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Development of Spatially Referenced Data Layers for Use in the Identification and Delineation of Candidate Ecologically and Biologically Significant Areas in the Newfoundland and Labrador Shelves Bioregion

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

A series of spatially referenced data layers were developed in support of the work to identify and delineate candidate Ecologically and Biologically Significant Areas (EBSAs) in the Newfoundland and Labrador (NL) Shelves Bioregion north of the Placentia Bay Grand Banks Large Ocean Management Area (LOMA). The purpose of this report is to document the many and diverse datasets that were used to create the spatially referenced data layers for the analysis and to describe the tools and analytical techniques employed in this study. Numerous data management, statistical and spatial analysis software applications were used to process, analyze and display the data. Statistical and spatial analysis techniques were applied to the data to transform them for inclusion in the analysis. Additional data reduction techniques were applied to some of the larger datasets to reduce the number of variables and simplify their interpretation. The data used in this study characterized many biological components of the marine environment including corals, sponges, fishes, marine mammals and seabirds in addition to oceanographic and other environmental data.

Élaboration de couches de données à référence spatiale à utiliser pour la désignation et la délimitation des zones candidates d'importance écologique et biologique dans la biorégion des plateaux de Terre-Neuve-et-Labrador

RÉSUMÉ

Une série de couches de données à référence spatiale a été élaborée à l'appui des travaux visant à désigner et à délimiter les zones candidates d'importance écologique et biologique dans la biorégion de Terre-Neuve-et-Labrador au nord de la zone étendue de gestion des océans (ZEGO) de la baie Placentia et des Grands Bancs. L'objectif du présent rapport est de consigner les nombreux et divers ensembles de données qui ont été utilisés pour créer les couches de données à référence spatiale aux fins d'analyse et pour décrire les outils et techniques d'analyse employés dans le cadre de cette étude. De nombreuses applications logicielles de gestion de données, d'analyse statistique et spatiale ont été utilisées pour traiter, analyser et afficher les données. Des techniques d'analyse statistique et spatiale ont été appliquées aux données pour les transformer aux fins d'inclusion dans les analyses. D'autres techniques de réduction des données ont été appliquées à certains des plus grands ensembles de données pour réduire le nombre de variables et simplifier leur interprétation. Les données utilisées dans le cadre de cette étude caractérisaient de nombreuses composantes biologiques du milieu marin, notamment les coraux, les éponges, les poissons, les mammifères marins et les oiseaux de mer, en plus de données océanographiques et d'autres données environnementales.

INTRODUCTION

Guidance on the identification of Ecologically and Biologically Significant Areas (EBSAs) (Fisheries and Oceans [DFO] 2011) recommends that the rationale for areas identified must be well documented, including type, origin, scale, spatial and temporal range for each data layer considered. Methodologies, including weighting or other prioritization should be defined. As such, this exercise set out to develop spatially referenced data layers for use in the identification and delineation of candidate EBSAs in the Newfoundland and Labrador (NL) Shelves Bioregion north of the Placentia Bay Grand Banks (PBGB) Large Ocean Management Area (LOMA), i.e., the Grand Banks.

A Steering Committee led this EBSA identification exercise by providing expert advice on data collection, processing and analysis. The committee collaborated with other species specialists and subject-matter experts when additional input was required.

A geographic information system (GIS) was used to store, manage, analyze, and display the spatially-referenced data used in the delineation of candidate EBSAs. Data from various sources representing biological, physical and oceanographic features were formatted for use within the GIS. The data were processed to create spatially-referenced layers that were analyzed within the GIS to identify the most ecologically and biologically important areas. The important areas identified in the GIS analysis were then available for a subsequent consideration to identify and delineate candidate EBSAs.

Interpretation of the results of all analyses can be found in Wells et al. 2017.

MATERIALS AND METHODS

STUDY AREA

The biogeographic unit in which candidate EBSAs (hereafter referred to as “EBSAs”) were identified is the NL Shelves Bioregion, and specifically that portion north of the PBGB LOMA. This study area is off the northeastern coast of the island of Newfoundland and the Labrador coast between 49.8^{o}N and 61.1^{o}N and extends eastward from the shoreline to Canada’s Exclusive Economic Zone (EEZ). It is inclusive of Northwest Atlantic Fisheries Organization (NAFO) Divisions 2GHJ3K (Figure 1).

EBSAs were identified using data that fell within the boundaries of study area; data that fell outside of the boundaries were clipped from the data layer and excluded from the analyses. EBSAs were identified using calculations based on relative measures to determine areas of high concentrations to locate the areas of higher biological importance. Given significant differences in the environmental and ecosystem characteristics between the northern (study area) and the southern (Grand Banks) portions of the NL Shelves, the inclusion of data from the PBGB LOMA would have likely obscured any biologically important areas within the study area and produced a significantly different result..

SOFTWARE

Numerous software packages were used in the preparation, management and processing of the data. Spreadsheet, database and statistical packages were used to prepare and reformat the data for import and analysis in the GIS, including Microsoft Excel and Access for formatting and organizing. Additional data processing and preparation was performed using the R Project for Statistical Computing (The R Project 2012).

ArcGIS v10.0 (ESRI 2010) was used to create, analyze and display all spatially referenced datasets.

SPATIAL INTERPOLATION

Spatial interpolation is an analytical technique used in GIS to create continuous surfaces from discrete measurements. Kernel Density (KD) and Inverse Distance Weighted (IDW) are interpolation techniques that were used in this project to create surfaces that were used to identify the high concentration areas. KD calculates a density value raster and the IDW calculates a weighted average of the input data.

Kernel Density Analysis

KD analysis was used to create raster surfaces for many of the point datasets which enabled the identification of areas of high density. The ArcGIS Kernel Density tool calculates the density of features in a neighborhood around those features. Conceptually, a smooth surface is fitted over each point where the volume under the surface is equal to the value being modeled and is created such that the value is highest at the sampling point and diminishes to zero at the chosen neighbourhood distance, referred to as the search radius. The cells of the output raster are then calculated by summing the values of the kernel surfaces created over the individual points that overlay the raster cell and expressed as a density (ESRI 2010). The search radius used for the analysis was 31km based on Geostatistical Analysis which examined the spatial relationship of the individual data points relative to the areal coverage.

Deroba (2010) and Kenchington et al. (2010) used KD analysis to interpolate surfaces of catch weight data collected during research vessel surveys.

Inverse Distance Weighted

IDW interpolation was applied to some of the point datasets to highlight the areas of highest concentration. As with KD analysis this interpolation technique creates a continuous or near-continuous raster surface from discrete point data. Input points are weighted using a decay function such that the measured value diminishes with increasing distance from the actual measurement to a value of zero at the defined search radius. The cells of the IDW surface are calculated using the weighted average of a combination of sample points (ESRI 2010).

IDW was applied to the Juvenile and Spawning data as it was in Ollerhead et al. (2004) and Ollerhead and French (2010). SPANS potential mapping, a variant of IDW (Kulka 1998), was used in Ollerhead et al. (2004) to create interpolated surfaces to identify concentrations of juvenile and spawning concentrations.

KD / IDW Considerations

KD and IDW analyses are techniques that create surfaces based on interpolated values and it is important to be cognizant of the computational artifacts that may arise in the resulting surfaces. Depending upon the search radius and distribution of the data points within the target raster, the analysis may create cells with artificially high values. Data-poor areas within the input data set and cells along the outer edges are the most susceptible to this phenomenon. This must be a consideration when using these types of analytical techniques; however the effect can be mitigated with an understanding of the potential for error and knowledge of the spatial distribution of the input data.

UPPER 10^{TH} PERCENTILE RULE

A decision rule was established for most of the data layers that were modeled using KD or IDW to define the threshold for the highest concentration areas. The modeled IDW and density surfaces were classified into ten quantile classes. The ArcGIS quantile classification creates break points within the domain of the calculated surface values such that there are an approximately equal number of cells within each interval (ESRI 2010). The topmost class in a ten-quantile classification scheme represents those cells that contain the highest 10% of the modeled surface values (hereafter referred to as the upper 10^{th} percentile). These high concentration areas were then extracted from the interpolated surface and exported to a new polygon layer (Figure 2).

For a small subset of the data layers processed, the upper 10^{th} percentile decision rule was not applied (see individual data layer descriptions below). Some layers were data-poor and required additional support to be useful in the candidate EBSA delineation exercise. In those instances, the highest concentration areas were delineated using all available data in conjunction with expert opinion.

Post-meeting it was discovered that the ArcGIS software was incorrectly calculating the quantile classifications for some data layers (mainly offshore fish and corals). When using 10 quantile classes, approximately 1/10 of the cells should be found in each of the 10 classes; the exact number of cells found in each class can vary slightly when the total number of cells is not a factor of 10. As a result of a software bug the raster cells in the IDW and KDE surfaces were not correctly classified and hence the extracted polygons did not actually represent the upper 10^{th} percentile. The severity of this issue varied between the layers (see Table 1) where the upper quantiles presented and considered for various layers actually contained between 3.01% and 8.97% of raster cell values (as opposed to the full 10%), with the exception of planktivore and plankpiscivore functional groups during the Engel period (0.5 and 0.54 percent respectively), and large gorgonian corals (1.35%). See Wells et al. (2017) for information on how this issue affected the interpretation of results.

PRINCIPAL COMPONENT ANALYSIS / CLUSTERING

Principal Components Analysis (PCA) is used to transform data and eliminate redundancy in multivariate datasets (Pepin et al. 2010). This is achieved through a mathematical transformation of the input datasets into a new multivariate space whose axes are rotated relative to the original axes. The result of an ArcGIS PCA is a multiband raster having one band for each component with the first component explaining the greatest variance; the second describing most of the remaining variance not explained in the first, and so on (ESRI 2010). Additionally, the PCA generates a table of eigenvalues which describes the amount of explained variance in each of the components.

Clustering is a method of grouping objects such that objects in the same cluster are, in some aspect, similar to each other and different than those in other clusters. There are many varied and commonly-used clustering algorithms. This exercise used a *k*-means algorithm that places the observations into *k* clusters based on the cluster with the nearest mean. The Calinski-Harabasz (C-H) statistic was calculated to determine the optimal number of clusters. The C-H statistic represents the amount of explained variance when processing the data using different numbers of clusters (Pepin et al. 2010).

PCA and clustering were applied to summarize all environmental and oceanographic data (Table 2) to create a single layer that depicted statistically-similar oceanographic regions. The results of a PCA/clustering analysis can be found in Figure 3. The derived oceanographic data layer was not used in the final cell statistics analysis but was used as supporting information during the candidate EBSA delineation exercise.

CELL STATISTICS ANALYSIS

The highest concentration areas identified using a KD or IDW analysis and the upper 10th percentile rule, as well as areas identified based on expert knowledge, were combined into groups called Conceptual Layers (Table 3). Conceptual Layers are collections of data with similar characteristics. A total of seven of the eight Conceptual Layers, representing 100 data layers, were used in a Cell Statistics analysis: Marine Mammals, Seabirds, Corals and Sponges, Core Fish Species, Fish Functional Groups, Rare and Endangered Fish Species, and Juvenile and Spawning Fish. The Conceptual Layer representing coastal information (Table 4) was not incorporated because the scale of the data was not comparable with that of the offshore data.

Each layer was given a value of one as all data were represented equally in the analysis. These layers were processed using the ArcGIS Cell Statistics tool which "…calculates a per-cell statistic from multiple input rasters…" (ESRI 2010). Within each Conceptual Layer, all constituent layers were added together to identify the highest concentration areas where each cell value represented the total number of layers present in that cell. For the RV survey data layers (Core Species, Functional Groups, Rare and Endangered Species, and Juveniles and Spawning), cell statistics were calculated for each gear type separately, and for both gears combined.

All of the Conceptual Layers were then summed to create a composite layer for all data (Figure 4). This Composite Layer then served as the basis for the initial identification and delineation of candidate EBSAs (Wells et al. 2017).

DATA DESCRIPTION

Most of the data used in the analysis were obtained from DFO sources. Additional data were provided by Environment Canada (EC), other government departments, non-governmental organizations and academia. Online data repositories were also mined for relevant information.

Original datasets were in point, polygon or raster format. Point data represent a discrete measurement and are associated with a single x/y geographic coordinate. Polygons are areal features that represent the shape and location of homogeneous feature types such as Important Bird Areas (IBAs) or waterfowl survey blocks. They can also be used to delineate areas identified as important for a specific species or ecological function. Raster layers are data stored as a matrix of cells arranged into rows and columns where each cell holds a value representing information.

Rare or endangered (R/E) species of birds, fish and mammals were acknowledged based on Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designations and were always considered separately (i.e. not included in functional groups). A subset of these species is protected legally under the *Species at Risk Act* (SARA).

All data layers were standardized to the Universal Transverse Mercator (UTM), Zone 21, WGS 1984 projection. The UTM projection uses a rectangular coordinate system and is very accurate in narrow East-West zones of a few degrees (ESRI 2010). A common projection ensures that any layers used in the spatial analyses are overlaid properly.

All layers were placed into one of two analytical categories related to the scale of data collection and extent: coastal and offshore. Coastal data were available at a higher resolution and often with limited spatial extent while the offshore data covered a much larger area and were collected and analyzed at coarser spatial resolutions.

COASTAL DATA

Many coastal data layers did not require a great deal of processing prior to their evaluation for the creation of candidate EBSAs. These data were used independently to define coastal candidate EBSAs as well as to augment the boundaries of candidate EBSAs that were created using offshore data (see Wells et al. 2017).

Community Coastal Resource Inventory Data

The Community Coastal Resource Inventory (CCRI) is focused on marine-based information which includes "marine resources near shore and land resources connected to the sea and the marine environment" (DFO 1998). Data were collected through 22 CCRI projects from 1996 to 2008 along the coasts of NL. Ten of these projects fall within in the EBSA study area: Bonavista-Notre Dame Bay, Fogo, Exploits, Green Bay, Baie Verte, White Bay, Northern Peninsula East, Southern Labrador, Lake Melville, and Northern Labrador.

The CCRI data is qualitative presence-only data based on Traditional Ecological Knowledge (TEK) collected through interviews with individuals having direct knowledge of local areas. (i.e. fishers or those with specialized local knowledge). Layers representing Aquatic Plants, Groundfish, Pelagic Fish, Shellfish, and Marine Mammals were extracted from the CCRI and used in the candidate EBSA delineation exercise. CCRI data were used to validate and/or augment scientific data but were not used exclusively to identify EBSAs.

Near Shore Fish Layers

Arctic Charr Landings

Arctic Charr (*Salvelinus alpinus*) landings data were collected during the Inuit fishery in northern Labrador from 1974 to 2010. Data collected after 1995 were excluded from the analysis because of the decrease in the number of fisherpersons, which may have influenced resource utilization estimates. Catch Per Unit Effort (CPUE) estimates were calculated by individual bay/fjord and represented as catch (kg) over effort (person-weeks). Average CPUEs were calculated for each individual bay/fjord over the entire 1974 to 1995 time series. Polygon extraction was based on the upper 25th percentile of Arctic Charr landings and historic commercial fishing areas as well as expert knowledge.

Atlantic Salmon Total Returns Data

Atlantic Salmon (*Salmo salar*) total returns data were obtained from counting fence facilities monitored by DFO (Dempson and Stansbury 1991). Eleven rivers fell within the study area and data were collected from 1984 to 2011. Returns for small (<63 cm Fork Length) and large (≥63 cm Fork Length) Atlantic Salmon for each year were combined to give total return estimates that were averaged for the entire time series for each river.

Geographic co-ordinates for the rivers were obtained from Reddin et al. (2010). Polygon delineation highlighting areas of importance was based on expert knowledge.

Capelin Spawning Data

Capelin (*Mallotus villosus*) spawning sites came from three sources: DFO research by Dr. B. Nakashima, academia, and the CCRI program. Internal DFO capelin research was a combination of spawning site surveys (Nakashima 2002) conducted between 2003 and 2007 and expert advice of Dr. Nakashima. Demersal spawning site data were provided by G. Davoren (Davoren et al. 2006; Penton and Davoren 2012) collected between 2003 and 2007 using underwater surveys. CCRI capelin spawning data were incorporated because they augmented scientific data sources where no surveys had been conducted to date.

American Eel Data

American eel (*Anguilla rostrata*) data were collected by eel fishers using commercial logbooks from 1990 to 2007. There is no eel fishery in Labrador so data were limited to the island portion of the province. The fishery was primarily focused in freshwater areas such as brooks and rivers. American eels were initially included in the analysis as they are known to utilize all available habitat from freshwater to marine (Veinott and Clarke 2011). To estimate fishing effort, a kernel density surface was created using total catch weight per location divided by the number of gear records for that location per year. Because not all sites had effort in all years, the data were skewed to those areas where the fishery occurred more regularly (Dr. G. Veinott, DFO, pers. comm.). Dr. Veinott advised that these data should not be incorporated into the EBSA process because they were more likely to reflect fishing effort rather than the significant presence of eels or their habitat.

Waterfowl Block Survey Data

All waterfowl data layers were provided by Canadian Wildlife Service (CWS), EC. Numerous species of waterfowl were ground-surveyed using defined survey blocks that surround headlands. Data were collected for the Atlantic region from 1960 to 2008, although the survey blocks that fell within the study area were surveyed in the 1980s and 1990s. Surveys took place in the spring and fall and were collected as polygon data representing the maximum count of individuals.

Data provided by EC had species classified by guild with the exception of Rare or Endangered (R/E) species which were kept separate. Functional groups were created for Bay Ducks, Dabbling Ducks, Geese and Sea Ducks (Table 5). The R/E species are Barrow's Goldeneye (*Bucephala islandica*) and Harlequin Duck (*Histrionicus histrionicus*) (*Species at Risk Act* 2002).

Polygon extraction of the highest concentration areas was performed using the upper 10^{th} percentile rule for most species and functional groups. Due to the low amount of data in the Bay Ducks layer it was only possible to classify the data into seven quantiles where the highest class represented the upper 14^{th} percentile.

Common Eider Aerial Survey Data

Common Eider (*Somateria mollissima*) aerial survey data were provided by CWS, EC. Although Common Eiders were included in the functional group block survey data, this dataset contained more recent information and the collection methods differed. While Common Eiders were the target species of these surveys, information on Black Guillemot (*Cepphus grylle*) aggregations was also collected and this was the only source of information available for this species. Surveys were conducted in the winter of 2003, summer and winter of 2006, and winter of 2010. Kernel density surfaces were created based on maximum counts of individuals, and summer data were treated as colony data, based on the biology of the species. Polygon extraction of the highest concentration areas was performed using the upper 10th percentile rule. All data were used for the final polygon extractions with the exception of winter 2003 data, as there was spatial overlap between this dataset and the winter 2006 data.

Seabird Colony Data

Seabird colony data based on maximum counts of individuals were provided by CWS, EC (Table 6). The dataset ranged from 1928-2011; however, only data after 1960 were used to generate a kernel density surface as these data were collected on a more regular basis. The highest concentration areas were extracted using the upper 10th percentile rule. These polygons then served as the input layer for offshore seabird colony buffers layers detailed in the following section.

Important Bird Areas (IBAs)

Important Bird Area (IBA) data were provided by Bird Studies Canada and Nature Canada (Bird Studies Canada 2012). This dataset was used to validate the location of bird hotspots within the study area but was not explicitly used to identify EBSAs or delineate EBSA boundaries (Wells et al. 2017).

OFFSHORE DATA

Offshore data were processed to identify features at a scale representative of the average length of an RV survey trawl as well as the large spatial extent of the datasets. All offshore data layers were processed to 20 km x 20 km raster grids. A 20 km cell size was chosen to be representative of the resolution of the data collected in the offshore and was presumed to be sufficient to depict major distributional features.

Environmental Layers (Oceanography)

Oceanographic and bathymetric layers were gathered to conduct an environmental analysis of the study area (Table 2). Where applicable, they were divided into seasonal layers with the seasons defined as winter (December-February), spring (March-May), summer (June-August), and fall (September-November). The layers with no seasonal component, such as bathymetry and bathymetric complexity, were incorporated into all analyses.

The oceanographic layers, represented as rasters, were buffered to 100km beyond the study area to minimize any computational artifacts at the edges that may have arisen from any analysis. All rasters were normalized from the original and varied measurement scales to z-scores (Pepin et al. 2010). The following is a general description of the layers in the study area used in the Principal Components Analysis.

- Measurements for **pack ice duration** were calculated from Canadian Ice Service data. The presence of a particular ice type per year is defined as “the median of predominant ice type in conjunction with the frequency of presence of sea ice”.
- **Chlorophyll-a** values were calculated from Modis Satellite imagery (NASA, 2014) collected at a one km resolution. Data for the North Atlantic were averaged to produce a weekly composite map. Semi-monthly composites were then computed as an average of chlorophyll values for a given grid point over a period of years. We

converted these to seasonal maps by calculating the seasonal means over each year of the period of the dataset.

- SeaWifs satellite imagery of Chlorophyll A and Sea Surface Temperature (SST) were combined to estimate **Primary Productivity** values (Platt et al. 2008). These were converted to seasonal maps by calculating the seasonal means across the period of the dataset.
- **Sea Surface Temperature** was recorded as degrees Kelvin from Glorys2 reanalysis of NOAA satellite imagery (Ferry et al. 2012). The original product was a monthly mean for 1993-2009. Seasonal means were calculated over all months within a season across all years.
- **Sea Surface Salinity** was calculated as Practical Salinity Units from Glorys2 reanalysis of NOAA satellite data (Ferry et al. 2012). The original product was a monthly mean for 1993-2009. Seasonal means were calculated over all months within a season across all years.
- **Surface Current Velocity** was calculated from two Glorys2 datasets reanalyzed from NOAA satellite imagery. Meridional (east to west) and zonal (north to south) velocities were extracted for latitude and longitude to calculate monthly 2D velocity values using data collected from 1993 to 2009.
- **Sea Bottom Temperature** data were collected during DFO RV surveys from 1971-2011. Data were rasterized from the original point dataset based on bottom temperature recorded as degrees Celsius. Seasonal means were calculated for all months within a season across all years.
- **Sea Bottom Current Velocity** was calculated from two Glorys2 datasets reanalyzed from NOAA satellite imagery. Meridional (east to west) and zonal (north to south) velocities were extracted for latitude and longitude to calculate monthly 2D velocity values using data collected from 1993 to 2009.
- **Bathymetry** data were extracted from General Bathymetric Chart of the Ocean (GEBCO) data and resampled to a 20 km grid.
- **Bathymetric Complexity** was calculated from the bathymetric dataset as a ratio of surface area/flat area using the DEM Surface Toolset (Jenness 2012).

Research Vessel Survey Data

Multispecies surveys have been conducted by DFO RV since the early 1970s. The data used in the analyses was extracted from fall surveys conducted between 1977 and 2011. An Engel Hi-Lift Otter Trawl was used to conduct surveys until the fall of 1995 after which the gear was switched to a Campelen shrimp trawl (McCallum and Walsh 1997). Given the different characteristics of the two gears and the fact that conversion factors only exist for a small group of commercial species all Engel data cannot be scaled to comparable Campelen catches and thus any analysis on the RV data treated the two datasets separately (Koen-Alonso pers. comm.).

RV survey data were divided into core fish species, fish functional groups, rare or endangered fish species, and juvenile and spawning fish data for Cell Statistics analysis and for evaluation during the EBSA delineation process. RV data were also used to perform diversity/richness/evenness analyses.

Core Fish Species

There are a number of core species which are fished commercially and which contribute significantly to the overall biomass of RV survey data. These species were extracted from the overall dataset and analyzed independently. The selection of the core species was based on expert opinion and included Redfish *(Sebastes spp.)*, Atlantic Cod *(Gadus morhua)*, Greenland Halibut (Turbot) (*Reinhardtius hippoglossoides)*, American Plaice *(Hippoglossoides platessoides)*, Capelin *(Mallotus villosus)*, Witch Flounder *(Glyptocephalus synoglossus)*, Shrimp *(Pandalus spp.)*, and Snow Crab *(Chionoecetes opilio).*

For each species, a kernel density surface was created from the point data based on the kilograms per tow recorded for each trawl set within the study area over the duration of the time series (Engel or Campelen). Polygon extraction was based on the upper 10th percentile rule.

Fish Functional Groups

The remaining fish species in the survey dataset were divided into fish functional groups. These groupings are based on general size characteristics and known food habitats (Koen-Alonso pers. comm.). For a complete list of species considered in each functional group refer to the Table 7:

- Small Benthivores – maximum mean size <45 cm.
- Medium Benthivores – maximum mean size >45 cm and < 80cm
- Large Benthivores – maximum mean size >80 cm
- Piscivores
- PlankPiscivores (Plankton-Piscivores)
- Planktivores

For each functional group, a kernel density surface was created from the point data based on the kilograms per tow recorded for each trawl set within the study area. The upper 10th percentile of the density surface was extracted and converted to a polygon layer.

Rare or Endangered Fish Species

Rare or endangered (R/E) species are species listed as threatened, endangered, extirpated, or of special concern under *SARA* (*SARA* 2002). They also include species designated by COSEWIC. Under our criteria the species considered rare or endangered were Northern Wolffish (*Anarhichas denticulatus*), Atlantic Wolffish (*Anarhichas lupus*), Spotted Wolffish (*Anarhichas minor*), Roundnose Grenadier (*Macrourus berglax*), and Skates (*Raja* sp.).

A kernel density surface was created from the point data based on kilograms per tow and the upper 10th percentile was extracted and converted to a polygon layer.

Juvenile / Spawning Areas

Length-sex-maturity (LSM) data were used where possible to identify areas of juvenile and spawning aggregations. LSM data were collected for a limited number of species on DFO RV surveys where the maturity of an individual was determined by a visual inspection of the gonads (Templeman et al. 1978).

IDW surfaces representing the average number of juveniles and spawning females per set were created and the upper tenth percentile was extracted for four finfish species over varied time spans: American Plaice, Atlantic Cod, Greenland Halibut, and Witch Flounder. Juvenile IDW surfaces were developed for all species, however due to lack of data, spawning surfaces were only generated for Atlantic Cod and American Plaice (Table 3).

These datasets were often small and had a limited and uneven spatial distribution within the study area and hence the areas identified as the upper 10th percentile were confirmed by species experts to be accurate and not computational anomalies. Only those areas confirmed to be true areas of aggregation were considered in the analysis.

Total Biomass, Diversity, Richness, Evenness

DFO RV survey data were also considered in terms of overall biomass, diversity, richness and evenness. These layers were used for reference purposes to ensure that the selection of candidate EBSAs effectively captured important areas highlighted by these indices. Total Biomass was defined as the total kilograms per tow in a single survey record. Point values for total kilograms per tow were extracted to a 20 km x 20 km grid with the value of each cell being the average of all point values within that grid cell.

Diversity was calculated using the Shannon-Weiner diversity index which takes into account both the relative abundance of species and the species richness within a defined area. Calculated as follows where “pi” is the proportion of individuals of species “i” in a tow (ni/N where “n” is the number of individuals in a given species per tow and N is the total number of individuals per tow) (Gray 2000).

$$H' = -\sum_{i=1}^{S} (pi)(\ln(pi))$$

Richness was calculated as the number of individual species per tow.

Evenness was calculated as the proportion of diversity value H’ to the maximum possible value of H’ if all species were equally represented (H’max, which is calculated as ln*S, where S equals the total number of species) (Gray 2000).

$$E = H'/H'max$$

These indices initially included all species in the survey data. They were also recalculated without the inclusion of the core species. This was done because the core species were analyzed independently and, given their dominance, they heavily influence the diversity results, obscuring the signal of less dominant species.

Acoustic Capelin Data

From 1989-1994, acoustic Capelin (*Mallotus villosus*) data were collected during fall (September and October) RV surveys. A kernel density estimate surface was created and based on the “density” parameter as defined by the number of Capelin per square meter for entire ensonified water column. Polygon extraction was based on expert advice.

Salmon Drift Net Data

Salmon (*Salmo salar*) drift net data were taken from Stenson et al. (2011). Data were analyzed and kernel density surfaces were created for spring (March-June) and summer (July-October). The single winter (November) record was excluded from the analysis. Kernel density surfaces were created based on salmon/km/hr, as a measure of number of fish caught per unit effort. Only the kernel density estimate for summer was used for the final extraction, as the spring layer was relatively data-poor. Polygon extraction was based on the upper 10th percentile rule.

Marine Mammals

Harp and Hooded Seal Whelping Patch Data

Data collection methods for seal whelping patches are outlined in Stenson et al. (2006) and Stenson et al. (2010). Whelping patches (breeding concentrations) were identified using fixed-wing and helicopter aerial surveys of areas historically used by Harp (*Pagophilus groenlandicus*) and Hooded (*Cystophora cristata*) seals. Harp and hooded seal data were compiled by J. Anderson. Additional harp seal whelping areas were digitized from Stenson et al. 1995, Stenson et al. 2000, Stenson et al. 2005 and Stenson et al. 2010. Additional Hooded Seal whelping areas were digitized from Stenson et al. 2006. Whelping data are temporally discontinuous with the range for Harp Seals being 1951-2008 and for Hooded Seal data was collected from 1951-2005. For harp and hooded seals, overlapping polygons from years 1971-77, 1980 and 1984 were merged because of multiple data sources; patch boundaries were extended to enclose small, adjacent patches. To create a presence layer for Harp and Hooded Seals whelping areas, polygons were converted to raster format and aggregated to the standard 20 km x 20 km grid. Probability layers were created for both species by dividing the years whelping occurred by the years surveyed.

Harp Seal Telemetry Data

Harp Seal movement patterns were derived from telemetry data (Stenson unpublished data). Data were filtered using the algorithm developed by Freitas et al. 2008. Kernel density surfaces were created for biologically meaningful periods throughout the year. These were: post-molt (May to mid-June), spring migration (mid-June to July), fall migration (December), summer feeding (August-November) and winter feeding (January-March). For each of these layers, probability contours (percent volume thresholds) were calculated for 50%, 80%, 90%, and 95% volume. Polygon extraction was based on expert advice using these data.

Hooded Seal Telemetry Data

Hooded seal telemetry data were taken from Anderson et al. (2012). Separate kernel density surface were created for males, females and juveniles during April-June and August-February. Kernel density calculations were based on First-Passage Time (FPT) (Anderson et al. 2012), which is defined as the time required for an individual seal to cross a circle of a particular radius (Johnson et al. 1992; Fauchald and Tveraa 2003) and is a measure of residency time (Fauchald and Tveraa 2003). Based on expert advice the final layers considered for analysis were females (both time periods), males (August-February) and juveniles (August-February). Final polygon extraction was based on the upper 10th percentile rule.

Eastern Hudson Bay Beluga Data

Eastern Hudson Bay Beluga (*Delphinapterus leucas*) (EHB) information came from two sources (Lewis et al. 2009 and Bailleul et al. 2012). From Lewis et al. (2009) a map (Figure 3-e from the original paper) showing home range probabilities calculated from winter telemetry data was digitized and imported into the GIS. The 50% probability band was extracted. FPT maps produced in Bailleul et al. (2012, see Figure 4a) showing 95% density curves were digitized and imported into the GIS. No additional extraction was performed and final polygon selection was based on expert advice (Dr. J. Lawson, DFO, pers. comm.).

International Whaling Commission (IWC) Data

Historical whaling data were partitioned into three seasons to coincide with the seasonal PCA analysis of the oceanographic data. Spring (May), summer (June-August) and fall (September-November). Over 60% of the 4,000 records fell into the summer season. The largest portion of the remainder occurred in the fall with only 10 records in the spring. Kernel density surfaces were created for summer and fall data and the data-poor spring data were displayed as points. Final polygon extraction was based on expert advice using these data (Dr. J. Lawson, DFO, pers. comm.).

Cetaceans - Survey Data

Aerial survey data were divided into two broad categories: effort-corrected data and non-effort-corrected data. Effort-corrected data consisted of DFO aerial surveys (2002 and 2003) and Trans North Atlantic Sightings Survey (TNASS) data. Non-effort-corrected data came from non-targeted cetacean survey observers. Kernel density estimates were made for effort-corrected and non-effort-corrected datasets that were partitioned by functional group (Table 8). Final polygon extraction was based on expert advice using these data (Dr. J. Lawson, DFO, pers. comm.).

Seabird Data

Pelagic Seabird Surveys

Pelagic Seabird Survey data were received from CWS, EC in raster format displaying linear density (number of birds/km travelled). This is an effort-corrected estimate which was calculated by dividing kernel density estimates by days visited (by the observer). Linear density rasters were at the species level or in some cases guild level (Table 9). The original rasters were processed to the standard 20 km x 20 km offshore grid. Polygon extraction was based using the upper 10th percentile rule.

Seabird Colony Buffers

Seabird colony buffer distances were created with advice from CWS, EC and involved the creation of kernel density surfaces of colony maxima for seabirds found in Atlantic Canada (Table 6). Colony maxima data were extracted using the upper 10th percentile rule. Funk Island was extracted independently because it is the only breeding colony for Northern Gannet (*Morus bassanus*) within the study area. The extracted data was then used as the input layer for the buffer creation; buffer distances varied by species (Table 6) and were based on expert advice (Thaxter et al. 2012).

Murre Distributional Maps

Distributional maps for Common Murres (*Uria aalge*), Thick-billed Murres (*Uria lomvia*) and Sooty Shearwaters (*Puffinus griseus*) were provided by Memorial University. These data were the result of graduate research conducted at W.A. Montevecchi's lab. Distributional maps consisted of kernel density surfaces for home ranges for Murre species from breeding colonies in Newfoundland and Labrador through the eastern Canadian Arctic and Sooty Shearwaters from breeding colonies in the South Atlantic Ocean, all of which use key habitat areas in the Northwest Atlantic (Montevecchi et al. 2012).

Corals and Sponges

RV Data

Corals data originated from two sources: DFO RV survey data collected data in NAFO Divisions 2HJ3K from 2004-11, and Northern Shrimp Surveys (NSS) in 2G from 2005-11. As DFO RV Survey and NSS data were collected using the same stratified-random survey design they were merged into a single dataset (McCallum and Walsh 1997; Wareham et al. 2010). Coral species were aggregated into functional groups based on habitat function: Large Gorgonians, Small Gorgonians, Stony Cup Corals, Black Corals, Sea Pens and Soft Corals (Table 10)

Each of the functional group layers was then processed to create kernel density surfaces of total catch weight and the areas of highest concentration were selected and extracted using the upper 10th percentile rule.

Corals Observer Data

In 2004, deep-sea corals were added to the watch list of DFO's Fisheries Observer Program, which deploys observers on fishing vessels from Baffin Basin to southern Newfoundland (Wareham and Edinger 2007). The use of these data was limited because they report only presence and are biased by fishing effort. The data could only be displayed as point data and a density surface could not be interpolated. Because there was high spatial overlap between this dataset and the DFO RV/NSS datasets, the observer data were not considered for this project.

Sponges

Sponge (*Porifera*) data were collected on DFO RV surveys from 2004 to 2011 and were found over the entire 2GHJ3K study area. All species of Sponges were processed together based on the best level of confidence in sponge taxonomy which is Phylum (Kenchington et al. 2010). A kernel density surface was created and the upper 10th percentile rule was applied to identify and extract the highest concentration areas.

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REFERENCES

Andersen J., Wiersma, Y.F., Stenson, G.B, Hammill, M.O., Rosing-Asvid. A. and Skern-Maurizen, M. 2013. Habitat selection by hooded seals (*Cystophora cristata*) in the Northwest Atlantic Ocean. ICES Journal of Marine Science. 70(1). 173-185.

Bailleul, F., Lesage, V., Power, M., Doidge, D.W. and Hammill, M.O. 2012. Difference in driving and movement patterns of two groups of beluga whales in a changing Arctic environment reveal discrete populations. Endangered Species Research. 17: 27-41.

Bird Studies Canada and Nature Canada. 2012. Important Bird Area of Canada Database 2004-2012. Port Rowan, Ontario: Bird Studies Canada.

Davoren, G.K., Anderson, J.T., Montevecchi, W.A. 2006. Shoal behaviour and maturity relations of spawning capelin (*Mallotus villosus*) off Newfoundland: demersal spawning and diel vertical movement patterns. Can. J. Fish. Aquat. Sci. 63:268-283.

Dempson, J.B. and D.E. Stansbury. 1991. Using counting and a two-sample design for mark-recapture estimation of an Atlantic salmon smolt population. North American Journal of Fisheries Management. 11: 27-37.

Deroba, JJ. 2010. An updated spatial pattern analysis for the Gulf of Maine-Georges Bank Atlantic herring complex during 1963-2009. US Dept Commerce, Northeast Fish Sci Cent Ref Doc. 10-18: 18 p.

DFO. 1998. Community Based Coastal Resource Inventories in Newfoundland and Labrador: Procedures Manual. St. John's NL: Canning and Pitt Associates.

DFO. 2011. Ecologically and Biologically Significant Areas – Lessons Learned. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/049.

ESRI Inc. 2010. ArcGIS Version 10.0. Desktop Help for ArcGIS release 10.0. Environmental Systems Research Institute (ESRI), Redlands, CA, USA.

Fauchald, P. and Tveraa, T. 2003. Using first-passage time in analysis of area-restricted search and habitat selection. Ecology. 84: 282-288.

Ferry, N., L. Parent, S. Masina, A. Storto, K. Haines, M. Valdivieso, B. Barnier, and J. M. Molines. Quality Information Document MyOcean V2 System For Global Ocean ReAnalysis Product. Tech. no. MYO-WP4-QUID-V2.1-GLO-REAPHYS- 001-004.v2.1.doc. V2.1 ed. N.p.: n.p., 2012.

Freitas, C., Lyderden, C., Fedak, M.A. and Kovacs, K.M. 2008. A simple new algorithm to filter marine mammals Argos locations. Marine Mammal Science. 24:315-325.

Gray, J.S. 2000. The measurement of marine species diversity, with an application to the benthic fauna of the Norwegian continental shelf. Experimental Marine Biology and Ecology 250: 23-49.

Jenness, Jeff. 2012. Jenness Enterprises - ArcGIS Tools; DEM Surface Tools. Jenness Enterprises - ArcGIS Tools; DEM Surface Tools.

Johnson, A.R., Wiens, J.A., Milne, B.T. and Crist, T.O. 1992. Animal movements and population dynamics in heterogeneous landscapes. Landscape Ecology. 7:63-75.

Kenchington, E., Lirette, C., Cogswell, A., Archambault, D., Archambault, P., Benoit, H., Bernier, D., Brodie, B., Fuller, S., Gilkinson, K., Lévesque, M., Power, D., Siferd, T., Treble, M., and Wareham, V. 2010. Delineating Coral and Sponge Concentrations in the Biogeographic Regions of the East Coast of Canada Using Spatial Analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/041. vi + 202 pp.

Kulka, D.W. 1998. SPANdex – SPANS geographic information system process manual for creation of biomass indices and distributions using potential mapping. DFO Can. Stock Access. Sec. Res. Doc. 98/60. 28p.

Lewis, A.E., Hammill, M.O., Power, M., Doidge, D.W. and Lesage, V. 2009. Movement and aggregation of Easter Hudson Bay Beluga whales (*Delphinapterus leucas*): A comparison of patterns found through satellite telemetry and Nunavik traditional ecological knowledge. Arctic. 62: 13-24.

McCallum, B.R., and Walsh, S.J. 1997. Groundfish Survey Trawls Used at the Northwest Atlantic Fisheries Centre 1971 to Present. NAFO Sci. Council Studies. 29: 93-104

Montevecchi, W.A., A. Hedd, L. McFarlane Tranquilla, D.A. Fifield, C.M. Burke, P.M. Regular, G.K. Davoren, S. Garthe, G.J. Robertson and R.A Phillips. 2012. Tracking seabirds to identify ecologically important and high risk marine areas in the western North Atlantic. Biol. Cons. 156: 62-71.

Nakashima, B. S., and Wheeler, J. P. 2002. Capelin (*Mallotus villosus*) spawning behaviour in Newfoundland waters – the interaction between beach and demersal spawning. ICES Journal of Marine Science. 59: 909–916.

NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. Moderate-resolution Imaging Spectroradiometer (MODIS) Aqua Ocean Color Data; 2014 Reprocessing. NASA OB.DAAC, Greenbelt, MD, USA. doi: 10.5067/AQUA/MODIS_OC.2014.0.

Ollerhead, L.M.N., Morgan, M.J., Scruton, D.A., and Marrie, B. 2004. Mapping spawning times and locations for 10 commercially important fish species found on the Grand Banks of Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 2522: iv + 45p.

Ollerhead, L.M.N. and E.B.S. French. 2010. Mapping the Spatial Distribution of Juvenile and Spawning Activities for Five Selected Finfish Species off the Labrador and Northeastern Newfoundland Shelf. Environmental Studies Research Funds Report No. 188. St. John’s, NL 31 p.

Penton, P.M. and Davoren, G.K. 2012. Physical characteristics of persistent deep-water spawning sites of capelin: Importance for delimiting critical marine habitats. Marine Biology Research. 8: 778-783

Pepin, P., Cuff, A., Koen-Alonso, M., and Ollerhead, N. 2010. Preliminary Analysis for the Delineation of Marine Ecoregions on the NL Shelves. Serial No. N5871. NAFO SCR Doc 10/72, 24 p.

Platt, T., Sathyendranath S., Forget, M., Whiteiii, G., Caverhill, C.,Bouman, H., Devred, E.and Son, S. 2008. Operational Estimation of Primary Production at Large Geographical Scales. Remote Sensing of Environment 112(8): 3437-3448.

Reddin, D.G., Poole, R.J., Clarke, G., and Cochrane, N. 2010. Salmon rivers of Newfoundland and Labrador. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/046. iv + 24 p.

Stenson, G.B., Hammill, M.O., Kingsley, M.C.S., Sjare, B., Warren, W.G. and Myers, R.A. 1995. Pup production of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic during 1994. DFO Can. Sci. Advis. Sec. Res. Doc. 95/20. 32 p.

Stenson, G.B., Hammill, M.O., Gosselin, J.F. and Sjare, B. 2000. 1999 pup production of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2000/080. 35 p.

Stenson, G.B, Hammill, M.O., Lawson, J., Gosselin, J.F. and Haug, T. 2005. 2004 pup production of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2005/037. iv + 34 p.

Stenson, G.B., Hammill, M.O., Lawson, J. and Gosselin, J.F. 2006. 2005 Pup production of hooded seals, *Cystophora cristata*, in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/067. Iv + 40 p.

Stenson, G.B., Hammill, M.O. and Lawson, J.W. 2010. Estimating pup production of Northwest Atlantic Harp Seals, *Pagophilus groenlandicus*: Results of the 2008 surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/103. iv + 39 p.

Stenson, G.B., Benjamins, S. and Reddin, D.G. 2011 Using bycatch data to understand habitat use of small cetaceans: lessons from an experimental driftnet fishery. ICES J. Mar. Sci. 68:937-946.

Templeman W., Hodder, V.M. and Wells, R. 1978. Sexual maturity and spawning in haddock, *Melanogrammus aeglefinus*, of the southern Grand Bank. ICNAF Res. Bull. 13: 53–66.

Thaxter, C.B., Lascelles, B., Sugar, K., Cook, A.S.C.P., Roos, S., Bolton, M., Langston, R.H.W. and Burton, N.H.K. 2012. Seabird foraging ranging as a primary tool for identifying candidate marine protected areas. Biological Conservation. 156: 53-61.

The R Project for Statistical Computing. 2012. R Project.

Veinott, G and Clarke, K. 2011. Status of American Eel in Newfoundland and Labrador Region: Prepared for the Pre-COSEWIC and Eel Zonal Advisory Process (ZAP), Ottawa, August 31 to Sept 3, 2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/138. iv + 20 p.

Wareham, V.E. and Edinger, E.N. 2007. Distributions of deep-sea corals in the Newfoundland and Labrador region, Northwest Atlantic Ocean. Bull. Mar. Sci. 81: 289-312.

Wareham, V.E, Ollerhead, L.M.N. and Gilkinson K. 2010. Spatial Analysis of Coral and Sponge Densities with associated Fishing Effort in Proximity to Hatton Basin (NAFO Divisions 2G-0B). DFO Can. Sci. Advis. Sec. Res. Doc. 2010/058. vi + 34 p.

Wells, N.J., Stenson, G.B., Pepin, P., and M. Koen-Alonso. 2017. Identification and Descriptions of Ecologically and Biologically Significant Areas in the Newfoundland and Labrador Shelves Bioregion. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/013. v + 74

FIGURES

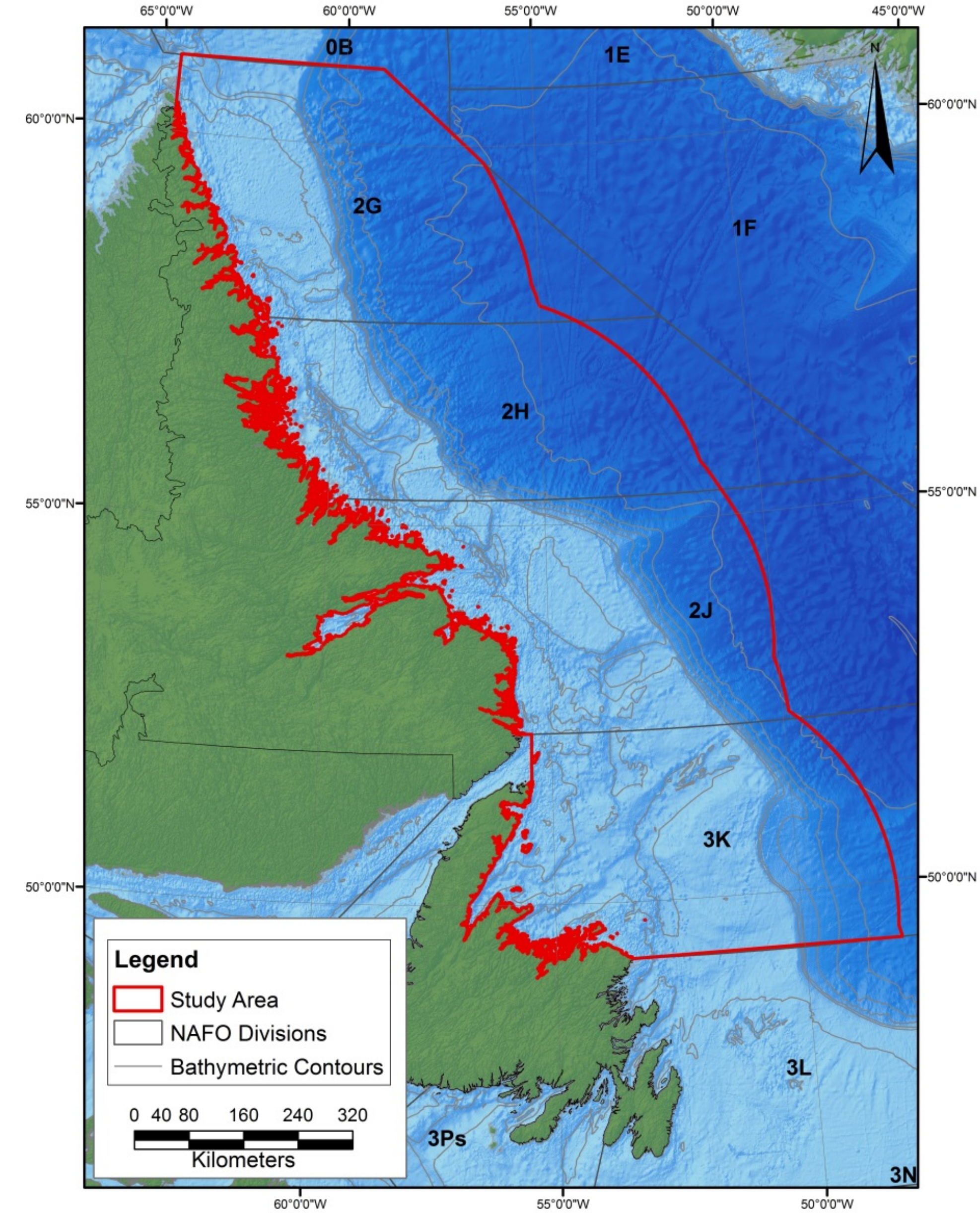

Figure 1: Study Area.

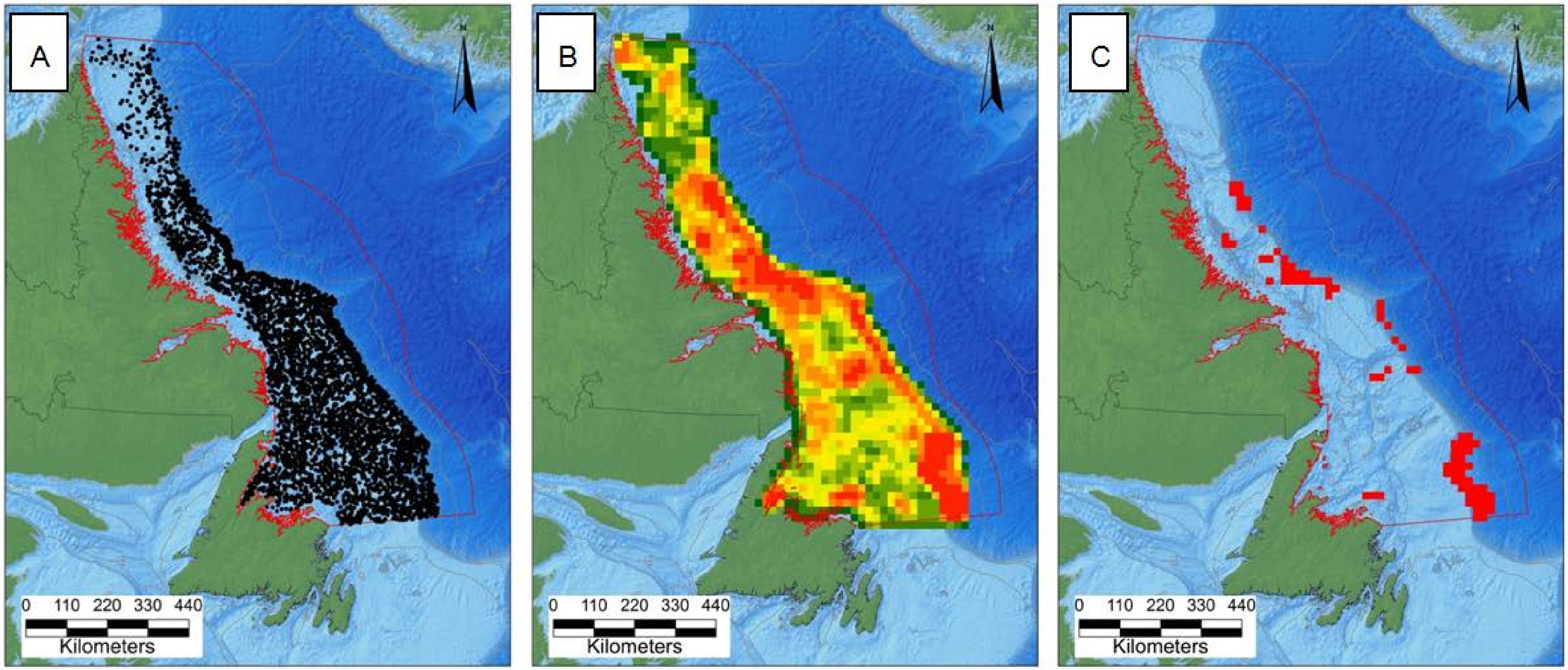

Figure 2: Illustration of GIS data processing flow for the Small Benthivores functional group for the Campelen time period. A) initial point layer, B) KD surface generated from the point layer, C) top ten percentile.

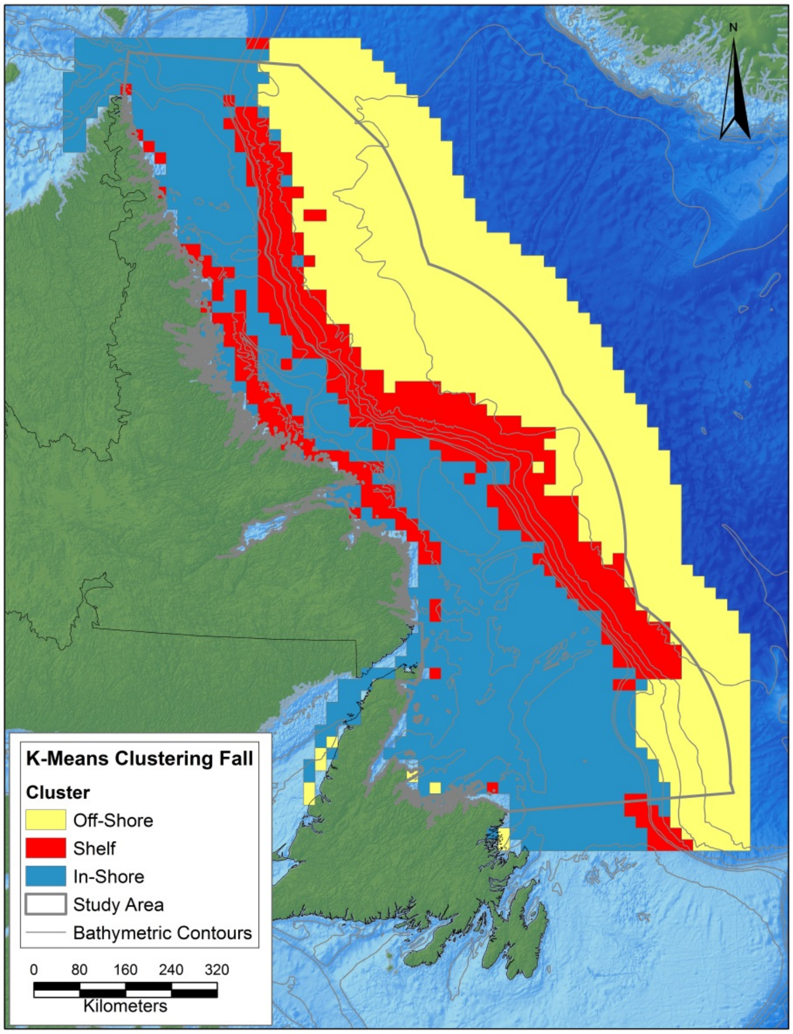

Figure 3: PCA and Clustering Results.

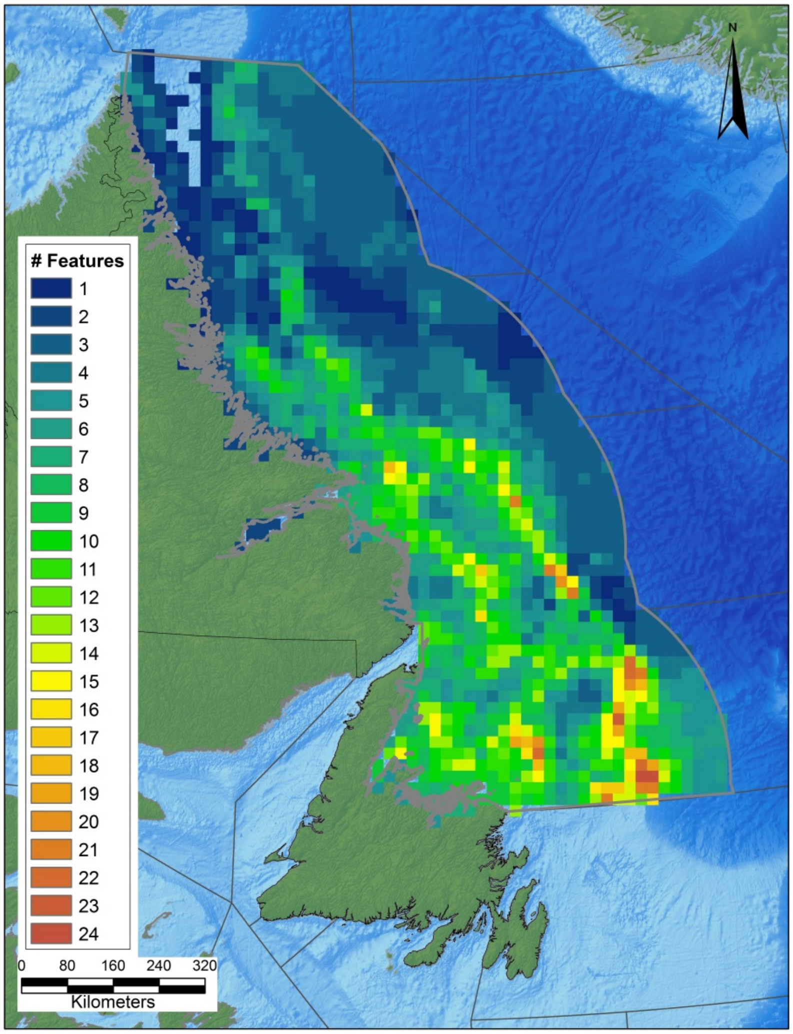

Figure 4: Cell Statistics Results for Composite Layer.

TABLES

Table 1: Actual percentage of area depicted in "upper 10th percentile" for each data layer.

Conceptual Layer	Layer	% In Top Class
Functional Groups Campelen	*Small benthivores*	*8.44*
	Medium benthivores	*7.48*
	Large benthivores	*4.63*
	Planktivores	*3.89*
	PlankPiscivores	*6.75*
	Piscivores	*6.07*
Functional Groups Engel	*Small benthivores*	*6.46*
	Medium benthivores	*7.40*
	Large benthivores	*7.55*
	Planktivores	*0.50*
	PlankPiscivores	*0.54*
	Piscivores	*3.80*
Core Species Campelen	*American plaice*	*6.08*
	Witch flounder	*3.01*
	Turbot	*5.86*
	Redfish	*3.93*
	Capelin	*3.47*
	Cod	*4.69*
	Shrimp	*7.14*
	Snow crab	*5.81*
Core Species Engel	*American plaice*	*5.64*
	Witch flounder	*6.58*
	Turbot	*6.75*
	Redfish	*4.36*
	Cod	*4.14*
N/A	***Capelin Acoustic Data***	*1.90*
RE Species Campelen	*Atlantic wolffish*	
	Spotted wolffish	*7.69*
	Northern wolffish	*7.30*
	Skate	*6.25*
	Roundnose grenadier	*5.12*
RE Species Engel	*Atlantic wolffish*	*8.54*
	Spotted wolffish	*7.77*
	Northern wolffish	*8.04*
	Skate	*7.74*
	Roundnose grenadier	*4.45*
Corals and Sponges	*Black corals*	*8.97*
	Soft corals	*6.54*
	Sea pens	*6.21*
	Stony cup corals	*8.11*
	Small gorgonians	*3.86*
	Large gorgonians	*1.35*
	Sponges	*2.72*

Table 2: List of offshore environmental layers, data sources for each layer, and treatment of final layer for PCA/k-means clustering analysis. Conceptual later – Oceanography.

Data Layers	Data Source	Temporal Extent	Source Data Type
Ice	Data was averaged over a period of years to create a composite layer of pack ice duration. Measured as duration (number of days a year present). Canadian Ice Service.	2001-2011	Raster
Sea Surface Temperature	Reference simulation of global ocean physics on a scale of .25 degrees (18km grid). Originally netCDF format in Kelvin converted to ArcGIS in Celcius.	1993-2009	Raster
Sea Bottom Temperature	Bottom temperature in Celcius collected during DFO RV surveys	1971-2011	Raster
Sea Surface Salinity	Original monthly average sea surface salinity raster data extracted from GLORYS2 NetCDF files. (Practical Salinity Units – PSU). Converted to ArcGIS.	1993-2009	Raster
Sea Bottom Salinity	Salinity units converted from conductivity measurements obtained during DFO RV surveys.	1971-2011	Raster
Bottom Current Velocity	GLORYS2 reference simulation of global ocean physics; 2-dimensional velocity (m/s).	1993-2009	Raster
Surface Current Velocity	GLORYS2 reference simulation of global ocean physics; 2-dimensional velocity. Netcdf files converted to ArcGIS (m/s).	1993-2009	Raster
Chlorophyll-a	Satellite imagery 1 km resolution - semi-monthly climatology of processed MODIS data. (µg/m3 seasonal avg.)	2002-2010	Raster
Primary Production	Semi-monthly composites of processed SeaWIFs satellite data (1.5km grid). Measured as mg C/m2/day	1997-2004	Raster
Bathymetric Complexity	Calculated from the GEBCO (General Bathymetric Chart of the Oceans) dataset as the surface area/flat area ratio using DEM surface tools. GEBCO (General Bathymetric Chart of the Ocean)	2008	Raster
Bathymetry	GEBCO (General Bathymetric Chart of the Oceans) developed based on a database of depth soundings interpolated to a 1 arc minute grid. GEBCO (General Bathymetric Chart of the Ocean)	2008	Raster

Table 3: List of offshore biological conceptual and nested data layers, data sources for each layer, and treatment of final layer for compound analysis and EBSA identification.

Conceptual Layer	Data Layers	Data Source	Temporal Extent	Source Data Type
Corals	• Large gorgonians • Small gorgonians • Stony cup corals • Black corals • Sea pens • Soft corals	KD of DFO RV (2004-2011, 2HJ3K) and NSS (Cape Ballard, 2005-2011, 2G only) biomass data	• 2004-2011 (DFO RV) • 2005-2011 (NSS)	point
Sponges	• All Sponges	KD of DFO RV data	• 2004-2011	point
Capelin Acoustic Data	-	Acoustic data collected during fall surveys – presence only.	• 1989-1994	point
Core Species Campelen	• Capelin • Witch flounder • American plaice • Cod • Redfish • Turbot • Crab • Shrimp	DFO fall RV surveys (kg / tow). Campelen gear.	• 1995-2010	point
Core Species Engels	• Capelin • Witch flounder • American plaice • Cod • Redfish • Turbot	DFO fall RV surveys (kg / tow). Engels gear.	• 1977-1994	point
SARA Species - Campelen	• Roundnose grenadier • Skate • Northern wolffish • Spotted wolffish • Atlantic wolffish	DFO fall RV surveys (kg / tow). Campelen gear.	• 1995-2010	point

Table 3: Continued.

Conceptual Layer	Data Layers	Data Source	Temporal Extent	Source Data Type
SARA Species - Engels	• Roundnose grenadier • Skate • Northern wolffish • Spotted wolffish • Atlantic wolfish • Skate • Northern wolffish • Spotted wolffish • Atlantic wolffish	DFO fall RV surveys (kg / tow). Engels gear.	• 1977-1994	point
Functional Groups Campelen	• Small benthivores • Medium benthivores • Large benthivores • Planktivores • PlankPiscivores • Piscivores	DFO fall RV surveys (kg / tow). Campelen gear.	• 1995-2010	point
Functional Groups Engels	• Small benthivores • Medium benthivores • Large benthivores • Planktivores • PlankPiscivores • Piscivores	DFO fall RV surveys (kg / tow). Engels gear.	• 1977-1994	point
Juvenile Areas Engels	• Atlantic Cod • American Plaice • Greenland Halibut • Witch Flounder	IDW of LSM data collected on DFO fall RV surveys. Engels gear.	• Atlantic Cod: 1978-1994 • American Plaice: 1987-1994 • Greenland Halibut:1979-1994 • Witch Flounder: 1980-1994	point
Spawning Areas Engels	• Atlantic Cod • American Plaice	IDW of LSM data collected on DFO fall RV surveys. Engels gear.	• Atlantic Cod: 1971-1994 • American Plaice: 1987-1994	point
Juvenile Areas Campelen	• Atlantic Cod • American Plaice • Greenland Halibut • Witch Flounder	IDW of LSM data collected on DFO fall RV surveys. Campelen gear.	• 1995-2001	point
Spawning Areas Campelen	• Atlantic Cod • American Plaice	IDW of LSM data collected on DFO fall RV surveys. Campelen gear.	• 1995-2001	point

Table 3: Continued.

Conceptual Layer	Data Layers	Data Source	Temporal Extent	Source Data Type
Marine Mammals	• Eastern Hudson Bay Belugas	Residency areas based on satellite telemetry data & home range probabilities calculated with TEK and winter telemetry data.	• 1993-2003 Bailleul et al. 2012) & 1993-2009 (Lewis et al. 2009)	polygon (digitized)
	• Historical Whaling Data	KDE based on historical International Whaling Commission (IWC) data.	• 1935-1972	-
	• Harp Seal Whelping	Probability of use based on presence/absence of whelping	• 1951-2008	mixed
	• Hooded Seal Whelping	Probability of use based on presence/absence of whelping	• 1951-2005	mixed
	• Harp Seal Movement	KDE based on the full spatial extent of telemetry data.	• 1993-1997, 2004	point
	• Hooded Seal Movement (Males August-February; Juveniles August-February; Females April-June; Females August-February)	KDE based on the full spatial extent of first passage time tracking data.	• 2004-2008	Point
	• Cetacean Surveys	Aerial survey data (DFO, TNASS) & observer data.	• 2002-2003 (DFO) • 2007 (TNASS) • 1958-2011 • (Observer Data)	Point
Pelagic Bird Transect Survey Data Layers	• Atlantic Puffins • Black-legged Kittiwake • Cormorants • Cory's Shearwater • Dovekie • Great Black-backed Gull • Greater Shearwater • Herring Gull • Ivory Gull • Murres • Northern Fulmar • Phalaropes • Razorbill • Skuas & Jaegers • Sooty Shearwater • Storm Petrels • Terns	KD based on and pelagic bird transect surveys. Corrected for effort and spatial extent was restricted to Canadian waters.	• 1966-1987 (PRIOP) • 2006-2011 (ECSAS)	raster

Table 3: Continued.

Conceptual Layer	Data Layers	Data Source	Temporal Extent	Source Data Type
Buffered colonies	• Atlantic Puffin • Common Murre • Glaucous Gull • Great Black-backed Gull • Herring Gull • Northern Fulmar • Northern Gannet • Razorbill • Terns • Thick-billed Murre	KD based on max count colony (provided by E and buffered based on Thaxter et al. 2012 and foraging range information provided by CWS.	• N/A	raster
Murre Distribution Maps	• Common Murre Fall	Kernel Home Range distributions from 3 colonies in Eastern Canada.	• 2007-2011	polygon
	• Common Murre Early Winter	Kernel Home Range distributions from 3 colonies in Eastern Canada.	• 2007-2011	polygon
	• Common Murre Late Winter	Kernel Home Range distributions from 3 colonies in Eastern Canada.	• 2007-2011	polygon
	• Thick-billed Murre Fall	Kernel Home Range distributions from 5 colonies in the Arctic and Eastern Canada	• 2007-2011	polygon
	• Thick-billed Murre Early Winter	Kernel Home Range distributions from 5 colonies in the Arctic and Eastern Canada	• 2007-2011	polygon
	• Thick-billed Murre Late Winter	Kernel Home Range distributions from 5 colonies in the Arctic and Eastern Canada	• 2007-2011	polygon
	• Thick-billed Murre Spring	Kernel Home Range distributions from 5 colonies in the Arctic and Eastern Canada	• 2007-2011	polygon

Table 4: List of coastal biological conceptual and nested data layers, data sources for each layer, and treatment of final layer for EBSA identification.

Conceptual Layer	Data Layers	Data Source	Temporal Extent	Source Data Type
Fish	• Charr Landings	Aboriginal fishing data (CPUE) *Only 1974-1995 considered for analysis	• 1974-2010*	point
	• Salmon Returns	Total returns from counting fence data	• 1984-2011	point
	• Salmon Surveys	Spring and summer drift net surveys. (salmon/km/hr)	• 1965-2001	point
	• Capelin spawning sites	Beach and demersal capelin spawning sites	• 2003-2007	point
N/A	• American Eel	Eel fishery data for the island of Newfoundland-presence only	• 1990-2007	point
N/A	• Important Bird Areas (IBA)	IBA Canada	-	-
Waterfowl	• Harlequin Duck (SARA) • Barrow's Goldeneye (SARA) • Seaducks • Geese • Dabbling Ducks • Bay Ducks	Maximum counts of individuals (count)	• 1960-2008	polygon
Eider surveys	• Common Eiders	Maximum observations based on coastal survey block data (count)	• 1960-2008	polygon
	• Common Eiders	Winter maximum counts of individuals (count)	• 2010	point
	• Common Eiders	Summer maximum counts of individuals (count)	• 2006	point
	• Black Guillemots	Summer maximum counts of individuals (count)	• 2006	point
Seabird Colonies	• Common Murre • Glaucous Gull • Great Black-backed Gull • Herring Gull • Northern Fulmar • Northern Gannet • Atlantic Puffin • Razorbill • Terns • Thick-billed Murre • Glaucous Gull	KDE of colonies based on maximum counts. (count) *Data post 1960 were used to create kernel density surfaces	• 1928-2011*	raster

Table 4: Continued.

Conceptual Layer	Data Layers	Data Source	Temporal Extent	Source Data Type
CCRI Groundfish	• American plaice • Atlantic cod • Brook trout • Charr • Flounder • Greenland cod • Halibut • Lumpfish • Redfish • Rock cod • Salmon • Skate • Smelt • Turbot • Winter flounder • Witch flounder • Wolffish	Qualitative presence only data based on Traditional Ecological Knowledge (TEK) This data was used as a confirmation for quantitative data layers or in data poor regions of the study area.	• 1996-2004	polygon
CCRI Pelagics	• Arctic char • Atlantic salmon • Brook trout • Brown trout • Eel • Herring • Mackerel • Salmon • Shark • Smelt • Tuna	Qualitative presence only data based on Traditional Ecological Knowledge (TEK) This data was used as a confirmation for quantitative data layers or in data poor regions of the study area.	• 1996-2008	polygon

Table 4: Continued.

Conceptual Layer	Data Layers	Data Source	Temporal Extent	Source Data Type
CCRI Shellfish	• Clam • Giant scallop • Lobster • Mussel • Rock crab • Sea urchin • Shrimp • Snail • Snow crab • Soft shell clam • Squid • Toad crab • Whelk	Qualitative presence only data based on Traditional Ecological Knowledge (TEK) This data was used as a confirmation for quantitative data layers or in data poor regions of the study area.	• 1996-2008	polygon
CCRI Aquatic Plants	• Eelgrass • Goose grass • Irish moss • Kelp • Rockweed • Seagrass	Qualitative presence only data based on Traditional Ecological Knowledge (TEK) This data was used as a confirmation for quantitative data layers or in data poor regions of the study area.	1996-2008	polygon

Table 5: Waterfowl Guild Groups Species List.

Group	Common Name	Scientific Name
Bay Ducks	Lesser Scaup	*Aythya affinis*
	Redhead	*Aythya americana*
	Greater Scaup	*Aythya marila*
	Ring-Necked Duck	*Aythya collaris*
Dabbling Ducks	Northern Pintail	*Anas acuta*
	American Wigeon	*Anas americana*
	northern shoveler	*Anas clypeata*
	Green-Winged Teal	*Anas crecca*
	Blue-Winged Teal	*Anas discors*
	Mallard	*Anas platyrhynchos*
	American Black Duck	*Anas rubripes*
	Gadwall	*Anas strepera*
Geese	Atlantic Brant	*Branta b. bernicla*
	Canada Goose	*Branta canadensis*
	Lesser Snow Goose	*Chen c. atlantica*
	Greater Snow Goose	*Chen c. caerulescens*
Sea Ducks	Common Goldeneye	*Bucephala clangula*
	bufflehead	*Bucephala albeola*
	long-tailed duck	*Clangula hyemalis*
	hooded merganser	*Lophodytes cucullatus*
	black scoter	*Melanitta americana*
	white-winged scoter	*Melanitta fusca*
	surf scoter	*Melanitta perspicillata*
	merganser	*Mergus merganser*
	red-breasted merganser	*Mergus serrator*
	common eider	*Somateria mollissima*
	king eider	*Somateria spectabilis*

Table 6: Species of seabirds for which colony data were available.

Common Name	Scientific Name	Buffer distance (km)
Razorbill	*Alca torda*	300*
Northern fulmar	*Fulmarus glacialis*	300
Atlantic puffin	*Fratercula arctica*	60
Herring gull	*Larus argentatus*	60
Greater black-backed gull	*Larus marinus*	60
Glaucous Gull	*Larus hyperboreus*	60
Northern gannet	*Morus bassanus*	300
Common Murre	*Uria aalge*	60
Thick-billed murre	*Uria lomvia*	60
Terns	-	20
Black tern	*Chlidonias niger*	20
Caspian tern	*Hydroprogne caspia*	20
Bridled tern	*Onychoprion anaethetus*	20
Roseate tern	*Sterna dougallii*	20
Forster's Tern	*Sterna forsteri*	20
Common tern	*Sterna hirundo*	20
Arctic tern	*Sterna paradisaea*	20
Least tern	*Sternula antillarum*	20
Royal tern	*Thalasseus maximus*	20
Sandwich tern	*Thalasseus sandvicensis*	20

*Buffer distance parameter for Razorbill was incorrectly set at 300 km; correct distance should have been 30 km. Buffered colonies were not used to delineate EBSAs and therefore had no effect on the identification exercise.

Table 7a: List of species in each Fish Functional Group – Small Benthivores.

Common Name (as displayed in NL DFO Archive)	Scientific Name
ALLIGATORFISH (NS)	*Agonidae*
ALLIGATORFISH,COMMON	*Aspidophoroides monopterygius*
ANGLEMOUTHS (NS)	*Cyclothone*
ARGENTINE,LARGE EYED	*Nansenia groenlandica*
ATLANTIC GYMNAST	*Xenodermichthys copei*
BATFISH,ATLANTIC	*Dibranchus atlanticus*
BIGSCALEFISHES, RIDGEHEADS	*Melamphaidae*
BLACK SWALLOWER	*Chiasmodon niger*
BLACKSMELT,GOITRE	*Bathylagus euryops*
BUTTERFISH (NS)	*Stromateidae*
DEEPSEA SCULPIN,PALLID	*Cottunculus thomsonii*
DEEPSEA SCULPIN,POLAR	*Cottunculus microps*
EELPOUT,SOFT	*Melanostigma atlanticum*
FANGTOOTH (Ogrefish) Ana	*Anoplogaster cornuta*
FEELERFISH,NOTCH	*Bathypterois dubius*
FOURBEARD ROCKLING	*Enchelyopus cimbrius*
FOURLINE SNAKEBLENNY	*Eumesogrammus praecisus*
GRENADIER,COMMON (MARLIN	*Nezumia bairdii*
GRENADIER,ROUGHNOSE	*Trachyrincus murrayi*
GRENADIERS (NS)	*Gadiformes*
GRENADIERS (NS)	*Macrouridae*
HOOKEAR SCULPIN (NS)	*Artediellus*
HOOKEAR SCULPIN,ARCTIC	*Artediellus uncinatus*
HOOKEAR SCULPIN,ATL.	*Artediellus atlanticus*
LEPIDION (NCN)	*Lepidion eques*
LIGHTFISHES (NS)	*Gonotomatidae*
LIZARDFISH,OFFSHORE	*Synodus poeyi*
LOOSEJAW	*Malacosteus niger*
LUMPFISH (NS) EUM.SP.	*Eumicrotremus*
LUMPFISH,SPINY	*Eumicrotremus spinosus*
LUMPSUCKER,LEATHERFIN	*Eumicrotremus derjugini*
MAILED SCULPIN,ARCTIC	*Triglops nybelini*
MAILED SCULPIN,NORTHERN	*Triglops pingelii*
MAILED SCULPINS (NS)	*Triglops*
MANEFISH, ATLANTIC	*Caristius groenlandicus*
RIDGEHEAD (NCN)	*Poromitra Capito*
SCULPIN, ARCTIC	*Myoxocephalus scorpioides*
SCULPIN, MOUSTACHE	*Triglops murrayi*

Table 7a: Continued.

Common Name (as displayed in NL DFO Archive)	Scientific Name
SCULPIN,SPATULATE	*Icelus spatula*
SCULPIN,ARCTIC STAGHORN	*Gymnocanthus tricuspis*
SCULPIN,TWOHORN	*Icelus bicornis*
SCULPINS (NS)	*Cottidae*
SEA DEVIL, WARTED	*Cryptopsaras couesii*
SEASNAILS (NS)	*Liparidae*
SPINY LUMPSUCKER	*Eumicrotremus Spinosus Variabilis*
THREEBEARD ROCKLING (NS)	*Gaidropsarus*
TWOHORN SCULPIN (NS)	*Icelus*
WOLF EEL (NS)	*Lycenchelys*
WOLF EEL,NORTHERN (COMMO	*Lycenchelys paxillus*
WOLF EEL,SAR'S	*Lycenchelys sarsii*
WOLF EEL,VERRILL'S	*Lycenchelys verrillii*

Table 7b: List of species in each Fish Functional Group – Medium Benthivores.

Common Name (as displayed in NL DFO Archive)	Scientific Name
BIGEYES (NS)	*Priacanthidae*
DUCKBILL EEL	*Nessorhamphus ingolfianus*
EELPOUT (NS)	*Lycodes*
EELPOUT,ARCTIC	*Lycodes reticulatus*
EELPOUT,ESMARK'S	*Lycodes esmarkii*
EELPOUT,VAHL'S	*Lycodes vahlii*
FISH DOCTOR (GREEN OCEAN	*Gymnelus viridis*
GRENADIER,LONGNOSE	*Caelorinchus caelorhincus carminatus*
HAKE,BLUE	*Antimora rostrata*
HALOSAURUS (NS)	*Notacanthoidei*
LIPOGENYS	*Lipogenys gillii*
LONGNOSE EEL	*Synaphobranchus kaupii*
LUMPFISH,COMMON	*Cyclopterus lumpus*
MORA (NCN) HAL.JOH.	*Halargyreus johnsonii*
SCULPIN, RIBBED (HORNED)	*Myoxocephalus*
SCULPIN,FOURHORN	*Myoxocephalus quadricornis*
SCULPIN,LONGHORN	*Myoxocephalus octodecemspinosus*
SCULPIN,SHORTHORN	*Myoxocephalus scorpius*
SEA RAVEN	*Hemitripterus americanus*
SHARK,DEEPSEA CAT	*Apristurus profundorum*
SNAKE BLENNY	*Lumpenus lampretaeformis*
SNIPE EEL,SHORTNOSE	*Serrivomer beanii*

Table 7b: Continued.

Common Name (as displayed in NL DFO Archive)	Scientific Name
SNUBNOSE EEL	*Simenchelys parasitica*
WHITING,BLUE	*Micromesistius poutassou*
YELLOWTAIL FLOUNDER	*Limanda ferruginea*

Table 7c: List of species in each Fish Functional Group – Large Benthivores.

Common Name (as displayed in NL DFO Archive)	Scientific Name
ANGLER,COMMON(MONKFISH)	*Lophius americanus*
CHIMAERA,DEEPWATER	*Hydrolagus affinis*
CHIMAERA,LONGNOSE	*Harriotta raleighana*
CUSK	*Brosme brosme*
DEEPSEA ANGLER,BIG	*Ceratias holboelli*
GRENADIER,ROUGHHEAD	*Macrourus berglax*
HADDOCK	*Melanogrammus aeglefinus*
SEA DEVILS (NS)	*Ceratiidae*
SMOOTHHEADS (NS)	*Alepocephalidae*
SNIPE EEL,ATLANTIC	*Nemichthys scolopaceus*
SPINY EELS (NS)	*Notacanthidae*
WRYMOUTH	*Cryptacanthodes maculatus*

Table 7d: List of species in each Fish Functional Group – Piscivores.

Common Name (as displayed in NL DFO Archive)	Scientific Name
ANGLERS	*Lophiiformes*
BARRACUDINAS (NS)	*Paralepididae*
DOGFISH,BLACK	*Centroscyllium fabricii*
DRAGONFISH,BOA	*Stomias boa ferox*
GADOIDS (NS)	*Gadidae*
GULPER (NCN) SAC.AMP.	*Saccopharynx ampullaceus*
HAKE,OFFSHORE SILVER	*Merluccius albidus*
HAKE,SILVER	*Merluccius bilinearis*
HAKE,WHITE (COMMON)	*Urophycis tenuis*
HALIBUT (ATLANTIC)	*Hippoglossus hippoglossus*
LAMPREY, SEA	*Petromyzon marinus*
LANCETFISH, SHORTNOSED	*Alepisaurus brevirostris*
LANCETFISHES (NS)	*Alepisauridae*
POLLOCK	*Pollachius virens*
SCABBARDFISH,BLACK	*Aphanopus carbo*
SHARK,PORTUGUESE	*Centroscymnus coelolepis*
VIPERFISH	*Chauliodus sloani*

Table 7e: List of species in each Fish Functional Group – PlankPiscivores.

Common Name (as displayed in NL DFO Archive)	**Scientific Name**
COD,ARCTIC	*Boreogadus saida*
GULPER,PELICAN	*Eurypharynx pelecanoides*

Table 7f: List of species in each Fish Functional Group – Planktivores.

Common Name (as displayed in NL DFO Archive)	**Scientific Name**
ARGENTINE,ATLANTIC	*Argentina silus*
HERRING,ATLANTIC	*Clupea harengus*
HERRING,BLACK	*Bathytroctes*
LANTERNFISHES (NS)	*Myctophidae*
RONDELETIIDAE	*Whalefishes, Redmouth*
SAND LAUNCE,OFFSHORE	*Ammodytes dubius*
SHANNY,RADIATED	*Ulvaria subbifurcata*
STICKLEBACK,THREESPINE	*Gasterosteus aculeateus*

Table 8: Cetacean Functional Groups.

Functional Group	Common Name	Scientific Name
Beaked whale	Sowerby's Beaked Whale	*Mesoplodon bidens*
	Mesoplodon sp.	*Mesoplodon spp.*
Beluga whale	Beluga whale	*Delphinapterus leucas*
Blue whale	Blue whale	*Balaenoptera musculus*
Fin whale	Fin whale	*Balaenoptera physalus*
	Sei whale	*Balaenoptera borealis*
Humpbacked whale	Humpback whale	*Megaptera novaeangliae*
Minke whale	Minke whale	*Balaenoptera acutorostrata*
Mysticete whale	Unknown large whale	*N/A*
	Unknown baleen whale	*N/A*
Northern Bottlenose Whale	Northern Bottlenose whale	*Hyperoodon ampullatus*
Small Cetacean	Unknown dolphin	*N/A*
	Common dolphin	*Delphinus delphis*
	Atlantic white-beaked dolphin	*Lagenorhynchus albirostris*
	Harbour Porpoise	*Phocoena phocoena*
	Striped dolphin	*Stenella coeruleoalba*
	Stenella spp.	*Stenella spp.*
	Bottlenose Dolphin	*Tursiops truncatus*
Squid Easters	Atlantic Long-finned Pilot Whale	*Globicephala melas*
	Sperm Whale	*Physeter macrocephalus*
	Risso's Dolphin	*Grampus griseus*
Unknown Cetacean	Unknown whale	*N/A*

Table 9: Pelagic Seabird Species List.

Species Guild	Common Name	Scientific Name
Phalaropes	Red Phalarope	*Phalaropus fulicarius*
	Red-necked Phalarope	*Phalaropus lobatus*
Murres	Common murre	*Uria aalge*
	Thick-billed murre	*Uria lomvia*
	Unknown murre	*N/A*
Storm-Petrels	White-faced storm-petrel	*Pelagodroma marina*
	Wilson's storm-petrel	*Oceanites oceanicus*
	Leach's storm-petrel	*Oceanodroma leucorhoa*
	Wedge-rumped storm-petrel	*Oceanodroma tethys*
Skuas and Jaegers	South polar skua	*Stercorarius maccormicki*
	Long-tailed jaeger	*Stercorarius longicaudus*
	Pomarine jaeger	*Stercorarius pomarinus*
	Parasitic jaeger	*Stercorarius parasiticus*
	Great skua	*Stercorarius skua*
Terns	Black tern	*Chlidonias niger*
	Caspian tern	*Hydroprogne caspia*
	Bridled tern	*Onychoprion anaethetus*
	Roseate tern	*Sterna dougallii*
	Forster's Tern	*Sterna forsteri*
	Common tern	*Sterna hirundo*
	Arctic tern	*Sterna paradisaea*
	Least tern	*Sternula antillarum*
	Royal tern	*Thalasseus maximus*
	Sandwich tern	*Thalasseus sandvicensis*
N/A	Dovekie	*Alle alle*
	Razorbill	*Alca torda*
	Cory's shearwater	*Calonectris diomedea*
	Northern fulmar	*Fulmarus glacialis*
	Atlantic puffin	*Fratercula arctica*
	Herring gull	*Larus argentatus*
	Greater black-backed gull	*Larus marinus*
	Northern gannet	*Morus bassanus*
	Ivory gull	*Pagophila eburnea*
	Great shearwater	*Puffinus gravis*
	Sooty shearwater	*Puffinus griseus*
	Black-legged kittiwake	*Rissa tridactyla*

Table 10: Corals Functional Groups.

Coral Functional Group	Scientific Name
Black Corals	*Antipatharian spp.*
	Stauropathes arctica
Stony Cup Corals	*Desmophyllum dianthus*
	Flabellum spp.
	Flabellum angulare
	Flabellum alabastrum
	Flabellum mandrewi
	Fungiacyathus marenzelleri
Large Gorgonians	*Acanthogorgia armata*
	Keratoisis grayi (=K. ornata)
	Paragorgia arborea
	Paramuricea sp.
	Paramuricea grandis
	Primnoa resedaeformis
	Paramuricea placomus
Small Gorgonians	*Acanella arbuscula*
	Anthothela grandiflora
	Chrysogorgia spp.
	Radicipes gracilis
Sea Pens	*Anthoptilum grandiflorum*
	Distichoptilum gracile
	Funiculinia quandrangularis
	Halipteris finmarchica
	Pennatula spp.
	Pennatula aculeata
	Pennatula grandis
	Pennatula phosphorea
	Umbellula spp.
	Unknown Sea Pen spp.
Soft Corals	*Anthomastus agaricus*
	Anthomastus grandiflorus
	Anthomastus purpureus
	Drifa sp.
	Drifa glomerata
	Duva florida
	Gersemia spp.
	Heteropolypus cf. insolitus
	Nephtheidae spp.