBSA. DFO RV trawl survey data are not collected in shallow nearshore waters (i.e. closest set to Baccalieu Island is ~20 km away) so information on all fish and shrimp species are not available in these areas. However, acoustic surveys have been conducted closer to shore in this area and have confirmed the presence of Capelin aggregations (Mowbray 2014).

Killer Whales and Mysticetes IAs are found here based on sightings data. These cetacean species are also likely taking advantage of the highly productive waters in the area.

Eastern Avalon (3L)

The Eastern Avalon EBSA is located on the eastern side of the Avalon Peninsula and extends from the southern boundary of Chance Cove Provincial Park north to Pouch Cove. The seaward boundary was delineated based on the foraging range (60 km) of piscivorous seabirds that occupy colonies within Witless Bay. This EBSA was identified based on a combination of coastal data, including Capelin spawning beaches, waterfowl areas and seabird colonies, with additional key features identified based on offshore data.

Eelgrass habitat is not particularly common in this EBSA but one area is found in Deadmans Bay and Blackhead Bay, just north of Cape Spear. Capelin spawning is more prevalent along the coast in this EBSA with 29 spawning sites having been identified within the boundaries delineated.

American Plaice IAs were found toward the outer boundary of this EBSA (and extending out on Grand Bank) during the Engel time series. IAs for this species have primarily been distributed on the Southeast Shoal and in Halibut Channel during the Campelen years. As with all EBSAs on the east coast of Newfoundland, Killer Whales and Mysticetes are commonly sighted in the Eastern Avalon EBSA.

At least 10 species of seabirds have important colonies in this area, including the only significant Northern Fulmar colony in the study area, near Bauline East. Furthermore, this area contains the Witless Bay Islands IBA, which supports the largest colony of Atlantic Puffins in eastern North America (Website). Significant colonies for six species are found on islands within Witless Bay. In addition to the only Northern Fulmar colony in the top decile being found here, two of three Atlantic Puffin colonies, three of five Razorbill colonies, five of fourteen Black-legged Kittiwake colonies, one of two Common Murre colonies, and both Thick-billed Murre colonies in the top decile for each respective species are located within this EBSA.

A high count of dabbling ducks observed within one coastal block polygon within the EBSA is believed primarily to be the result of anthropogenic rather than natural food resources in the vicinity of the city of St. John's. Consequently, this information was not considered in the evaluation of this EBSA.

In addition, pelagic seabird transect survey data confirm IAs for several seabird functional groups in this EBSA: plunge-diving piscivores, pursuit-diving piscivores and surface shallow-diving piscivores. These birds rely on forage fish prey in the waters surrounding these islands and adjacent areas on the Grand Bank. Acoustic surveys have shown that Capelin are found in this area, with some years having higher densities than others (Mowbray 2014). This was confirmed by the presence of Capelin IAs in this area, however only the Engel fall IA took up a large portion of the EBSA.

St. Mary's Bay (3L)

The St. Mary's Bay EBSA includes St. Mary's Bay and Cape St. Mary's and was primarily identified using coastal data. The eastern boundary is the headland of St. Mary's Bay just east of St. Shott's and the western boundary is on the opposite headland near St. Bride's. The seaward extension of this EBSA was delineated based on the foraging range (60 km) of piscivorous seabirds that nest at Cape St. Mary's.

This area is known to be important to several species of seabirds and waterfowl, specifically wintering sea ducks, and it also contains a number of Capelin spawning beaches, eelgrass beds and important salmon rivers. Salmonier River, which drains into this Bay, has been found to contain part of a genetically distinct population of salmon that inhabits rivers on the Avalon and Burin Peninsulas (Bradbury et al. 2015, Moore et al. 2014).

This EBSA contains two features unique to the study area. The waters surrounding Cape St. Mary's contain the only IA for the endangered Harlequin Duck in the study area. These non-breeding concentrations occur mainly during the winter months. The only Northern Gannet colony in the upper tenth percentile in the study area is also found in this EBSA at Cape St. Mary's. In addition to Northern Gannet, the IBA hosts at least an additional 25,000 breeding pairs of seabirds, with Common Murre and Black-legged Kittiwake being the most abundant (Website).

Several additional features were identified based on the offshore with the EBSA boundary delineated to reflect the foraging range of seabirds. Capelin IAs are found here towards the outer boundary while Mysticetes are found in high concentrations near the headlands and into the Bay. Hooded Seals are also found outside the Bay (and all along the south coast of Newfoundland) as they migrate through the area from the Gulf of St. Lawrence to Greenland during late May to June. While the Leatherback Turtle Important Habitat polygon does extend slightly into this EBSA, the core area for this species is Placentia Bay, which was also identified as an EBSA (see below).

Placentia Bay (3Ps)

The Placentia Bay EBSA boundary extends across the mouth of the Bay from St. Lawrence on the west side to the St. Mary's Bay EBSA boundary on the east side. It primarily was identified based on coastal data, but the seaward boundary was extended south to capture IAs for corals and sponges as well as Leatherback Turtle important habitat. This EBSA has important salmon rivers, Capelin spawning beaches, eelgrass habitat and seabird colonies in the nearshore, and many other key features just outside the bay.

Piper's Hole River and Cape Rodger River, which drain into this bay, have been found to contain part of a genetically distinct population of salmon that inhabits rivers along the Avalon and Burin Peninsulas (Bradbury et al. 2015, Moore et al. 2014). Capelin spawning beaches are heavily concentrated on the east side of the bay but a few are also found on the west side. Spawning beaches also exist on the southern tip of the Burin Peninsula. Eelgrass habitat is found in many coves and harbours throughout the bay, however the invasive Green Crab is having an impact on the health of this important habitat in this area (Matheson et al. 2016).

Leatherback Turtles are known to frequent the entire bay, with 18% of all sightings from the 2016 NAISS survey found within the boundaries of this EBSA (J. Lawson, unpublished data). Furthermore, Placentia Bay was identified as the only area in the study area that contains important habitat for Leatherback Turtles (DFO 2012). Another large area of important habitat is identified in the DFO (2012) report which extends slightly into the study area and is captured by the South Coast EBSA (see below) but the size of that area is insignificant compared to the area found within Placentia Bay. This EBSA also captures part of a larger area denoted as important for Blue Whales (DFO 2018). While no Blue Whales were sighted in the bay during the 2016 NAISS survey (Lawson and Gosselin 2018), one IA was identified on the southern tip of the Burin Peninsula based on sightings and survey data. Mysticetes and Hooded Seal IAs are also found throughout the bay out to the headlands.

Large Gorgonian Coral, Soft Coral and Sponge IAs are found near the seaward boundary of the Placentia Bay EBSA. They are mostly found in parts of Halibut Channel, St. Pierre Channel and in the Placentia Bay nearshore region.

This EBSA contains the Placentia Bay IBA which was identified based partly on the large numbers of shearwaters that are lured into Placentia Bay to feed on spawning capelin. More than 100,000 individuals of Greater Shearwater have been recorded, which is a globally significant concentration (Website). Note that Greater Shearwater and Sooty Shearwater do not breed anywhere in the Northern Hemisphere. As such, large numbers of individuals of these species travel to this specific area primarily to access abundant and predictable prey resources during their non-breeding season. Almost 40% of the tern species colonies identified in the upper tenth percentile are found in Placentia Bay. Terns, Common Murre and Black-legged Kittiwake forage throughout the bay. Some 1000 to 2000 Common Eiders often winter around the Virgin Rocks, Placentia Bay (Rao et al. 2009).

Two areas noted for high concentrations of ichthyoplankton in the Bay, which were identified during the 2016 EBSA refinement exercise (DFO 2016 taken from Bradbury et al. 2003), were also used as overlays to ensure they were captured by the candidate EBSA boundary. One area extends along the western side of Placentia Bay from the coast to the center of the Bay, and from Southeast Bight to Burin. The second area occurs at the head of the Bay (Swift Current/Come By Chance area) and extends all the way out and across the Bay as far south as Fox Harbour. Furthermore, Lawson and Rose (2000) found that there are several important spawning areas for Atlantic Cod within the boundaries of this EBSA.

South Coast (3P)

The South Coast EBSA is located along the South coast of Newfoundland from Cape Ray to just east of the island of Ramea. The western boundary matches the boundary between NAFO Divisions 4R and 3Pn while the southern boundary extends seaward by roughly 35-40 km to include the northwest portion of the Laurentian Channel and Rose Blanche Bank. During initial review of the composite layer (spring RV survey data only) and the Marine Mammals group layer, this EBSA was originally identified as two separate areas. After considering unpublished data and expert opinion (J. Lawson, pers. comm.), the two areas were joined based on the fact that this area is known to be important habitat for the endangered Blue Whale and other marine mammals.

Other key features noted in this area include three fish functional groups (planktivores, piscivores and plankpiscivores), two seabird functional groups (surface shallow-diving coastal piscivores and surface shallow-diving piscivores), and two seal species (Hooded Seals and Grey Seals). Atlantic Cod, redfish and shrimp IAs are also found in this EBSA. Cod and Redfish are found toward the west (Rose Blanch Bank area) while shrimp are found toward the east. Sea pen and sponge sensitive benthic areas (SBAs) are found in this EBSA. The largest Sea pen SBA is found at the northern end of the Laurentian Channel just southwest of Rose Blanche Bank while the only sponge SBA is relatively small and found just below the 200 m contour roughly 7 km southwest of Grand Bay-West (Kenchington et al. 2016b).

A review of coastal data revealed that several eelgrass beds are found along the coast with the largest beds located between Cape Ray and Channel-Port aux Basques. The two most important Common Eider colonies occur in this EBSA, however they are relatively small (<30 individuals each) in comparison to the larger colonies (up to hundreds of individuals) found in other parts of Atlantic Canada. There are two IBAs in this area. The Grand Bay West to Cheeseman Provincial Park area was recognized as an IBA because it provides coastal dune nesting habitat and intertidal foraging habitat for the globally vulnerable and nationally endangered Piping Plover (Website). The Big Barasway IBA also supports a significant population of Piping Plover (Website).

The large Black Dogfish area identified by Kulka (2006) extends into the western portion of this EBSA. The Smooth Skate area identified by Kulka et al. (2006) almost covers the entire EBSA.

Offshore EBSAs

Seven candidate EBSAs were identified in the offshore portion of the study area, mostly based on the composite layer with spring RV data only. Data layers used to identify offshore areas included those for corals and sponges, at-risk species, core fish species, fish functional groups, seabird functional groups and marine mammals.

In the offshore, using a combination of data and expert knowledge, much of the shelf edge and slope along the Grand Banks was highlighted as ecologically important based on measures of high productivity and diversity relative to the shelf itself. The most significant areas of aggregation were often associated with areas of unique bathymetry, such as banks, channels, slopes, shoals, troughs, canyons and fjords. Some areas along the shelf edge and slope fall outside the study area, but nonetheless were delineated as EBSAs (see below).

Northeast Slope (3L)

The Northeast Slope EBSA is found on the northeast edge of Grand Bank and extends from the Trinity Basin east and south along the shelf edge and slope to the Sackville Spur. This EBSA was delineated based on the composite layer (spring RV survey data only). The northwest boundary was extended westward based on the composite layer including both spring and fall RV survey data, as well as IAs for sponges, Atlantic Cod, shrimp, Greenland Halibut, and Spotted Wolffish. The northeast portion of this EBSA, which includes the Labrador Slope and part of the Trinity Trough, is adjacent to the southern boundary of the Orphan Spur EBSA (DFO 2013). The key data layers that contributed to this area include those for Capelin, shrimp, Greenland Halibut, Witch Flounder, American Plaice, Atlantic Cod, all three species of wolffish, Thorny Skate, Smooth Skate, Roughhead Grenadier, all six fish functional groups, sea pens, black corals, soft corals, sponges, Common and Thick-billed Murre and Hooded Seals. Several other species or functional groups are also found here.

Most species or functional groups were identified here based on the aggregation criterion. However, six species were identified based on the uniqueness criterion: two core fish species (Greenland Halibut, shrimp), three at-risk species (Northern & Spotted Wolffish and Roughhead Grenadier) and a coral functional group (Black Corals). This was the only IA for Greenland Halibut on the Engel fall data layer. While Greenland Halibut were found outside this EBSA boundary on other data layers (i.e. Campelen fall, Campelen spring, Engel spring), the majority of all high concentration areas for Greenland Halibut were found in this area. Similarly for shrimp, the IA on the Campelen fall data layer was found in this area, but extends southwest and southeast beyond the EBSA boundary. One of two Shrimp IAs on the Campelen spring data layer had a similar distribution. The other, much smaller, IA for shrimp is found along the South Coast of Newfoundland. Most of the IAs for all the threatened Northern Wolffish data layers (except Campelen spring) are found within this EBSA and extend from the Trinity Basin area along the shelf edge and onto the Labrador Slope. Spotted Wolffish (also threatened) show a similar distribution and this area was confirmed as being important for this species by Kulka et al. (2004). Roughhead Grenadier (special concern under COSEWIC) IAs are found on the slope in this EBSA with distributions extending to the Sackville Spur. The only Roughhead Grenadier IAs found in the study area on the Engel fall data layer were found in this EBSA. Finally, Black Corals, which are a rare, non-aggregating species, were found in this EBSA. Only two Black Coral IAs were found in the study area: in this EBSA along the Labrador Slope and in the SW Slope EBSA (see below); both were small in size.

Five other at-risk species were found here as key biological features, meaning the fitness consequences criterion applies to them, along with the three at-risk species discussed above. American Plaice IAs were generally distributed across the Grand Bank during Engel years, with one large IA being found on the shelf edge in the NE Slope EBSA. In the Campelen years IAs identified for this species shifted southward towards the Southeast Shoal, with the exception of one small IA which was found in the NE Slope EBSA. Large IAs for Atlantic Cod were found in this EBSA in three of four data layers. Cod IAs on the Campelen spring layer were found in NAFO Divs. 3NOP only. Atlantic Wolffish IAs are found in two main areas in the study area – the NE Slope EBSA and the SE Shoal EBSA. A few other IAs are found outside of these EBSAs but not consistently across data layers like those found in the NE Slope and SE Shoal areas. Smooth Skate and Thorny Skate IAs were found in the NE Slope EBSA during the Engel years but IAs for these species were only found in more southern areas (SW Slope, Laurentian Channel for both species; SE Shoal for Thorny Skate) during the Campelen years.

Other core fish species found here include Capelin and Witch Flounder. Capelin IAs were mainly found throughout the northern portion of NAFO Division 3L, including the NE Slope EBSA, on all data layers except Engel spring, which showed a more southerly distribution. It was noted by Carscadden et al. (2013) that Capelin distributions have changed over the last few decades. However, the methods used to find IAs may not be sufficient to see the finer-scale spatial and temporal changes for this species that appear to be influenced by factors such as temperature and population abundance. Witch Flounder IAs were mainly found throughout the NE Slope EBSA, the SW Slope EBSA and the Laurentian Channel EBSA and this pattern was consistently found on all data layers for this species.

The majority of fish functional group IAs were found in EBSAs that were identified on shelf edges and slopes, including the NE Slope EBSA. Small benthivore IAs were found in this EBSA on all four data layers. Planktivore IAs were found here only on Campelen data layers. Medium benthivores and piscivores were found here on only fall data layers. Large benthivores were found here only on the Engel fall data layer. Plank-Piscivores were found here on all data layers except Campelen spring. Piscivore IAs were found here only on fall layers. A review of all Piscivore IAs revealed that the Laurentian Channel and SW Slope are more important areas for this functional group.

Other than Black Corals, two other coral groups, plus sponges, are found in this EBSA. Large Gorgonian IAs were found in patches along the Labrador Slope in this EBSA and the same areas were identified as SBAs (Kenchington et al. 2016b). Soft Coral IAs were found all along the Labrador Slope to the EEZ boundary. Sponge IAs were found near the Trinity Moraine/Trinity Basin end of this EBSA, however this IA was not identified as a Sponge SBA.

During non-breeding, Common Murre are found in the eastern half of this EBSA, as well as areas north and south, with concentrations occurring there during early and late winter. Thick-billed Murre are found throughout the middle of this EBSA and as far south as the Virgin Rocks EBSA during early winter. Finally, Hooded Seals are found in this EBSA in the Labrador Slope area as well as areas north and south. They feed primarily on squid, Arctic Cod, Atlantic Cod, Greenland Halibut and redfish in the deep waters along the shelf edge during the winter (December to late February) prior to pupping and in late April-May after pupping has finished (Hammill and Stenson 2000, Stenson, pers. comm.).

Virgin Rocks (3LO)

The Virgin Rocks EBSA is found at the center of the Grand Bank and includes a unique geomorphological feature that covers several square kilometers. Shallow shoals of jagged underwater ridges and rocks are nearly exposed in some areas – as shallow as 3.6 m from the surface of the water (Rao et al. 2009).

This EBSA was originally delineated based on the composite layer (spring RV survey data only), meaning a high diversity of species aggregate here. A review of individual data layers revealed that most IAs were located south of the Virgin Rocks. However, it was decided to modify the boundary to encompass areas north, south, east and west of the Virgin Rocks feature. The radius of the circle (~50 km) was chosen based on the distance from the center of the Virgin Rocks to the outer edge of the grid cell in the top 60% of the spring composite layer.

A subsequent review of all data layers revealed that the key features in this area are core fish species, at-risk species and pelagic seabirds. Core fish species include Sand Lance and Capelin, which constitute important prey for predatory seabirds, fish and cetaceans also found in high concentrations in this area. It is worth noting however, that Capelin IAs were only found here on the Engel spring data layer. In Campelen years (1995-2016), Capelin IAs were generally found further north. Given that Capelin distributions have changed over the last few decades (Carscadden et al. 2013), the methods used to find IAs may not be sufficient to see the finer-scale spatial and temporal changes for this species that appear to be influenced by factors such as temperature and population abundance.

American Plaice IAs on Engel fall data layer cover a large portion of the Grand Bank and includes the Virgin Rocks. An IA for Sooty Shearwater covers most of this EBSA and extends east and south to the EEZ. A Thick-billed Murre IA also covers this EBSA and extends north to the study area boundary. While none of the pelagic seabird IAs were considered key features of this EBSA, IAs for 5 seabird functional groups were found here. Finally, an IA for Killer Whales was found at the center of this EBSA.

This area was identified as a Special Marine Area by Canadian Parks and Wilderness Society (CPAWS) (Rao et al. 2009) and is described in that report as an area with high plankton productivity and diverse and productive kelp beds. This area also has important spawning habitat for Atlantic Cod, American Plaice and Yellowtail Flounder, and is a congregation area for capelin and seabirds.

Lilly Canyon-Carson Canyon (3N)

The Lilly Canyon-Carson Canyon EBSA is found just inside the EEZ on the western edge of Grand Bank. This EBSA was delineated based on the composite layer (spring RV survey data only) and includes the Lilly Canyon and Carson Canyon, which were previously identified as an EBSA (Templeman 2007). The new EBSA boundary includes the shelf and slope areas surrounding the canyons. The key species with IAs in this EBSA include Snow Crab, Greenland Halibut, American Plaice, redfish, Roughhead Grenadier, Thorny Skate, Common Murre, Sooty Shearwater, Soft Corals, sponges, Blue Whales and Harp Seals. The key functional groups include small and large benthivores (fish), shallow pursuit generalist seabirds and surface shallow-diving piscivores. Most features were identified based on either the aggregation or fitness consequences criteria; however, Roughhead Grenadier was identified here based on uniqueness. The IAs for this species on the Campelen fall data were mainly found in this EBSA, although one small area was found at the east end of the NE Slope EBSA, extending beyond the EEZ.

As this EBSA is relatively small compared to other offshore EBSAs, most key features were found throughout the entire EBSA. IAs were found here on two or more data layers for most fish species. Small benthivore IAs were found here on all four data layers. IAs for some species (i.e. Harp Seals, Sooty Shearwater, Common Murre) were found in this EBSA and over large parts of the eastern Grand Bank, including the shelf edge and slope. Soft Corals are found mostly in the southern end of this EBSA on the shelf edge. Sponge IAs were found in deeper waters near the EEZ boundary, while a small Sponge SBA was identified between the 200 m and 500 m bathymetric contour in Carson Canyon near the north end of the EBSA. This area is also known to have a high proportion of Iceland Scallops (Ollerhead et al. 2004, DFO 2016).

Southeast Shoal (3NO)

The Southeast Shoal EBSA is found just inside the EEZ on the southeast portion of Grand Bank. It includes the portion of the Southeast Shoal inside the EEZ as well as part of the Outer Shelf Zone of the Grand Bank. This area was originally a smaller area delineated based on the 60% composite layer (spring RV survey data only) but the area was extended to incorporate IAs for Atlantic Wolffish and American Plaice, two at-risk species.

Most species and functional groups were identified here based on the aggregation criterion but there are some unique features of the SE Shoal and the area has fitness consequences for several species.

In terms of fitness consequences, this area has previously been noted as an important feeding, spawning and juvenile area for Yellowtail Flounder (Frank et al. 1992, Walsh 1992, Walsh et al. 2001, Kulka et al. 2003, Fuller and Myers 2004, DFO 2016), an important nursery area for American Plaice (Walsh et al. 2001, Walsh et al. 2004) and a spawning area for Capelin (Carscadden et al. 1989, Fuller and Myers 2004). Furthermore, the SE Shoal is the only EBSA that contains IAs for Yellowtail Flounder, making it unique. Walsh et al. (2001) stated that the SE Shoal is the single nursery area of the entire stock of Yellowtail Flounder. In their report, they proposed both small and large closed areas based on their distribution. American Plaice IAs were found here and south of the EEZ during Campelen years but were mostly distributed further north over the Grand Bank in earlier years. American Plaice spawning also occurs in this

EBSA but a small portion of this spawning area extends into the Southwest Slope EBSA (see below).

Capelin IAs were found in a small portion of this EBSA (and further south outside the EEZ) in the spring data layers. The SE Shoal has been identified as the only known Capelin offshore spawning site on Grand Bank (Templeman 2007, Fuller and Myers 2004). However, at least one earlier study has indicated that Capelin appear to spawn at various places on offshore bank areas provided that suitable bottom conditions are available at proper depths (Pitt 1958).

Several at-risk species, other than those discussed above, have IAs in this EBSA. These include Atlantic Wolffish, Northern Wolffish, Thorny Skate and White Hake. As mentioned above, Atlantic Wolffish IAs are found in two main areas in the study area – here and in the NE Slope EBSA. The only IA for White Hake based on Engel fall data was found here, although this may not be representative as the Engel trawl was less efficient than the Campelen trawl at catching small fish (Kulka et al. 2005).

Core fish species that have key IAs here include Sand Lance and Witch Flounder. Sand Lance IAs are distributed across 3NOP during Engel and Campelen years, with some IAs falling within the SE Shoal EBSA. Witch Flounder are mainly found in the Laurentian Channel, SW Slope and NE Slope EBSAs, with some IAs falling within the SE Shoal EBSA boundary.

Medium and large benthivore fish functional group IAs are found on the northeast side of this EBSA but are not unique to this area.

Though not unique to this area, this EBSA encompasses a large portion of the largest contiguous cluster visible on the IA layer for shallow pursuit generalist seabirds, likely indicative of occurrence of forage fish resources in this area.

While the Mysticetes functional group IA was not a key feature of this area, Whitehead and Glass (1985) described the significance of this area to humpback whales and other cetacean species. They noted that, during the summer months, humpbacks concentrated on the central part of the shoal over concentrations of prey, which were likely spawning capelin.

Walsh et al. (2001) also indicated that the SE Shoal contains the highest benthic biomass on the Grand Bank.

Southwest Slope (3OPs)

The Southwest Slope EBSA extends along the southwest slope of Grand Bank from the southern end of the Laurentian Channel to the boundary of the EEZ. It ranges in depth from 200 m to just over 2,000 m. This EBSA was delineated based on the 60% composite layer (spring RV survey data only), meaning it contains important areas for a number of species and taxonomic groups. The boundary was extended to the south to capture IAs for corals and species at risk. This EBSA had a high number of key features, similar to the NE Slope EBSA. While the NE Slope EBSA had more unique and aggregating features, the SW Slope had more features based on fitness consequences. In the SW Slope EBSA, at-risk fish species, corals and fish functional groups were the main groups driving the patterns appearing in the composite layer. Witch Flounder IAs are found here along with IAs for 11 at-risk species: American Plaice, Atlantic Cod, Northern Wolffish, Redfish, Roundnose Grenadier, Smooth Skate, Thorny Skate, White Hake, Winter Skate and Blue Whale. IAs for 5 fish functional groups are found here, including small and large benthivores, planktivores, plankpiscivores and piscivores. Coral IAs include those for Black Corals, Small and Large Gorgonian Corals, Stony Cup Corals and Sea Pens. Finally, surface shallow-diving piscivorous seabird IAs are found here.

Many of the IAs for individual species are found throughout the entire length of the SW Slope EBSA (Witch Flounder, Redfish, Thorny Skate, White Hake, Blue Whale). The same can be said for several of the fish functional groups (small and large benthivores, plankpiscivores, piscivores). However, the IAs for some species were mainly concentrated in the northwest end of the EBSA (Atlantic Cod, Winter Skate) while others like Northern Wolffish were concentrated in the southeast end of the EBSA. American Plaice IAs were found at both ends. Other IAs were found all along the SW Slope but not beyond the edge of Halibut Channel (Smooth Skate, planktivores fish functional group). Surface shallow-diving piscivore seabird IAs were found from the center of the EBSA and extending toward the southeast, with the largest IA directly south of Whale Deep.

Most of the coral IAs were generally found beyond the 200 m depth contour. A small Black Coral IA was found near the southeast end. Large Gorgonian Coral IAs were mostly found in the northwest end of the EBSA but one large IA was found in same area as the IAs for Black Coral and surface shallow-diving piscivorous seabirds. Stony Cup Corals were found all along the slope as far as Halibut Channel. Another small IA is found at the north end extending into French territorial zone/Laurentian Channel. Sea Pen IAs are found in patches all throughout the length of the EBSA.

In 2007, a research team completed a deep-sea cruise at three stations that all fall within the boundaries of the SW Slope EBSA: Haddock Channel, Halibut Channel and Debarres Canyon. The objective of this cruise was to collect *in situ* observations of deep-sea corals in the area. Over 160,000 coral colonies were enumerated and 28 species were found over 7 ROPOS dives (Baker et al. 2012). This study confirmed the presence of many of the coral species and groups that were found here during DFO RV surveys.

In terms of uniqueness, all known Small Gorgonian IAs in the study area were located in this EBSA. However, a small SBA for Small Gorgonian corals also occurs in 3L (see Kenchington et al. 2016b, Figure 54), and is not included within the boundary of any EBSA. The majority of IAs for Roundnose Grenadier were found throughout the entire EBSA. Finally, a Haddock feeding and spawning area, as well as a redfish spawning area (Ollerhead et al. 2004) that was digitized during the 2016 EBSA refinement process (DFO 2016) was included as an overlay in this area and is captured almost entirely by the candidate EBSA boundary.

The American Plaice spawning area digitized from the 2016 EBSA refinement process (DFO 2016) is mainly concentrated in the SE Slope EBSA, however a small portion of it extends into the SW Slope EBSA. The Atlantic Halibut areas acquired during the 2016 EBSA refinement process also fall within the boundaries of this EBSA. A review of RV survey point data for this species revealed that they are found in many other areas throughout the study area. These areas include the SE Shoal, the Laurentian Channel, and areas outside the EEZ boundary.

Haddock Channel Sponges (3O)

The Haddock Channel Sponges EBSA is found in the southern portion of the Avalon Channel and extends into the Haddock Channel. It was identified as an EBSA because it is the largest area identified as a Sponge SBA in the entire PBGB area (Kenchington et al. 2016b). Only two other species were considered key features of this area based on Engel data: Capelin and American Plaice.

Laurentian Channel (3P)

The Laurentian Channel EBSA extends through the Laurentian Channel south of Newfoundland. The northwest boundary extends slightly across the boundary between NAFO

Subdivisions 3Ps and 3Pn whereas the southern boundary ends just north of the Laurentian Fan. This EBSA is split by the EEZ maritime boundary between Canada and the French territory of St. Pierre and Miquelon. The EBSA boundary was delineated based on the composite layer (spring RV survey data only) meaning it contains IAs for a diverse set of species.

While it may appear that this EBSA is an extension of the SW Slope EBSA, the key features for each EBSA differed enough to recognize the areas separately. Also, the physical features of both of these areas differ substantially. The SW Slope EBSA extends along the edge of Grand Bank and down a steep slope to depths of almost 2000 m. The Laurentian Channel EBSA extends from the edge of St. Pierre Bank and Burgeo Bank and includes the relatively flat Channel itself which is up to 400 m deep. The Laurentian Channel area is comprised primarily of mud, clay, sand and gravel (DFO 2010), which is partially why the area supports high concentrations of Sea Pens. Habitat types of the SW Slope are more varied and support a high number and diversity of many types of corals and sponges (Edinger et al. 2011).

Most key features of the Laurentian Channel EBSA were identified based on the aggregation criterion, including Greenland Halibut, Witch Flounder, all six fish functional groups, Sea Pens, Small Gorgonian Corals and Blue Whale. IAs for several at-risk species are also found here including Smooth Skate, Thorny Skate, White Hake, Winter Skate and Blue Whale. Some species or functional groups were found throughout the entire Laurentian Channel EBSA including Witch Flounder, Smooth Skate and the following fish functional groups: planktivores, plankpiscivores and piscivores. IAs for some species or groups were found in the southern two-thirds of the EBSA above the 400 m bathymetric contour (Thorny Skate and large benthivores). An IA for medium benthivores showed a similar distribution but extended up onto St. Pierre Bank. Small benthivore IAs were found in the north half of the EBSA only. For White Hake, a couple of small IAs were found in the center of the EBSA above the 400 m bathy contour while another IA extended into the French territorial zone and the SW Slope EBSA. A Sea Pen IA was found in the channel below the 200 m depth contour. There is also one large Sea Pen SBA centered in the EBSA and a smaller Sea Pen SBA in the north end that extends beyond the northern boundary. A Small Gorgonian IA was found in the southern end of the EBSA and a small SBA for this group was found in the same area. Blue Whale Important Habitat was identified both at the northern and southern ends of this EBSA, however most of this area has been identified as highly suitable habitat for Blue Whale (Gomez et al. 2017).

The Laurentian Channel has a high occurrence of Black Dogfish, and some studies have inferred that it may be a place where pupping occurs (Kulka 2006). The southeastern boundary of the polygon created during a 2008 review (DFO 2016) based on RV survey data from 1971-2005 ends at the French EEZ. Recent survey point data show a similar pattern but extend beyond this area into SW Slope and Hermitage Channel. A KD analysis was not done for this species and IAs were not extracted based on the upper tenth percentile so there is uncertainty regarding the uniqueness of IAs for this species, especially given that additional data have been collected since the original polygon was created in 2008. Smooth Skates also use the Laurentian Channel as an important juvenile/nursery area (Kulka et al. 2006).

The polygon created for Spiny Dogfish during a 2008 review (DFO 2016) extends beyond the southern boundary of this EBSA into the SW Slope. The point data for this species show a similar pattern but are also found in areas outside the polygon. Again, given that no further analysis was done for this species, we cannot comment on the uniqueness of this area for this species.

The Laurentian Channel was one of two IAs identified for Greenland Halibut on the Campelen spring layer, meaning it is somewhat of a unique feature for the study area. However, the NE Slope EBSA seems to be consistently more important for this species. The only IAs identified for Winter Skate are located in the southern end of this EBSA but extend through French territorial waters and onto St. Pierre Bank, as well as into the northern end of the SW Slope EBSA.

While there was no data layer for Porbeagle Shark, it is known that they are found in this area in spring and migrate to areas further south during late fall (Campana et al. 2012). A portion of one of their known mating grounds occurs in the southern part of the Laurentian Channel (Campana et al. 2012, Simpson and Miri 2013).

Comparison of 2017 EBSAs to 2007 EBSAs

The EBSAs identified using a Delphic approach in 2007 (Templeman 2007) were compared to the EBSAs identified in this study (Wells et al. 2019). Nine of the EBSAs identified during both exercises show considerable overlap and/or they are based on similar features (Laurentian Channel, Southwest Slope, Southeast Shoal, Lilly Canyon-Carson Canyon, Virgin Rocks, Northeast Slope, Placentia Bay, Eastern Avalon, Smith Sound), however there were some changes to the boundaries. Two new EBSAs (South Coast and St. Mary's Bay) overlap with small portions of the 2007 EBSAs. Three new EBSAs were identified in areas not previously considered (Bonavista Bay, Baccalieu Island and Haddock Channel Sponges).

The area contained within the 2007 Burgeo Bank EBSA had fewer important biological features relative to surrounding areas in this study, however roughly 20% of this EBSA is found within the 2017 South Coast EBSA. Finally, the 2007 St. Pierre Bank EBSA was based on the highest and only concentration of Sea Scallops on the Grand Banks. A data layer for Sea Scallops was not included in this analysis. A large portion of St. Pierre Bank is included in the Laurentian Channel EBSA, however the majority of the bank did not meet the 60% threshold on the composite layers and no other data layers in this area met the criteria for fitness consequences or uniqueness. The amount of overlap between the 2007 and 2017 EBSAs is noteworthy, lending confidence to the Delphic approach that was undertaken by Templeman (2007). However, the 2017 EBSAs were identified using the most recent available data, and therefore the results of this process should be considered as the current set of EBSAs for the PBGB study area.

Sources of Uncertainty

Some data sets were considered but not processed or included in the analysis for various reasons. For example, data layers could not be created for all at-risk species due to limited availability of data. Also, there are several new initiatives underway that could help refine EBSA boundaries, or even identify new EBSAs. For example, several recent studies have collected seabird tracking data in the study area and standardized methods have been developed to guide the use of this data to identify important areas for marine conservation (Lascelles et al. 2016).

There are likely many ecosystem features in the study area for which data were not available. For example, large giant kelp beds are known to exist in areas on the south coast of Newfoundland, however spatial data were not available for these features (Rao et al. 2009). Spatial data for other benthic invertebrates such as scallops were also not incorporated into this analysis. Furthermore, productivity in nearshore waters along the east coast of Newfoundland has been studied and linked to the importance of nearshore spawning and nursery areas based on protective habitat (e.g. eelgrass and kelp beds) (Bradbury et al. 2008, Gregory et al. 2016, Warren et al. 2010). However, other than eelgrass, capelin spawning, and seabird data, there are limited spatial data that exist at a scale that covers the entirety of the coast in the study area. Furthermore, there has been little research done on trophic interactions at broad spatial scales in the study area, especially in the coastal zone. Further research on these and other important ecosystem components, including other benthic community types, would help to identify and describe these highly productive areas, as well as determine which of these areas are the most ecologically significant.

Similar to the 2013 EBSA process (Wells et al. 2017), naturalness and resilience were difficult to quantify or map. This is particularly true in this study area given high fishing pressures over the past century. Discovery by Europeans of fish resources in this area occurred in the 1490s (Lear 1998). Cod traps and lines were introduced in the late 1800s and otter trawls in the early 1900s. It is therefore difficult to characterize the naturalness of this area given 500 years of human use. Trawling patterns have changed over time due to moratoria in certain fisheries but in general, numerous persistent areas of trawling spread mainly along the shelf edge and between the banks (Kulka and Pitcher 2001). Resilience refers to the ability of an area to withstand or quickly recover from perturbations. It was difficult to quantify or characterize this property with the data available for this project. However, it would be expected that EBSAs defined on the basis of benthic ecosystem components (e.g. corals) are far less resilient to perturbations than areas defined by concentrations of mobile organisms like fish.

CONCLUSIONS AND ADVICE

Fourteen EBSAs were identified and described in two different categories: 7 were based on coastal data; and 7 were identified using offshore data. 272 layers of biological and geomorphological data were used to define these significant areas, along with many hours of meetings with scientific experts. The use of the uppermost class (i.e. decile) for each data layer enabled the identification of the most important areas for a multitude of species within the region. This approach does not preclude the notion that areas other than those identified may be significant for individual species; rather, it identified areas significant to many species, and therefore the ecosystem as a whole.

Key features were described for each EBSA but it should be noted that many other species likely occur in each of them, even in addition to those listed in Appendix I of Wells et al. 2019. Identifying important areas for migratory species or those that are found everywhere is difficult using the methods employed here. However, given that most of the areas identified are highly productive and important for a large number of species, they are likely also important for highly mobile species such as seals, whales, and seabirds. A literature review has shown that many of the EBSAs (especially those at the shelf edge and along the slope) are known or probable areas of occurrence for transient at-risk species (see Wells et al. 2019 for more information).

Similar to the 2013 EBSA process, bathymetry was a key characteristic underlying the delineation of boundaries for many of the EBSAs. Strong gradients in bathymetry influence currents and other properties of the water column. The strong association of many EBSAs with features such as channels and the continental slope indicates that a robust approach to define critical properties to be used for conservation measures would require a more comprehensive and detailed analysis of local features than was possible in this study. The scale of these features is largely what drove the size of the EBSAs delineated, similar to the 2013 EBSA process, and this may be part of the reason why EBSAs from both processes were within a similar size range (Wells et al. 2019).

Areas that were not identified as EBSAs during this evaluation have some level of ecological importance. The distinction is that such areas may not warrant an enhanced level of protection relative to other areas, or there is not enough information currently available to identify these areas as EBSAs.

The boundaries for each EBSA were drawn based on the best available knowledge, using relevant, available data. As per EBSAs identified in previous processes (DFO 2013), areas selected for further protection or management should be examined in greater detail to identify all features in the area. The scale at which these features are associated with the area also warrant further investigation, potentially requiring refinement of the boundaries. Furthermore, the boundaries delineated here do not necessarily indicate a transition from an important area to a non-important area, rather they are meant to encircle an area that appears to be ecologically or biologically significant. If management actions are ever taken in a particular EBSA, further investigation of the boundary should occur at that time, and will be dependent on the conservation objectives that are established for the area.

As per previous science advice (DFO 2011), these EBSAs should be re-evaluated over time (every 5-10 years), as new data becomes available for the study area or if there are large changes in the ecosystem. EBSA boundaries can also be refined as necessary, based on a more detailed analysis of local characteristics, and coastal EBSAs should be a higher priority for refinement.

To conclude, these EBSAs were identified using a large and diverse data set. Steps were taken to maximize the spatial information derived from as many data sources as possible, while focusing on the EBSA criteria to drive the identification and delineation of areas. When data were unattainable, published literature and expert opinion were used to identify important areas, especially for those taxa with limited available information. The EBSAs identified here do not necessarily capture the most important areas for every individual ecosystem feature; rather, they are intended to capture significant areas in the broader ecosystem context.

OTHER CONSIDERATIONS

Two other areas were proposed as candidate EBSAs but further investigation of these areas is required. It was noted that a high degree of overlap occurs between areas identified using murre telemetry data and IAs identified for Sand Lance. This area was located on the Grand Bank, just east of the Virgin Rocks. Given that Sand Lance are an important prey item of Common Murre, this observation is not unexpected. However, there were few other IAs found in this area, and therefore it was decided that further investigation would be required before identifying this area as an EBSA. The second candidate area that requires further investigation is the Burgeo Bank-Hermitage Channel area. As described above, this area had fewer important biological features relative to surrounding areas in this study, however, data layers that may contribute to the identification of this area as an EBSA were not utilized or available for this process. Furthermore, a portion of this area is found within the 2017 South Coast EBSA.

The Placentia Bay-Grand Banks study area is part of the North Atlantic influenced by the North Atlantic subpolar gyre. The Labrador Current is a multi-branch western boundary current of this system that influences shelf-slope waters. The Labrador Current originates in the Labrador Sea and continues to the northeast Newfoundland Shelf and southward into the Grand Banks region with the exception of a small flow through the Strait of Belle Isle to the Gulf of St. Lawrence and an eastward transport north of the Flemish Cap. There are two distinct branches of the current off eastern Newfoundland, a low transport inshore flow around the Avalon Peninsula into the

Southern Shelf and a high transport shelf-break branch flowing south through the Flemish Pass toward the Tail of the Grand Bank. At the Tail of the Grand Bank, the offshore branch further splits with flow along the southern Newfoundland Shelves and flow offshore (eastward) towards the Newfoundland Basin. Several hundred kilometers from the shelf edge is the Gulf Stream, the western boundary current of the North Atlantic subtropical gyre. The Gulf Stream influences the southern shelf regions indirectly through Slope Waters and transient rings. See Loder et al (1998) and Appendix L of Wells et al. (2019) for a more complete description of the physical environment of the study area.

The distribution and abundance of breeding and foraging seabirds usually reflects the availability of prey in the marine ecosystems on which the birds depend (Birkhead and Furness 1985, Hunt 1991). Clearly, globally significant and persistent seabird colonies found on the east coast of Newfoundland are sustained by persistently highly productive waters nearby. The breeding season foraging ranges of piscivorous colonial seabirds were used as a proxy to indicate areas where a high abundance of forage species for these birds is likely to occur. In the absence of long-term tracking studies at individual colonies, use of mean maximum foraging range provided the most appropriate prediction of spatial use during breeding (Soanes et al. 2016; Bogdanova et al. 2014; Thaxter et al. 2012; Cairns 1987). More information on the main prey types for these species can be found in Wells et al. (2019). The foraging buffers were used to delineate the seaward extension of some coastal EBSAs, and in most cases this meant that IAs identified in offshore data layers were captured by the EBSA boundaries. Therefore, all offshore data layers were also reviewed within the boundaries of each coastal EBSA and key ecosystem features were identified based on the EBSA criteria.

The entire NL Shelves Bioregion has not been assessed for the identification of EBSAs as one full unit. Rather, the northern area and the PBGB area have been considered separately. In an ecoregion analysis, the northern shelf area was clearly distinguish from the Grand Bank (Pepin et al. 2014), therefore these two study areas can be recognized as two different parts of a larger bioregion. However, some EBSA boundaries are likely artifacts of the study areas that were considered. For example, the Northeast Slope is likely a continuation of the Orphan Spur EBSA (DFO 2013), even though the boundaries of these two EBSAs are not well aligned. It is not clear if assessing the entire bioregion would have implications for the size or scale of EBSAs that have been identified in the two areas. Also, uniqueness was assessed at the scale of the study areas and therefore, some things may not be unique at the bioregion scale but were found to be unique in the study area. Therefore, it would be advised to assess the bioregion as a whole when it is determined that the areas should be re-evaluated.

EBSAs outside the EEZ

The 60% composite layers (both for spring and spring/fall) were used to delineate areas outside the EEZ (Wells et al. 2019). While describing these areas in detail is beyond the scope of this report, the overlap or adjacency of these areas with EBSAs that were identified by CBD is noteworthy (Website). Further to that, it is interesting to note that the areas in the 60% composite layer on the Southeast Shoal mostly fall outside (between) the boundaries of the two areas identified by the CBD. Further investigation into the features of these areas is required to determine the reason for this observation.

LIST OF MEETING PARTICIPANTS

Name	Affiliation
Tanya Edwards	Canadian Parks and Wilderness Society (CPAWS) – NL Region
Bobbi Rees	Department of Fisheries, Forestry and Agrifoods
Erika Parrill	DFO – Centre for Science Advice – NL Region
Jennifer Janes	DFO – Oceans Program – NL Region
Mardi Gullage	DFO – Oceans Program – NL Region
Melissa Abbott	DFO – Oceans Program – NL Region
Tony Bowdring	DFO – Oceans Program – NL Region
Victoria Howse	DFO – Oceans Program – NL Region
Fred Phalen	DFO – Policy and Economics – NL Region
Nadine Templeman	DFO – Science – National Capital Region
Andry Ratismandresy	DFO – Science – NL Region
Bob Gregory	DFO – Science – NL Region
Christina Bourne	DFO – Science – NL Region
Christina Pretty	DFO – Science – NL Region
Cynthia McKenzie	DFO – Science – NL Region
Danny Ings	DFO – Science – NL Region
David Cote	DFO – Science – NL Region
Fran Mowbray	DFO – Science – NL Region
Garry Stenson	DFO – Science – NL Region
Geoff Veinott	DFO – Science – NL Region
Hannah Murphy	DFO – Science – NL Region
Jack Lawson	DFO – Science – NL Region
Katherine Skanes	DFO – Science – NL Region
Keith Clarke	DFO – Science – NL Region
Kent Gilkinson	DFO – Science – NL Region
Krista Tucker	DFO – Science – NL Region
Kyle Matheson	DFO – Science – NL Region
Lauren Gullage	DFO – Science – NL Region
Mariano Koen-Alonso	DFO – Science – NL Region
Mark Simpson	DFO – Science – NL Region
Nadine Wells	DFO – Science – NL Region
Neil Ollerhead	DFO – Science – NL Region
Nicolas LeCorre	DFO – Science – NL Region
Roanne Collins	DFO – Science – NL Region
Robyn Jamieson	DFO – Science – NL Region
Sarah Olson	DFO – Science – NL Region
Vonda Wareham	DFO – Science – NL Region
Veronique Lesage	DFO – Science – Quebec Region
April Hedd	Environment and Climate Change Canada
Dave Fifield	Environment and Climate Change Canada
Greg Robertson	Environment and Climate Change Canada
Karel Allard	Environment and Climate Change Canada
Jóhan Joensen	Fish, Food and Allied Workers
Kris Vascotto	Groundfish Enterprise Allocation Council (GEAC)
Paul Snelgrove	Memorial University
Michelle Valliant	Rapporteur
Fred Winsor	Sierra Club

SOURCES OF INFORMATION

This Science Advisory Report is from the January 17-18, 2017 Re-evaluation of the Placentia Bay – Grand Banks Large Ocean Management Area to identify Ecologically and Biologically Significant Areas. Additional publications from this meeting will be on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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PO Box 5667
St. John's, NL
A1C 5X1
Telephone: (709) 772-8892

Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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