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Canadian Science Advisory Secretariat (CSAS)

Research Document 2013/064

Maritimes Region

Marine Protected Area Network Planning in the Scotian Shelf Bioregion: Offshore Data Considerations

M. King[1], N. Shackell[2], M. Greenlaw[3], K. Allard[4], H. Moors[2], and D. Fenton[1]

[1]Fisheries and Oceans Canada, Ecosystems Management Branch, Oceans and Coastal Management Division, PO Box 1006, Dartmouth, Nova Scotia B2Y 4A2

[2]Fisheries and Oceans Canada, Science Branch, Oceans and Ecosystems Sciences Division, PO Box 1006, Dartmouth, Nova Scotia B2Y 4A2

[3]Fisheries and Oceans Canada, Science Branch, Coastal Ecosystems Science Division, 531 Brandy Cove Road, St. Andrews, New Brunswick E5B 2L9

[4]Environment Canada, Canadian Wildlife Services, Environmental Stewardship Branch, PO Box 6227, 17 Waterfowl Lane, Sackville, New Brunswick E4L 4N1

October 2013

Canada

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.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044

Correct citation for this publication:

King, M., Shackell, N., Greenlaw, M., Allard, K., Moors, H., and Fenton, D. 2013. Marine Protected Area Network Planning in the Scotian Shelf Bioregion: Offshore Data Considerations. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/064. vi + 24 p.

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ABSTRACT

Building on the preliminary Marine Protected Area (MPA) network analysis completed by Horsman *et al.* (2011), Fisheries and Oceans Canada (DFO) is leading a systematic approach to MPA network planning in the Scotian Shelf Bioregion. The major steps in the planning process are described in the *National Framework for Canada's Network of MPAs* (Government of Canada 2011). Guidance from the Convention on Biological Diversity (CBD 2009a; COP 9 Decision IX/20, Annexes I-III) will also be carefully considered. Early steps in the planning process include setting clear conservation objectives, compiling habitat classification and Ecologically and Biologically Significant Areas (EBSAs) data, and analyzing these data to identify a set of areas that would collectively satisfy the conservation objectives of the network. This research document offers a review of the habitat classification and EBSA data layers used in Horsman *et al.* (2011) and identifies additional data sources to be considered in the next iteration of the MPA network analysis for the offshore component of the bioregion. The Kostylev and Hannah (2007) classifications (Scope for Growth and Natural Disturbance) and the Fader[1] classification (Seabed Feature) are recommended to be used as a basis for evaluating habitat representation in designing the MPA network. A data-driven approach similar to that used by Horsman *et al.* (2011) is recommended for the identification or refinement of offshore EBSAs. Reliable data under each of the CBD EBSA criteria should be compiled and ultimately incorporated into the next iteration of the network design analysis. It is also recommended that the Scientific Expert Opinion (SEO) and Local Ecological Knowledge (LEK) EBSAs (Doherty and Horsman 2007, Maclean *et al.* 2009) be re-evaluated against the CBD EBSA criteria to ensure that known significant areas are not missed in the data-driven approach.

[1] G.B.J. Fader's unpublished consultant report to WWF-Canada (*Classification of Bathymetric of the Scotian Shelf*, 2007).

Planification du réseau d'aires marines protégées dans la biorégion du plateau néo-écossais : considérations liées aux données en haute mer

RÉSUMÉ

À l'aide de la version préliminaire de l'analyse du réseau d'aires marines protégées (AMP) effectuée par Horsman *et al.* (2011), Pêches et Océans Canada (MPO) dirige une approche systématique de la planification du réseau d'AMP dans la biorégion du plateau néo-écossais. Les principales étapes du processus de planification sont décrites dans le *Cadre national pour le réseau d'AMP du Canada* (gouvernement du Canada 2011). Les lignes directrices de la Convention sur la diversité biologique (CDB 2009a; Annexes I-III de la 9e Conférence des Parties, décision IX/20) seront aussi soigneusement examinées. Les premières étapes du processus de planification comprennent l'établissement d'objectifs de conservation clairs, la compilation des données sur la classification des habitats et les zones d'importance écologique et biologique (ZIEB), de même que l'analyse de ces données pour définir un ensemble de zones qui répondrait aux objectifs de conservation du réseau. Le présent document de recherche donne un aperçu des couches de données sur la classification de l'habitat et les ZIEB utilisées dans Horsman *et al.* (2011) et il présente d'autres sources de données à prendre en compte lors de la prochaine version de l'analyse du réseau d'AMP pour la composante hauturière de la biorégion. Il est recommandé de se baser sur les classifications de Kostylev et Hannah (2007) (potentiel de croissance et de perturbation naturelle) et la classification de Fader[2] (caractéristiques du fond marin) pour évaluer la représentativité de l'habitat au moment de concevoir le réseau d'AMP. Il est aussi recommandé d'utiliser une approche axée sur les données similaire à celle employée par Horsman *et al.* (2011) pour définir ou modifier les ZIEB hauturières. Les données fiables de chaque critère de la CDB en lien avec les ZIEB doivent être compilées, puis intégrées dans la prochaine version de l'analyse de la conception du réseau. Il est également recommandé de réévaluer les ZIEB fondées sur des avis scientifiques spécialisés et des connaissances écologiques locales (Doherty et Horsman 2007; Maclean *et al.* 2009) par rapport aux critères de la CDB en lien avec les ZIEB afin de s'assurer que les zones d'importance connues sont prises en compte dans le cadre de l'approche axée sur les données.

[2] Rapport de consultation non publié de G.B.J. Fader pour WWF-Canada (*Classification of Bathymetric of the Scotian Shelf,* 2007).

1.0 INTRODUCTION

As Fisheries and Oceans Canada (DFO) prepares to move forward with Marine Protected Area (MPA) network design in the offshore component of the Scotian Shelf Bioregion, the intention is to follow the general systematic approach outlined in the *National Framework for Canada's Network of MPAs* (Government of Canada 2011) and used by Horsman *et al.* (2011) in their initial MPA network analysis for the Scotian Shelf. The early steps in this approach include setting clear conservation objectives, compiling and preparing available data under the themes of habitat representation and Ecologically and Biologically Significant Areas (EBSAs), and analyzing these data to identify a set of areas that would collectively satisfy the conservation objectives of the network. Additional steps will be required before the network design is complete (Westhead *et al.* 2013), but input from the Science community is particularly important at these early stages to ensure the ecological foundation of the network is built on sound science. Guidance from the Convention on Biological Diversity (CBD 2009a; COP 9 Decision IX/20, Annexes I-III) will also be carefully considered throughout the process. The purpose of this research document is to review the habitat classification and EBSA data layers used in Horsman *et al.* (2011) and to describe other data sources that could be considered in the next iteration of the MPA network design. Recommendations are made on how to create or update certain data layers under the different CBD EBSA criteria. A draft list of data layers and sources to be considered as the analysis proceeds is provided and major ecological data gaps are identified.

Following the March 2012 DFO Maritimes Region Science Regional Advisory Process (RAP), an informal working group comprised of DFO Science and Oceans and Coastal Management Division (OCMD) staff (and potentially others) will be formed to compile, process, update and analyze the required data and eventually conduct the next network design analysis. This *MPA Network Working Group* (NWG) will be responsible for many of the tasks highlighted in this paper and the Science Advisory Report (DFO 2012a). In parallel development, the North American Marine Protected Areas Network (NAMPAN) and the International Council for the Exploration of the Seas (ICES) are developing "Scientific Guidelines for Designing Marine Protected Area Networks in a Changing Climate". Given the pace of climate change, the NWG will aim to incorporate these guidelines into the MPA network design.

This research document is organized into two major sections based on the overarching conservation objectives for the bioregional network (see DFO 2012a, Westhead *et al.* 2013); the first (Section 2) focuses on available ecosystem or habitat classification systems while the second (Section 3) examines data and approaches to be considered for identifying EBSAs. Section 4 offers a summary of the recommendations of this research document.

2.0 ECOSYSTEM/HABITAT CLASSIFICATION IN THE SCOTIAN SHELF BIOREGION

Representativity is recognized by the CBD as a required property of effective MPA networks (CBD 2007). Representativity can be considered at different spatial scales (DFO 2009), from the broad biogeographic regional scale to finer habitat or community scales. For a bioregional network of MPAs to be considered “representative”, it must capture intact examples of the full range of ecosystem, habitat, or community types that occur in the bioregion (Noss *et al.* 1999). Conservation approaches that focus on ecosystem or habitat representation are based on the assumption that protecting examples of all ecosystem or habitat types will protect the majority of biological communities and species in a region (Day and Roff 2000). This strategy is also known as the coarse-filter approach as it focuses on ecosystems and habitats instead of individual species (Noss *et al.* 1999). Given the general lack of detailed biological data in most marine regions, approaches that focus on ecosystem or habitat representation are particularly suitable in marine settings. To consider ecosystem or habitat representation in the design of an MPA network, an ecosystem or habitat classification system must be selected or developed.

2.1 EXISTING CLASSIFICATION SYSTEMS

The need for a scientifically robust ecosystem or habitat classification system for the Scotian Shelf Bioregion to be used in designing a network of MPAs and for broader integrated coastal and oceans management and planning has been recognized since the late 1990s. Since this time, several efforts have been made to classify the ecosystems or habitats of the bioregion (*e.g.*, Day and Roff 2000); including a multi-phased DFO Science RAP (DFO 2002). Phase 1 of that prior advisory process reviewed different benthic habitat classification approaches and provided recommendations for developing a classification that could inform oceans management decisions and be used as a basis for conserving benthic habitat diversity. Phase 2 produced a rigorous data-driven classification system that characterizes the range of growing conditions and natural disturbance regimes throughout the region (see below) (DFO 2005, Kostylev and Hannah 2007). With the exception of World Wildlife Fund (WWF)-Canada’s pelagic seascapes (see Crawford *et al*. 2006), all existing classification systems for the Scotian Shelf Bioregion focus on benthic ecosystems or habitats. The CBD guidance indicates that benthic and pelagic ecosystems or habitats should be classified and captured in representative networks of MPAs. The ecosystem or habitat classifications used in Horsman *et al.* (2011) and other available classifications are described below.

2.1.1 Classification Systems (used by Horsman *et al.* 2011)

Horsman *et al.* (2011) used three benthic classification systems in their MPA network analysis, including a classification of seabed features (Fader, unpublished report) and two classifications derived from Kostylev and Hannah (2007) that respectively characterize different Scope for Growth and Natural Disturbance conditions (see below).

Building on earlier work by Davis and Browne (1996), Fader (unpublished report) delineated the major seabed features (*e.g.*, Banks, Basins, Channels, etc.) of the Scotian Shelf Bioregion based on geomorphological and geological characteristics, which are recognized as the most enduring features of offshore marine environments (Figure 1). The classification, which was developed for WWF-Canada, was created based on available bathymetric and surficial geology data and knowledge of past and recent geomorphological processes. Horsman *et al.* (2011) included this classification because seabed features are generally recognizable to members of the marine user community and because conserving examples of each seabed feature type would capture a wide variety of habitats, communities and species. This classification also divides the Scotian Shelf into inner, middle and outer regions so including it in the analysis would ensure the inshore to offshore gradient of the shelf is represented in the network.

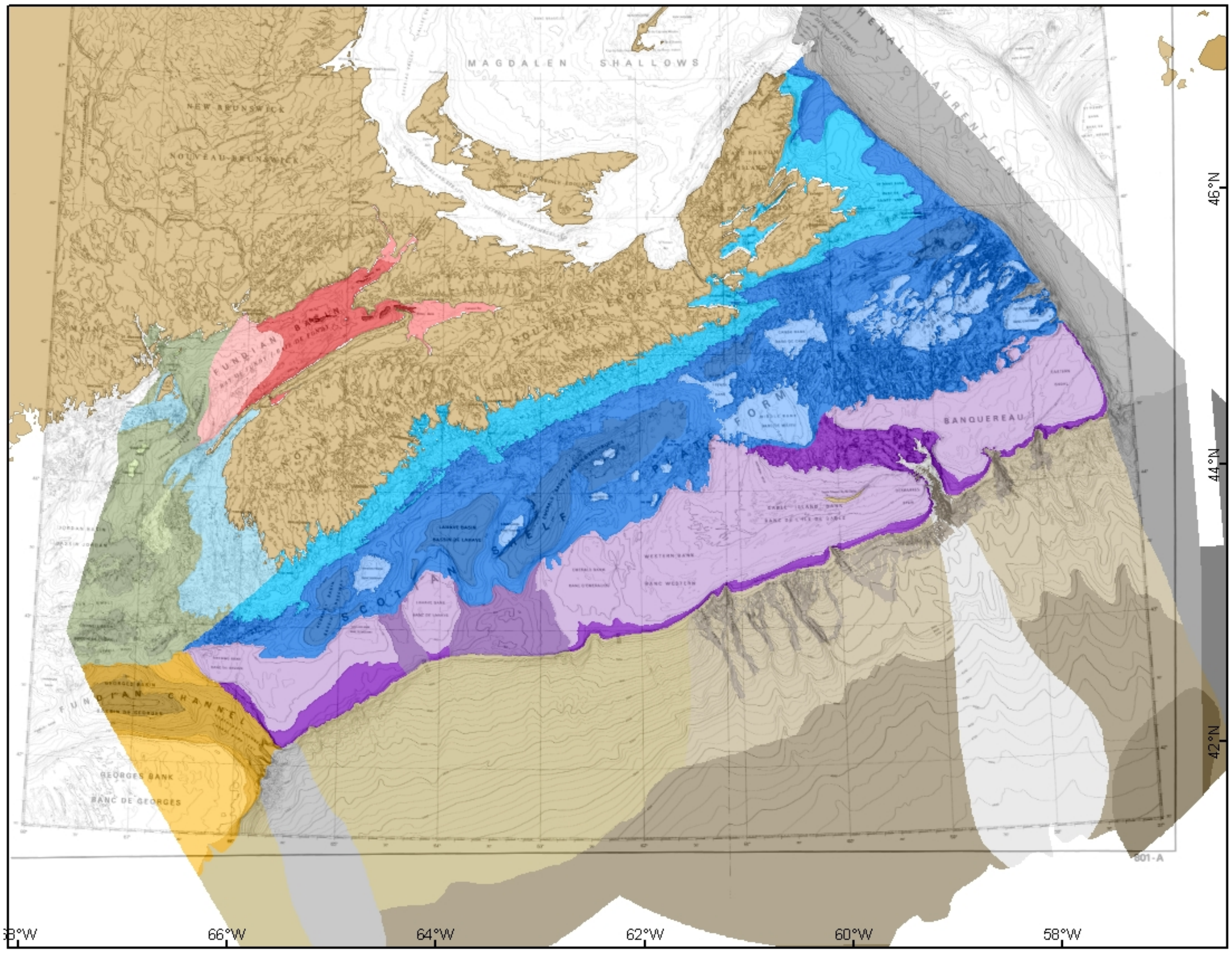

Figure 1. Major seabed features (e.g., banks, basins, channels, etc.) of the Scotian Shelf Bioregion delineated by Fader (unpublished report).

The Scope for Growth classification (Figure 2) was used by Horsman *et al.* (2011) to capture the full range of growing conditions on the shelf. To create this data layer, the Scope for Growth component of the Kostylev and Hannah (2007) benthic habitat classification model was divided into five classes based on natural breaks in the data. Capturing different Scope for Growth classes should ensure a wide range of community types is included in the network. The variables considered in developing this classification were: spring surface chlorophyll, summer stratification (surface to 50 m), annual average bottom temperature, annual range in bottom temperature, inter-annual variability in bottom temperature, and bottom oxygen.

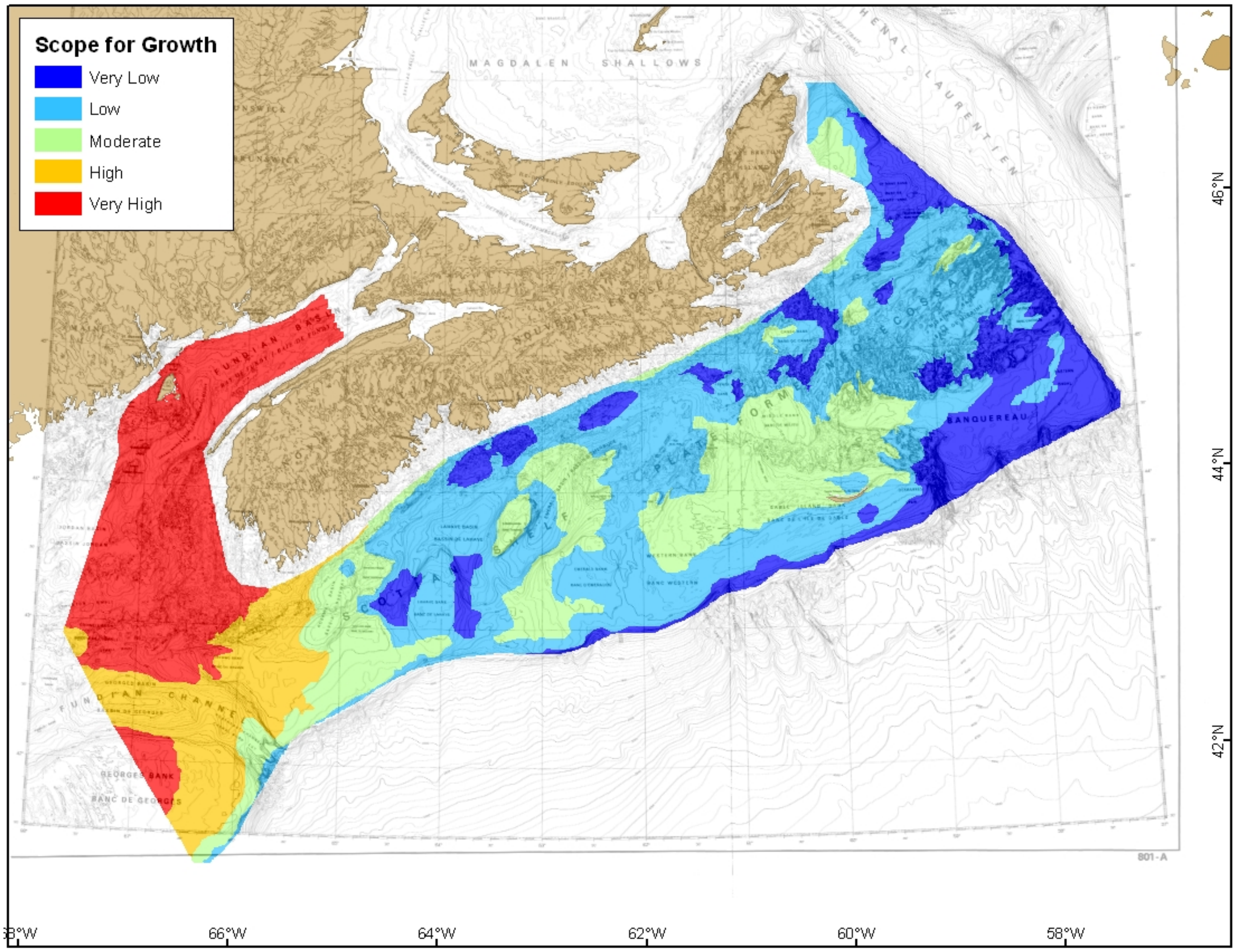

Figure 2. Scope for Growth classification for the Scotian Shelf Bioregion derived from the Kostylev and Hannah (2007) benthic habitat classification by Horsman et al. (2011).

The third classification used by Horsman *et al.* (2011) was a characterization of Natural Disturbance based on the Kostylev and Hannah (2007) benthic habitat classification model (Figure 3). Simply put, this classification describes the degree to which waves and currents disturb the substrate in different areas. Four Natural Disturbance classes were defined using natural breaks in the data. The variables that went into this classification were: water depth, grain size, root mean square (rms) tidal currents, and wave height and period.

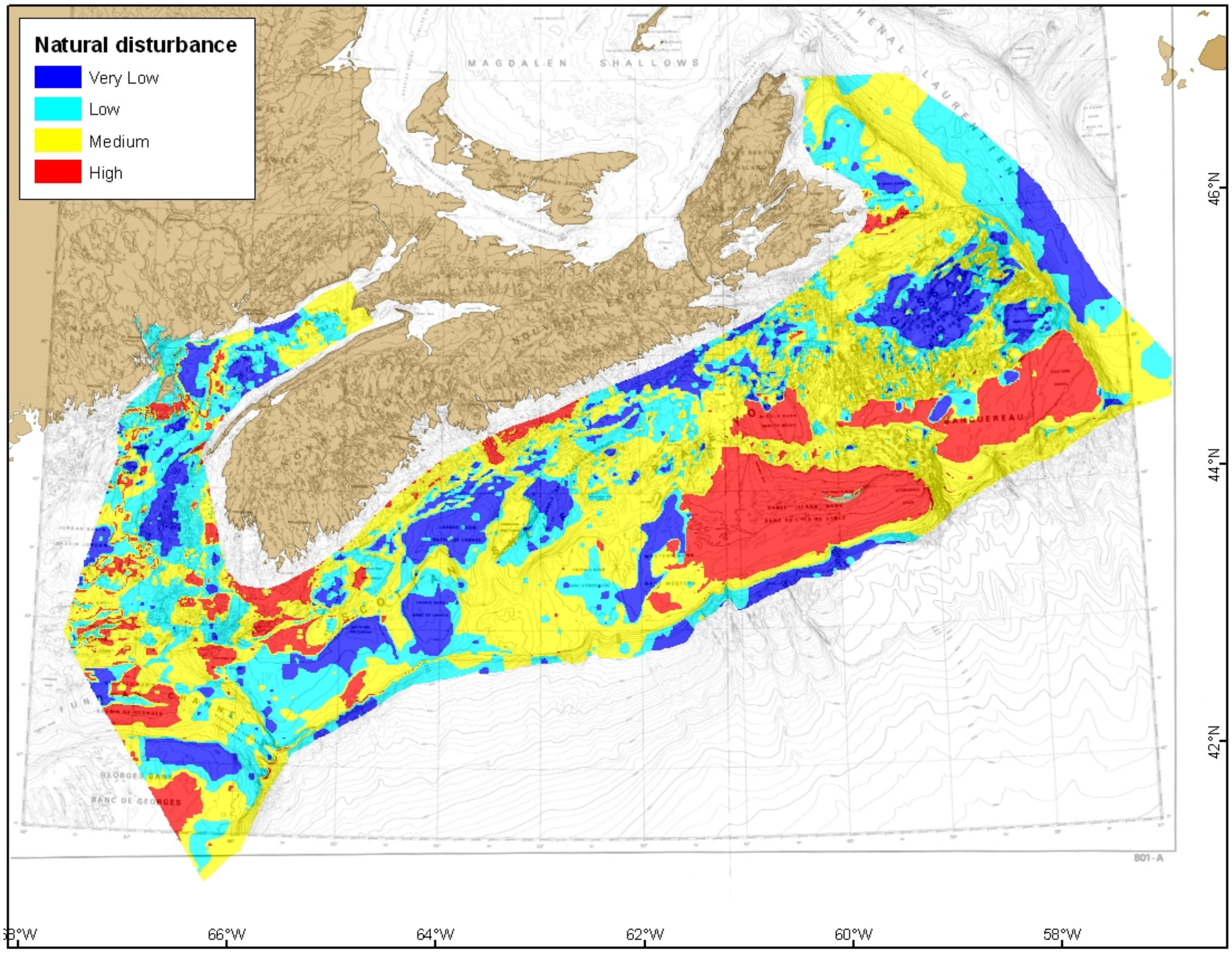

Figure 3. Natural Disturbance classification for the Scotian Shelf Bioregion derived from the Kostylev and Hannah (2007) benthic habitat classification by Horsman et al. (2011).

2.1.2 Other Classifications

From the late 1990s to the mid-2000s, WWF-Canada completed two iterations of its “seascapes” classification for the Scotian Shelf and the Gulf of Maine (Day and Roff 2000, Crawford *et al.* 2006). Seascapes are defined as physical habitat types classified on the basis of relatively enduring and recurrent abiotic features of the marine environment, such as temperature or substrate, that are known to influence the distribution of species and biological communities (Crawford *et al.* 2006). The original seascapes classification (Day and Roff 2000) was discussed during Phase 1 of the Benthic RAP (DFO 2002). The theory behind a hierarchical approach that focuses on physical variables was found to be promising; however, application of the approach on the Scotian Shelf was limited by poor input data. The substrate data were found to be particularly problematic. Other concerns were raised regarding scale and the weighting of different variables/data layers. Due to these factors, the delineated seascapes did not reflect relatively well-known species assemblage patterns. Improved data were used in the second iteration where benthic seascapes were defined based on bottom temperature and salinity, depth and substrate and pelagic seascapes were delineated based on sea surface temperature and salinity, depth and stratification. The second iteration of the seascapes classification was developed with input from regional experts but never underwent a formal scientific peer review. The seascapes approach was not adopted by government agencies but it did help trigger the Benthic RAP process that led to the development of the Kostylev and Hannah (2007) benthic habitat classification model.

2.1.3 Gradient Forest Method

Gradient forest (Ellis *et al.* 2012) is a multivariate statistical analysis method recently devised to analyze species-environment relationships. The method's outputs can be used to create a representative habitat layer for marine planning purposes. The method is considered an advance on previous approaches to create physiographic habitat layers from biological community data as it begins by determining regionally specific biological associations to different physical environmental variables. The representative habitat layer is then created based on a weighting scheme of how important each physical variable was in explaining the variation in species distribution and abundance (summed over all species that conform to certain statistical prerequisites in terms of distribution across the domain of interest). The method has added benefits in that it is robust to compare across surveys using disparate sampling and tools. However, the method is intensive as it requires dense biological data community data and coalition of many physical factors that could be associated to species distribution and abundance patterns. The method has recently been applied to mesoscale demersal trawl and benthic grab datasets from the Gulf of Maine in comparison to 23 physical environmental variables (Pitcher *et al*. 2012).

2.2 RECOMMENDATIONS

It is recommended that Kostylev and Hannah's (2007) Scope for Growth and Natural Disturbance classifications and Fader's (unpublished report) Seabed Feature classification be used as a basis for evaluating habitat representation in the design of a network of MPAs for the offshore components of the Scotian Shelf Bioregion. The same classification systems were used by Horsman *et al.* (2011). The strength of the Kostylev and Hannah approach is that it is not tied to one particular species but rather integrates the factors that determine species composition. It can also be used to address questions regarding sensitivity to human impacts *vis a vis* scope for growth and demographic rates. The Natural Disturbance component can also serve as an indicator of fish species richness and the Scope for Growth element provides an indicator of species evenness (Fisher *et al.* 2011). The spatial scale of Kostylev and Hannah is appropriate for MPA network planning because of its integrative nature. The classification also spans the entire shelf component of the bioregion and has been validated through at least two RAP processes.

Further consideration should be given to the gradient forest method, which could be applied to entire offshore component of the Scotian Shelf Bioregion. Building on Benthic RAPs I and II, the results of a gradient forest analysis for the bioregion could be reviewed in a separate RAP (Benthic RAP III).

3.0 EBSA IDENTIFICATION IN THE SCOTIAN SHELF BIOREGION

The CBD guidance states that effective networks of MPAs should capture EBSAs (CBD 2007), which are areas that provide important services to one or more species or populations in an ecosystem, or to the broader ecosystem as a whole (Government of Canada 2011). The CBD outlines seven criteria to be used to identify EBSAs (Table 1).

Table 1. CBD EBSA criteria outlined in Annex I to COP decision IX/20.

CBD EBSA Criteria	**CBD Definition**
1. Uniqueness or rarity	Area contains either (i) unique (“the only one of its kind”), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.
2. Special importance for life-history stages of species	Areas required for a population to survive and thrive.
3. Importance for threatened, endangered or declining species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.
4. Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.
5. Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.
6. Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.
7. Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.

DFO (2004) has also developed criteria for identifying EBSAs to inform integrated coastal and oceans management and planning, including MPA network design. There is general agreement that the DFO and CBD EBSA criteria are intended to identify similar types of areas (DFO 2010a). Since MPA network planning in Canada is a shared priority of federal, provincial, and territorial governments (instead of solely a DFO program), the CBD EBSA criteria will be used as the basis for identifying EBSAs for network planning (Government of Canada 2011).

This section includes an overview of past EBSA identification efforts in the Scotian Shelf Bioregion and outlines an approach for updating or refining the offshore EBSAs. The EBSA data layers used in the Horsman *et al.* (2011) MPA network analysis are also reviewed, and other potential data layers/sources to consider in the next iteration of the network design analysis are highlighted. Recommendations on how to identify EBSAs under each of the CBD criteria are provided in Section 4.

3.1 OVERVIEW OF PAST OFFSHORE EBSA ANALYSES IN THE SCOTIAN SHELF BIOREGION

Since the late 1990s, there have been several government, academic, and environmental non-government organization (ENGO) efforts to identify ecologically important areas in the Scotian

Shelf Bioregion (Beazley, unpublished report[3], Beazley *et al.* 2002, King, unpublished thesis[4], Breeze 2004, Buzeta *et al.* 2003, Buzeta and Singh 2008, Crawford *et al.* 2006, Doherty and Horsman 2007, Maclean *et al.* 2009, Horsman *et al.* 2011). A variety of methods were used in the different studies, ranging from compilations of Scientific Expert Opinion (SEO) (Beazley *et al.* 2000, Doherty and Horsman 2007) and Local Ecological Knowledge (LEK) (Maclean *et al.* 2009) to literature-based methods (Breeze 2004, P. Lane and Associates 1992) to strict data driven approaches (Crawford *et al.* 2006, Horsman *et al.* 2011). Additional regional-scale studies have identified important parts of the bioregion for specific taxa (*e.g.*, Horsman and Shackell 2009) while others have examined spatial patterns in species richness (*e.g.*, Strong and Hanke 1995, Shackell and Frank 2003, Cook and Bundy 2012).

In the Scotian Shelf Bioregion, DFO began to map EBSAs to support integrated coastal and oceans management, specifically the Eastern Scotian Shelf Integrated Management (ESSIM) initiative. The first offshore EBSA identification exercise was an SEO workshop where experts from various disciplines were asked to identify parts of the shelf or features that they knew to be significant (Doherty and Horsman 2007). This effort identified 42 areas of high ecological significance that collectively cover roughly 63% of the Scotian Shelf. This effort was followed by a complementary LEK compilation and mapping exercise that identified 75 EBSAs (Maclean *et al.* 2009). The results of the SEO and LEK studies were compared, revealing 17 general areas that were identified as EBSAs by both processes.

Given the large percentage of the shelf covered by the previously identified EBSAs, which presented management challenges, and the fact that substantial regional-scale biological and habitat data exist in the bioregion, the decision was made to initiate a data-driven approach identifying EBSAs within the context of designing an MPA network. This led to the Horsman *et al.* (2011) network analysis, which informed the selection of the St. Anns Bank Area of Interest through the *Health of the Oceans (HOTO) Initiative*.

3.2 DISCUSSION AND RECOMMENDATIONS

3.2.1 General Approach for Updating Offshore EBSAs

A data-driven approach similar to Horsman *et al.* (2011) is recommended to update or refine the offshore EBSAs of the Scotian Shelf Bioregion. This approach should include a general evaluation of available data under each of the CBD EBSA criteria. The data layers used by Horsman *et al.* (2011) should be examined along with other potentially useful data layers/sources. The final list of data layers should be mapped and eventually incorporated into the next iteration of the network design analysis.

It is also recommend that the original SEO and LEK EBSAs (Doherty and Horsman 2007, Maclean *et al.* 2009) be re-evaluated against the CBD EBSA criteria using an approach similar to that applied in the Bay of Fundy (Buzeta 2013) and Atlantic Coast (Gromack and Allard 2013). The purpose of this step would be to ensure that known significant areas are not overlooked in the data-driven approach due to data gaps. For example, the unique

[3] K. Beazley, R. Long, and P. MacKay's unpublished report for the Greater Laurentian Wildlands Project, South Burlington, Vermont, USA (Nova Scotia Wild Lands and Wild Seas Mapping Workshop,1999), *A Report on a Conservation Planning Process for a Terrestrial And Marine Biodiversity Conservation Vision In Nova Scotia*. Available at [Internet]: http://myweb.dal.ca/willison/BeazleyETALfinal.pdf (last accessed September 3, 2013).

[4] M.C. King's unpublished Master's Thesis, Dalhousie University, Halifax, NS, Canada, *Biodiversity Considerations for Marine Protected Area Network Planning in the Scotia-Fundy Region of Atlantic Canada* (2004).

concentrations of Russian Hat sponges (*Vazella pourtelesi*) in Emerald Basin did not emerge from the Horsman *et al.* (2011) analysis because adequate regional scale sponge data were not available. The sponge concentration was first identified through an analysis of fisheries observer data and later validated through *in situ* research, which led to its inclusion in the original SEO exercise (see Doherty and Horsman 2007). Evaluating the SEO and LEK sites against the CBD EBSA criteria may identify specific areas that should be retained and included in the next iteration of network analysis.

3.2.2 Data and Mapping Methods to be Considered in Identifying Offshore EBSAs

Potential data and mapping approaches to be considered in identifying EBSAs in the offshore Scotian Shelf are described and evaluated in the following sub-sections, which are organized based on the CBD EBSA criteria. The CBD (2009b) technical guidance on how to address each criterion was considered in the development of this section. The Scotian Shelf is generally considered data-rich compared to most marine regions; however, significant spatial, seasonal/temporal and taxonomic data gaps still exist. For instance, most of the slope and abyssal areas have not been surveyed and invertebrates and cetaceans are poorly sampled compared to demersal fishes. Despite these and other gaps, network planning in the Scotian Shelf Bioregion will proceed with the best available scientific information.

The most useful data sources for identifying EBSAs are those that can be used to characterize the relative spatial distribution of a particular ecosystem feature (*e.g.*, species, communities) or characteristic (*e.g.*, species richness) throughout the bioregion. To develop an accurate characterization of the relative distribution of a feature, the source data should: have broad spatial coverage (ideally the entire bioregion), span a significant period of time (*e.g.*, less than five years of data may not be sufficient), and cover different seasons, especially for highly mobile species. The best example of a long-term regional scale biological survey in the Scotian Shelf Bioregion is the DFO Summer Research Vessel (RV) Survey, which has taken place every summer since 1970 and spans most of the offshore components of the Scotian Shelf and Bay of Fundy (Simon and Comeau 1994).

Region-wide survey data are not a pre-requisite for identifying EBSAs as surveys that cover smaller but still significant portions of the shelf may still be useful in identifying important areas. Research in smaller areas can also be used to confirm or identify important areas for certain species or taxa. This approach has been used to map known concentrations of certain cold-water coral species (*e.g.*, Cogswell *et al.* 2009) and key habitats for endangered whale species (*e.g.*, Whitehead 2013).

3.2.2.1 Unique Areas

Although there has been no systematic assessment of uniqueness and rarity in the Scotian Shelf Bioregion, areas that are believed to be regionally unique have been identified through oceans planning exercises and research programs. The SEO EBSA workshop highlighted unique areas on the shelf, including the Rock Garden, a bedrock outcrop that supports a unique benthic community in the Gulf of Maine (Doherty and Horsman 2007). Additional examples of unique features in the bioregion include: the Gully (largest submarine canyon on the east coast of North America), the Stone Fence *Lophelia pertusa* reef (only known example in the Northwest Atlantic) (Cogswell *et al.* 2009), and the Emerald Basin Russian Hat sponge communities (possibly globally unique concentrations). The recommended approach for identifying unique and rare habitats in the offshore is to re-evaluate, confirm and refine (if necessary) each of the EBSAs identified in the SEO (Doherty and Horsman 2007) and LEK (Maclean *et al.* 2009) exercises.

3.2.2.2 Important Habitats for Species

CBD EBSA criteria two and three both focus on the habitat needs of individual species or other taxa and therefore have similar data requirements. For this reason, both of these criteria will be considered in this section of the report. The full list of species to be considered in designing the MPA network has not been determined at this time. Species should eventually be selected from a finalized list of Ecologically Significant Species (ESS), Depleted Species (DS)[5] and important bird species (see Gromack and Allard 2013). It is important to note that not all ESS or DS will be explicitly considered in the network design process. The final suite of species to be considered will be selected based on practical (*e.g.*, data availability), conservation (*e.g.*, status of species) and biological or ecological considerations (*e.g.*, life history characteristics, role in ecosystem). Certain species may be less suitable for spatial conservation measures because they are broadly distributed in the bioregion or their distribution has not been defined. An example of a species that may not be suitable for consideration in the MPA network design is the highly-migratory blue whale (*Balaenoptera musculus*), which is listed as *endangered* under the *Species at Risk Act,* but discrete critical habitat areas have not been defined in the bioregion.

The general steps for selecting the suite of species to be considered and building their habitat needs into the MPA network design are: (1) finalize the list of ESS, DS and other priority species; (2) select a suite of species to be considered in the network design; (3) compile data and develop maps of important habitat for each species; and (4) incorporate species habitat layers into next iteration of the network design.

Important habitats should be mapped for each of the selected species using the best available data. Important habitats for these species are technically considered EBSAs under the CBD criteria but locations that are important for multiple species will generally be considered to have higher conservation value. The CBD (2009b) guidance indicates that mapping should focus on discrete areas that support critical life-history stages, such as breeding grounds, spawning areas, and nursery areas or important habitats for migratory species, including feeding and overwintering areas. Relative distribution maps can be derived from regional scale survey data; however, the degree to which the data capture the natural variation in a species' distribution and behavior must be taken into account (CBD 2009b). Important considerations or discussion points regarding the data and methods that could be used to map the distribution of different species groups are highlighted below.

PLANKTON

Phytoplankton was not considered as a distinct layer(s) in the Horsman *et al.* (2011) MPA network analysis in part because surface chlorophyll data were used (as a proxy for primary productivity) in the Scope for Growth classification (Kostylev and Hannah 2007). This classification system should therefore capture spatial variation in primary productivity in the bioregion. Persistent or recurring areas of high primary productivity can be mapped using remote-sensing satellite data (Platt *et al.* 1995) and therefore could be built into the network design as discussed below in the *Areas of high biological productivity* EBSA category (see Section 3.2.2.4). Phytoplankton will not be considered at the species level in the network design.

[5] A preliminary evaluation of Ecologically Significant Species (ESS) and Depleted Species (DS) was completed by Michael Sinclair and presented as *Working Paper 2012/29* at the March 2012 DFO Maritimes Science RAP. Although the proposed list of species was considered an important step toward a comprehensive list of ESS and DS, it was not formally endorsed by the meeting participants. Additional work is required to finalize these species lists for the Scotian Shelf Bioregion. As a result, all references to ESS and DS in this report should be considered potential ESS and DS.

Similarly, zooplankton species distributions will not be explicitly factored in to the design of the MPA network, although *Calanus spp.* and several species of *Euphausiids* are vital forage species in the bioregion and therefore considered ESS. Spatial data for copepods do exist through the Atlantic Zonal Monitoring Program and the basic distribution of Euphausiids is understood (DFO 1996) but spatial approaches to management are not required or suitable for zooplankton (Erica Head, DFO, pers. comm.). Furthermore, areas of high zooplankton densities will be captured in the network through the protection of important habitats for other species and through habitat representation (*e.g.*, basins). For example, protecting critical habitats for the North Atlantic right whale (*Eubalaena glacialis*) will capture concentrations of *Calanus finmarchicus*.

BENTHIC INVERTEBRATES

American lobster (*Homarus americanus*) and snow crab (*Chionoecetes opilio)* are potential ESS in the offshore Scotian Shelf due to their roles as influential predators. As a whole, less is known about the distribution and role of benthic invertebrates in the Scotian Shelf ecosystem so further consideration should be given to which species within this group should be explicitly considered in designing the MPA network. Common and abundant species caught in bioregional-scale surveys could be considered influential species (*e.g.*, Horsman and Shackell 2009).

There is no dedicated bioregion-wide survey that targets benthic invertebrates; however, the Eastern Nova Scotia (ENS) Snow Crab Survey (DFO 2010b) and the DFO Summer RV Survey have been used to characterize the relative distribution of certain species (Tremblay 2007). Horsman *et al.* (2011) used data from the ENS Snow Crab survey to map the relative distribution of 12 common macro-invertebrate species. Areas of high relative abundance were considered important habitats. The biggest limitation of this dataset is the spatial coverage, which is mostly limited to the eastern Scotian Shelf.

Tremblay (2007) used the DFO Summer RV Survey to map the relative distribution of 16 common macro-invertebrate species (mostly decapod crustaceans). The most appealing characteristic of this survey is its broad spatial coverage but it is limited to the summer season and invertebrate information has only been regularly recorded since 1999. There have also been challenges with consistent species identification but the situation is improving (John Tremblay, DFO, Dartmouth, NS, pers. comm.).

Analysis of stomach contents of common groundfish species (*e.g.*, Atlantic cod) caught in the summer RV surveys (Cook and Bundy 2012) could potentially be used to map the distribution of certain smaller invertebrate species or juveniles of larger species.

Structure forming cold-water corals and aggregating sponges may also be ESS but these species will be addressed under the *Vulnerable Species, Habitats and Features* EBSA category (see Section 3.2.2.3).

FISHES

Demersal fishes (groundfish) are the best-studied species group in the bioregion, largely due to a series of dedicated DFO surveys intended to monitor their abundance and distribution. The longest running of these is the annual Summer RV Survey, which began in 1970 to collect distribution and abundance information primarily for the purposes of stock assessment (see Doubleday and Rivard (1981) for description of this survey). For most demersal species (but not, for example, cusk), the DFO Summer RV Survey is a robust estimator of relative biomass, length, age and distribution. Data from this survey have been used to characterize the relative summer distribution of groundfish in the region (see below). There are (or have been) other trawl and fixed gear groundfish surveys over the last several decades that could potentially be used to map the relative distribution of species for certain time periods.

Many large-bodied demersal fishes may qualify as ESS due to the role they play as important predators in the Scotian Shelf Bioregion (Bundy 2004, Bundy 2005, Horsman and Shackell 2009, Frank *et al.* 2011). Several demersal fish species are also considered to be *at-risk* under the *Species at Risk Act* or by COSEWIC and, as a result, qualify as DS (*e.g.*, Atlantic wolffish, *Anarhichas lupus*) (COSEWIC 2000). Several species are potential ESS and DS (*e.g.*, Atlantic cod, *Gadus morhua*). A list of ESS and DS should be developed for the bioregion and a subset of this list should be selected for consideration in the MPA network design based on ecological and practical considerations. Important habitats will be mapped for the selected species.

Horsman and Shackell (2009) used the Summer RV Survey data to identify important (or preferred) summer habitat for an initial list of ESS and other common fish species. The layers produced in that study were used in the Horsman *et al.* (2011) MPA network analysis. The focus was placed on capturing areas of persistently high abundance to account for the important role adult fish play in maintaining healthy populations. Preferred summer habitats for these species represent their distribution during the 'growing season' when feeding and growth is maximal. The energy allocated to (and success of) the reproduction of organisms during colder seasons depends on the amount of resources that they have acquired during the growing season (Huston and Wolverton 2011).Important feeding areas are listed by the CBD (2009b) as an example of the type of habitat that should be protected.

Spawning and nursery areas can also be protected within networks of MPAs. In identifying areas that support these critical life-history stages, the CBD (2009b) indicates that the significance of an area increases as reliability (persistence over time) and exclusivity (compared to other areas) of use increases. Thus, areas that are consistently used or sites that represent the only spawning or nursery area for a species or population are the most significant. Species that consistently spawn or aggregate as juveniles in discrete areas are well-suited for inclusion in MPA network design. Maturity data from the DFO RV surveys could be used to map the distribution of spawning fishes (Ollerhead 2007) and length data can be used to map juveniles (Crawford *et al.* 2006).

Another approach to consider for identifying important life history stages for demersal fishes is to map eggs and larvae data from ichthyoplankton surveys, such as the Scotian Shelf Ichthyoplankton (SSIP) Survey, which included stations throughout the bioregion but only ran from 1978 to 1982 (O'Boyle *et al.* 1984). The SSIP data have been used to map seasonal patterns in larval diversity and abundance for important fishes as well as to classify larval assemblages as cold/shallow, warm/deep, etc. (Shackell and Frank 2000, Horsman and Shackell 2009). The NWG should investigate these and other approaches for mapping spawning and nursery areas.

Cook and Bundy (2012) analyzed the stomach contents of common groundfish species caught in the RV survey to characterize species richness patterns of small fishes and invertebrates. These data can also be used to help map the distribution of small fishes, such as sand lance, an important forage species (Horsman and Shackell 2009).

CETACEANS

The distribution and abundance of cetaceans across the Scotian Shelf have not been described in detail for most species that occur in Atlantic Canadian waters. As a result, few studies provide a comprehensive overview of cetacean distribution and abundance in the region. However, there is some data available to help assess areas of importance for cetaceans on the Scotian Shelf. These include sightings data, survey data, acoustics data and information on prey availability and habitat preferences.

Cetacean sightings data include information on the date, time, location and species sighted. Large datasets are available such as the DFO Maritimes Region Cetacean Sightings Database and the North Atlantic Right Whale Consortium database (Kenney 2011).These databases include sightings dating back to the 1960s collected from various sources (such as researchers, marine mammal observers, fisheries observers, tourism operators and others) using a variety of methods (from directed survey efforts to opportunistic sightings). Plots of these data highlight what appear to be some areas of importance, but there are large spatial and temporal gaps in regional coverage. For example, most of the sightings have been collected from the Gulf of Maine and western Scotian Shelf while less effort has occurred in the eastern portion of the Scotian Shelf. As well, most sightings have been obtained from spring to early fall while relatively little effort has taken place over winter months. Effort parameters (*e.g.*, track line coverage and observation effort) have not been collected for many of the sightings or cannot be easily incorporated with the sightings data. Thus, over a variety of spatial scales, it is not known if areas which show no or few cetacean sightings are actually areas which are not used in general by cetaceans or by a specific species, or if these are areas for which there is low or no directed effort to collect sightings. Conversely, areas with many sightings may be either areas of relatively high importance or a result of concentrated effort.

It is important to note that available sightings data have been used to identify particularly important areas for some species on the Scotian Shelf, specifically North Atlantic right whales (Roseway Basin) and northern bottlenose whales (the Gully, Shortland and Haldimand canyons). Critical habitat under the *Species at Risk Act* has been designated for both of these endangered species using this approach (called the ‘area of occupancy’ approach). Critical habitat designated for endangered species may deserve special consideration for network planning.

There are some survey data available which accounts for effort to estimate density of cetaceans on the Scotian Shelf. For example, the Atlantic-wide Trans North Atlantic Sightings Survey (TNASS) was an aerial survey conducted in 2007 which covered the Scotian Shelf region (Lawson and Gosselin 2009). This data provides wide spatial coverage but does not address seasonal or annual variability, and the results are not intended to identify specific areas of the Scotian Shelf which may be important to cetaceans

There are some acoustic data available to help assess cetacean presence in specific areas. For example, the Whitehead Lab (Dalhousie University) and DFO have been conducting long-term acoustic monitoring studies of the Gully MPA and adjacent areas of the shelf edge since 2006. Though the presence of some species on these recordings has been assessed, the data has yet to be fully analyzed. A similar acoustic monitoring effort, directed at right whales in the mid-2000s, was conducted in the basins of the western Scotian Shelf (Mellinger *et. al*. 2007). While these data sets provide temporal coverage of a particular area, spatial coverage of the Scotian Shelf is limited and therefore not useful for a region-wide analysis.

Sutcliffe and Brodie (1977) published the results of whaling records for the region to suggest areas of concentrations or importance. Areas of importance to cetaceans can also be assessed indirectly through reviewing prey distribution or habitat modeling. As distribution of cetaceans often correlates to distribution of their prey (Gaskin 1982, Bowen and Siniff 1999, Stevick *et. al.* 2002), assuming that areas of high prey abundance are of increased importance to cetaceans is not an unrealistic proposition. However, this requires assessment of prey distribution and density across the Scotian Shelf, and data on some important cetacean prey in this area is sparse (*e.g.,* squid distribution and abundance on the Scotian Shelf). Habitat modeling is an approach that has been used to predict areas of importance to cetaceans. Breeze *et al.* (2002) adopt this approach using expert opinion to predict areas of importance on the Scotian Shelf, describing habitat preferences of various cetacean species. This approach requires an understanding of what environmental variables affect the distribution and abundance of various cetacean species, but given the limitations of other data available may offer the most practical approach for determining areas of importance to cetaceans.

Recognizing the limitations of available cetacean sightings data, Horsman *et al.* (2011) used the formally defined Critical Habitat under the *Species at Risk Act* for the North Atlantic right whale and the northern bottlenose whale (*Hyperoodon ampullatus*) as the only cetacean data layer in their initial MPA network analysis. A similar approach is recommended for the next iteration of the analysis unless more reliable spatial data become available or habitat models are developed.

BIRDS

Appendix B in Gromack and Allard (2013) lists seabird species that have been identified as priorities for Environment Canada (EC), Canadian Wildlife Service (CWS). Two sources of data can be used to begin to characterize the offshore distribution of these species. The first is the *Programme Intégré des Recherches sur les Oiseaux Pélagiques* (PIROP) database, which was created by EC CWS. PIROP data were gathered through ship-based linear transects of unlimited width and represent the total number of birds encountered per kilometre travelled. Unfortunately, due to lack of distance information for individual bird observations, data cannot be used to calculate aereal bird densities easily, although efforts have been made and methods proposed to do so (Diamond *et al.* 1986, Gaston *et al.* 1987). Incidental records of species other than marine birds (including cetaceans) appear in this database.

The *Eastern Canada Seabirds at Sea* (ECSAS) program (also operated by EC CWS) is more recent than PIROP and, as a result, coverage is sparser. However, all surveys follow an updated protocol, using fixed-width 300 m transects, producing raw measures of bird density (*i.e.*, number of birds per square kilometre). As distance information is gathered for each individual observation, raw densities calculated by species can be corrected to account for detection probabilities that decrease as distance from the observer increases. This strategy produces far more accurate overall measures of density. As detections outside transects continue to be recorded by observers, data can be compared and merged with PIROP data. Incidental records of species other than marine birds appear in this database.

The CWS (led by Karel Allard, Sackville, NB) has used the data described above to begin to characterize offshore seabird distributions in the Canadian Atlantic (presentation to provide more detail).

3.2.2.3 Vulnerable Species, Habitats and Features

The protection of certain species of cold-water corals (herein referred to as corals) and aggregating sponges is an important priority for Canada and internationally. Certain species of corals and sponges form complex structures on the seafloor that serve has habitat for smaller organisms and many of these species are long-lived and sensitive to disturbance (DFO 2010c). Corals and sponges are also sessile so spatial approaches to management can offer effective protection. In the Scotian Shelf Bioregion, two fisheries closures have been established to protect corals and one of the main reasons for creating the Gully MPA was to conserve the high diversity of coral in that area. DFO recently formalized its Sensitive Benthic Areas Policy, which aims to protect corals and sponges from potential impacts from fishing (DFO 2009).

Structure providing corals and aggregating sponges represent potential ESS in the bioregion. Available spatial cold-water coral and sponge data from DFO RV surveys, the Fisheries Observer Program (FOP), LEK studies and a growing list of Remotely Operated Vehicle (ROV) surveys have been compiled into a Maritimes Region Coral Database (Cogswell *et al.* 2009). These data were used to create general distribution maps for each of the five coral orders that occur in the region (Alcyonacea, Antipatharia, Gorgonacea, Pennatulacea, and Scleractinia) (Cogswell *et al.* 2009). These data cannot be used to develop accurate relative distribution maps due to sampling biases. The majority of records in the database are from areas that have been studied with ROVs. However, Kenchington *et al.* (2010) have since completed a Kernel

Density Analysis using data from the DFO Summer RV Survey to identify high concentrations of certain corals and sponges.

Research on coral distribution has also occurred through the Discovery Corridor initiative, which has focused on the Bay of Fundy, the Gulf of Maine and the western Scotian Shelf and slope. This work has been led by Anna Metaxas (Dalhousie University, Halifax, NS) and Peter Lawton (DFO, Biological Station, Saint Andrews, NB) and has helped describe an area in Jordan Basin known as the Rock Garden, which is a unique bedrock outcrop that supports a significant sponge and coral community.

In the initial network analysis, Horsman *et al.* (2011) aimed to capture areas of high species coral diversity and areas of high hard coral density, which they mapped using data from the Maritimes Region Coral Database. At a minimum, these data layers should be updated with new information for the next network design analysis. The NWG will consult with regional coral and sponge experts to examine alternative approaches to mapping these species. An ideal situation would be to have one relative distribution map for each of the species considered vulnerable/sensitive. This map could be used in the network design process and in implementing other relevant DFO policies.

3.2.2.4 Areas of High Biological Productivity

Parts of the ocean that display persistent or recurring high primary or secondary productivity offer core ecosystem services that support productivity at higher trophic levels (CBD 2009b). For example, areas of high primary productivity serve as important feeding areas for zooplankton and larval fishes, which attract larger predators, such as baleen whales. On the Scotian Shelf, the survival of larval fish can depend on the timing and magnitude of the spring phytoplankton bloom (Platt *et al.* 2003). Spatial patterns in relative primary productivity can be estimated based on satellite ocean colour and sea surface temperature data (Platt and Sathyendranath 1988, Platt *et al.* 1995, DFO 2012b). Satellite derived primary productivity estimates for the Scotian Shelf can be analyzed over a multi-year time series to identify persistent areas of high primary productivity in the bioregion. A similar approach was applied by Crawford *et al.* (2006) to identify areas of persistent high chlorophyll concentrations using SeaWiFS ocean colour data (see NASA 2012). Horsman *et al.* (2011) did not include areas of high primary productivity in the initial MPA network analysis because primary productivity data were incorporated in the Scope for Growth classification. This subject requires further consideration as areas of high primary productivity are pelagic features that could potentially be used as proxies for feeding areas for larger pelagic species for which little data exist. The Scope for Growth model is a benthic classification so two data layers would not be redundant. It is recommended that methods for identifying areas of high primary productivity for consideration in MPA network design should be explored by the NWG with the appropriate experts in this field.

3.2.2.5 Areas of High Biological Diversity

Areas of high biodiversity (or biodiversity ‘hotspots’) are often a key component of regional-scale nature conservation strategies because they allow for the protection of many species in a relatively small area (Norse 1993, Roberts *et al.* 2002). Regional scale biological surveys can be analyzed to describe spatial patterns in biodiversity and identify areas of high species richness. Significant research of this kind has occurred in the Scotian Shelf Bioregion over the last several decades. Much of the focus has been on understanding patterns in fish species richness. For instance, Strong and Hanke (1995) mapped the average number of species caught per tow in the DFO Summer RV Survey for each sampling strata in five-year increments between 1970 and 1993. Using the same data source, Shackell and Frank (2003) used a species richness index to measure the cumulative number of species sampled from different parts of the Scotian Shelf. The same authors also described patterns in larval fish diversity (Shackell and Frank 2000). In their initial network design analysis, Horsman *et al.* (2011) incorporated three layers of species richness derived from separate analyses of the summer RV survey, the ENS snow crab survey, and redfish/slope survey. Most recently, Cook and Bundy (2012) examined invertebrate and small fish species richness patterns based on an analysis of stomachs from common groundfish caught in the RV surveys. When detailed biological data are lacking (which is not the case in this bioregion), topographic complexity can be used as a surrogate for high biodiversity (Ardron 2002). Horsman *et al.* (2011) included a topographic roughness layer created from bathymetric data in the initial network design to capture areas of high naturalness.

For the next iteration of the network design, the data layers used by Horsman *et al.* (2011) should be updated and the Cook and Bundy (2012) stomachs analysis and Shackell and Frank (2000) larval fish analysis should be considered for inclusion.

3.2.2.6 Highly Intact Areas (High Naturalness)

The naturalness criterion aims to capture areas with minimal human-induced disturbance or degradation (CBD 2009b). In MPA network design, naturalness can be considered in two ways. First, highly intact areas (areas of high naturalness) can be identified and explicitly targeted in the network design. Horsman *et al.* (2011) employed this approach by mapping area of high topographic roughness to serve as indicators of areas of high naturalness. The second way this criterion can be incorporated in network design is to use relative naturalness to weight EBSAs and other conservation features. This approach is consistent with how DFO considers naturalness in identifying EBSAs, where: “Naturalness and resilience are not intended to be used as the sole basis for the identification of EBSAs, but rather serve as a key consideration in prioritizing EBSAs” (DFO 2011, p.2). Both approaches to incorporating naturalness warrant consideration. Both approaches also require an evaluation and spatial characterization of naturalness. The cumulative effects of human activities throughout the bioregion could be analyzed and mapped to identify areas of relatively low human-induced disturbance. The OCMD is in the process of updating its human use atlas to allow for this type of regional-scale analysis. One challenge to this approach is the lack of historical data on human use of the bioregion. For instance, fishing has taken place for hundreds of years but georeferenced commercial fishing data has only been systematically collected for about two decades.

4.0 SUMMARY OF RECOMMENDATIONS

Table 2 provides a summary of the recommendations of this research document, which are organized under the two overarching objectives for the network (representation and EBSAs) (DFO 2012a). The recommendations focus on what data layers or sources will be considered in the MPA network design process and what approaches could be used to analyze and map available data. Outstanding issues or data sources that require further consideration are also highlighted.

Table 2. Summary of ecological data layers and sources recommended for consideration in designing a network of MPAs for the Offshore Planning Area of the Scotian Shelf Bioregion.

Recommendation	Rationale/Comments
Objective: Protect examples of all marine ecosystem and habitat types (Representation)	
1. Use Scope for Growth and Natural Disturbance classifications (Kostylev and Hannah 2007) as a basis for ecosystem, habitat and community representation.	Integrates the factors that determine species distribution. Spans the entire bioregion and has been validated through two RAP processes.
2. Use Fader's (unpublished report) Seabed Feature classification as a proxy for coarse-scale habitat representation.	Recognizable enduring features that support different biological communities. Spans the entire bioregion.
3. Consider future application of the gradient forest method (Ellis *et al.* 2012).	Promising method based on physical and biological data.
Objective: Protect EBSAs and other special natural features	
Unique areas	
4. Re-evaluate each of the unique areas identified in the SEO (Doherty and Horsman 2007) and LEK (Maclean *et al.* 2009) EBSAs exercises.	There may be unique areas that are missed by a strictly data-driven approach due to data gaps. *E.g.*, Emerald Basin sponge communities did not emerge from Horsman *et al.* (2011) analysis.
Important habitats for species	
6. DFO should finalize the list of ESS and DS for the Bioregion (possibly through a separate RAP).	One list of ESS and DS that is endorsed by Science would support several DFO policies and programs (*e.g.*, MPA planning, Ecosystem Approach to Management, Sensitive Benthic Areas Policy, Bycatch Policy).
7. Determine the suite of species that will be explicitly considered in the MPA network design process. Species will be selected from the broader lists of ESS, DS and other potential priority species (*e.g.*, CWS priority bird species).	Not all ESS, DS or CWS priority bird species will be considered in the network design. Selection of species should be based on practical (*e.g.*, data availability) and ecological considerations. Only species that would benefit from spatial conservation measures will be considered.
8. Further consideration should be given to potential macro-invertebrate species that are considered in the MPA network design. As with Horsman *et al.* (2011), important habitats for dominant species caught in snow crab survey could be included in the network design. Common species caught in RV surveys should also be considered (Tremblay 2007).	Macro-invertebrates are more prominent in the ecosystem since the groundfish collapse and more data are becoming available for this species group.
9. Important habitats (such as feeding, nursery and spawning areas) for demersal fishes should be factored into the network design as per Horsman *et al.* (2011). The Horsman and Shackell (2009) approach should be used to map summer feeding areas. Data from the summer RV and other surveys should be	Many demersal fishes are considered potential ESS due to the important roles they play in the bioregional ecosystem. Some of the same species are also DS. Sufficient data exist to identify important habitats for many of these species. Feeding, nursery and spawning areas are important for critical life history processes and therefore the long-term survival of

Recommendation	Rationale/Comments
considered for mapping nursery and spawning areas. The stomachs data compiled by Cook and Bundy (2012) could be used to map the distribution of juvenile fishes.	these species. Healthy populations of these species will help maintain the overall structure and function of the ecosystem.
10. Cook and Bundy (2012) fish stomach contents data should be considered as approach to mapping the distribution of important forage species (*e.g.*, sand lance).	Stomach contents analysis will provide a more complete picture of the distributions and habitat preferences of small fishes (Cook and Bundy 2012).
11. Critical Habitat under the *Species at Risk Act* for the North Atlantic right whale and the northern bottlenose whale should be used as the only cetaceans layers in the network design as per Horsman *et al.* (2011).	Available data will not support a regional-scale analytical approach to identifying important habitats for a broader list of cetaceans. Critical habitats for these species are also important to other cetacean species.
12. Investigate ways to improve the utility of existing cetacean data (*e.g.*, correcting for biases in survey effort).	Significant data exist from a variety of sources but they cannot be used to identify areas of high relative importance to cetaceans because of biases in survey effort.
13. Habitat modeling approaches based on environmental variables and prey distribution could be used to predict cetacean habitat.	Models could help identify potential important habitats that have not been documented.
14. Important habitats for seabirds could be mapped and considered in the network design.	Seabirds represent an important component in pelagic ecosystems. Data are somewhat limited due to spatial biases in survey effort.
Vulnerable species, habitats and features	
15. Use the Maritimes Region Coral Database to update Horsman *et al.* (2011) coral diversity and hard coral density layers.	This approach captured known concentrations of corals.
16. Consult with experts to agree on list of structure providing coral species and aggregating sponge species to be considered in the network design and possibly other relevant DFO policies.	Considerable discussions on this subject have taken place at the international level (regarding species that can be used as indicators of Vulnerable Marine Ecosystems). A list may already exist for Maritimes Region.
17. Work with experts to create a Russian Hat sponge layer based on available data. Explore habitat modeling approaches or options for revising the kernel density analysis.	Potential globally unique concentrations of this species occur in the bioregion. Kenchington *et al.* (2010) kernel density analysis did not highlight known concentrations due to limited spatial data coverage.
Areas of high biodiversity	
18. Update species richness data layers used by Horsman *et al.* (2011) (summer RV, snow crab and redfish/slope surveys) and include in network design.	More recent data are available for the summer RV and ENS snow crab surveys.
19. Explore the use of the Cook and Bundy (2012) species richness analysis based on stomachs data.	Including these layer(s) would capture areas of high species richness for small fishes and invertebrates, two species categories for which little data exist.
20. Consider including the results of the Shackell and Frank (2000) larval fish diversity analysis.	Analysis was based on data from 1978-1982.
Areas of high biological productivity	
21. Explore methods for identifying areas of persistent or recurring high primary productivity using remote-sensing satellite data.	Areas of high primary productivity provide core ecosystem services and typically represent important feeding areas for a variety of species.
Areas of high naturalness (highly intact areas)	
22. Consider using the Horsman *et al.* (2011) topographic roughness layer as a surrogate for areas of high naturalness and incorporate in the	Areas of high topographic roughness may capture areas of high naturalness and areas of high biodiversity (Ardron 2002).

Recommendation	Rationale/Comments
network design.	
23. A cumulative impacts analysis (or a regional-scale risk analysis) could be completed for the bioregion to attempt to characterize the degree of human-induced disturbance in different areas. The results would highlight areas of high relative naturalness, which could be targeted in the network or the information could be used to prioritize among areas of high conservation value.	Data intensive exercise. Human use layers are being compiled by the OCMD. Results would be useful in a variety of other management applications.

5.0 ACKNOWLEDGEMENTS

The authors thank the Tim Hall, Glen Herbert, and Maxine Westhead of the Oceans and Coastal Management Division [DFO Maritimes Region] for their continued leadership and support for marine protected area network planning in the Scotian Shelf Bioregion. The authors would also like to acknowledge the guidance provided by Adam Cook, Charles Hannah, Erica Head, and John Tremblay in the development of this report. Finally, we would like to thank Jana Aker and Sarah Deller for formatting and Peter Lawton for reviewing the document.

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