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Design Strategies for the Scotian Shelf Bioregional Marine Protected Area Network

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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.

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ABSTRACT

Canada has made domestic and international commitments to establish a national network of marine protected areas (MPAs), including a commitment to protect 10% of coastal and marine areas by 2020. Fisheries and Oceans Canada (DFO) is leading the development of the national MPA network on behalf of the Government of Canada. Network development is guided by the 2011 National Framework for Canada's Network of MPAs, which states that MPA network planning and design will take place at the bioregional scale and will involve other federal, provincial, and territorial government departments, First Nations and Indigenous groups, stakeholders, and other interested parties. Over the last decade, DFO Maritimes Region has taken significant strides toward developing an MPA network plan for the Scotian Shelf Bioregion, including engaging interested parties and technical steps, such as compiling relevant ecological and human use data, setting MPA network objectives, selecting conservation priorities, and developing a preliminary MPA network design. Technical work to date has followed international guidance provided through the Convention on Biological Diversity and national direction. A hierarchy of objectives, which includes high-level national goals, regional strategic objectives, conservation priorities, operational objectives, and design strategies, has been developed to guide regional-scale MPA planning.

This document presents the coastal and offshore design strategies developed for the Scotian Shelf bioregional MPA network. Design strategies are detailed statements for each conservation priority and associated operational objective that specify the *area or feature to be conserved* and *how much of that area or feature* (i.e., the target) should be captured in the bioregional MPA network. Due to significant differences in the types of ecological data that are available in the coastal and offshore components of the bioregion, different methods were used to develop coastal and offshore design strategies. Coastal and offshore conservation priorities were organized into the two categories: coarse-filter features and fine-filter features. Coarse-filter conservation priorities are larger features (e.g., geomorphological features such as offshore banks) that generally have lower targets (e.g., 10–20%) while fine-filter conservation priorities are smaller features (e.g., significant concentrations of large gorgonian corals) that warrant higher targets (e.g., 80–100%). The design strategies presented in this paper will be used to develop a draft MPA network design for the Scotian Shelf Bioregion.

1.0 INTRODUCTION

Canada has made domestic and international commitments to establish a national network of marine protected areas (MPAs), including a renewed commitment by the Government to protect 5% of coastal and marine areas by 2017 and at least 10% by 2020[1]. Fisheries and Oceans Canada (DFO) is leading the development of the national MPA network on behalf of the Government of Canada. Network development is guided by the 2011 *National Framework for Canada's Network of MPAs* (Government of Canada 2011), which states that MPA network planning and design will take place at the regional scale and will involve other federal, provincial, and territorial government departments, First Nations and Indigenous groups, stakeholders, and other interested parties.

Indigenous coastal communities have a longstanding traditional and spiritual connection to the marine environment and marine resources. Indigenous Peoples in Canada have constitutionally protected Aboriginal and treaty rights that must be respected. The federal government is committed to ongoing consultation and engagement with Indigenous Peoples in planning, establishing, and managing marine protected areas.

Over the last decade, DFO Maritimes Region has taken some significant steps toward developing a regional MPA network plan. Available ecological and human use data have been compiled, the key players have been engaged, MPA network objectives and conservation priorities have been determined, and a preliminary MPA network analysis was completed (Horsman *et al.* 2011). Building on these efforts, DFO reinvigorated the process in 2015 to design and implement an MPA network in the Scotian Shelf Bioregion, which roughly coincides with the DFO Maritimes Region administrative boundary. The network design process follows the general approach and principles of systematic conservation planning (Margules and Pressey 2000). A draft MPA network design for the Scotian Shelf Bioregion will be released for consultation once completed.

DFO Science has provided national guidance on the design of MPA networks (DFO 2010a), including considerations for how to achieve representativity (DFO 2013). Additional science advice has been provided on MPA network objectives, data, and methods specific to the DFO Maritimes Region (DFO 2012, DFO 2014a). DFO Oceans has also crafted national guidance for regional MPA network development. This includes an *objectives hierarchy* to promote consistency in approach and terminology among regional MPA network development processes (Table 1).

Table 1. Objectives hierarchy for regional MPA network development in Canada.

Level in Hierarchy	Description
1. National goals	High-level statements that outline what the National MPA Network aims to achieve. Contained in the National Framework.
2. Strategic objectives	Relatively high-level statements that outline what a regional MPA network aims to achieve.
3. Conservation priorities	Specific species, habitats or other ecological features a regional MPA network aims to protect.

[1] Reaching Canada's marine conservation targets

Level in Hierarchy	Description
4. Operational objectives	Specific and measurable statements that indicate the desired state for each conservation priority for a regional MPA network.
5. Design strategies	Detailed statements that, for each operational objective, specify: (1) the types of areas or features to be conserved (e.g., significant concentrations, feeding aggregations, nursery areas, spawning areas); and (2) the relative targets for those area types (e.g., high, medium, low).

The national direction on MPA network planning and design is consistent with international best practices and guidance provided through Decision IX/20 of the Convention on Biological Diversity (CBD) (UNEP 2008). The CBD lists five criteria for effective networks of MPAs: *ecologically and biologically significant areas*, *representativity*, *connectivity*, *replicated ecological features,* and *adequate and viable sites*. The initial MPA network design process for the Scotian Shelf Bioregion has focused on addressing the ecologically and biologically significant areas and representativity criteria. Connectivity, replicated ecological features and adequate and viable sites will be addressed in the future to ensure the network provides comprehensive and effective protection. As noted below, the MPA network design process in this bioregion will be iterative. Thus, as new information or techniques related to connectivity or adequacy becomes available it will be incorporated into the design.

The strategic objectives, conservation priorities, and operational objectives for the Scotian Shelf bioregional MPA network are provided as context only and are not under review within this science advisory process. The data layers used to represent the various conservation priorities are not included in this report since they have been documented and reviewed through previous science advisory processes (DFO 2012, DFO 2014a, King *et al.* 2013, King *et al.* 2016).

The primary focus of this document is the formulation of design strategies for the conservation priorities and operational objectives of the Scotian Shelf bioregional MPA network. Design strategies are developed for each conservation priority and specify (1) the type of area or specific feature to be conserved; and (2) the relative target, which specifies how much of the area or feature to be conserved should be captured in the MPA network.

The purpose of this document is to:

- Present methods for developing coastal and offshore design strategies and associated targets for the conservation priorities and operational objectives of the Scotian Shelf bioregional MPA network; and
- Develop a preliminary set of design strategies and associated targets for the coastal and offshore conservation priorities of the Scotian Shelf bioregional MPA network.

At the outset of this exercise, it must be emphasized that a lack of information and empirical research specific to each of the various conservation priorities prevents the development of purely science-based, objective design strategies and targets. This is a common reality of most jurisdictions that have developed MPA networks. As a result, the approach described in this paper should be viewed as a practical, logic-based method for setting MPA network design strategies and associated targets. For this reason, general target ranges will be proposed for each conservation priority rather than precise targets.

1.1 CONTEXT: THE BROADER MPA NETWORK DEVELOPMENT PROCESS

The development of design strategies is just one step in an iterative MPA network design process (see Figure 1). Available ecological, economic, social, and cultural information has been compiled and will be used in the design process. Input from the provinces, First Nations and other Indigenous groups, and stakeholders will also help to shape the development of a draft MPA network design for the Scotian Shelf Bioregion. The integration of both scientific and traditional knowledge, which includes Indigenous and local sources of information, is essential for the design, development, and management of an effective MPA network. New information will continue to be sought during consultation on the draft MPA network design and during individual site design and implementation.

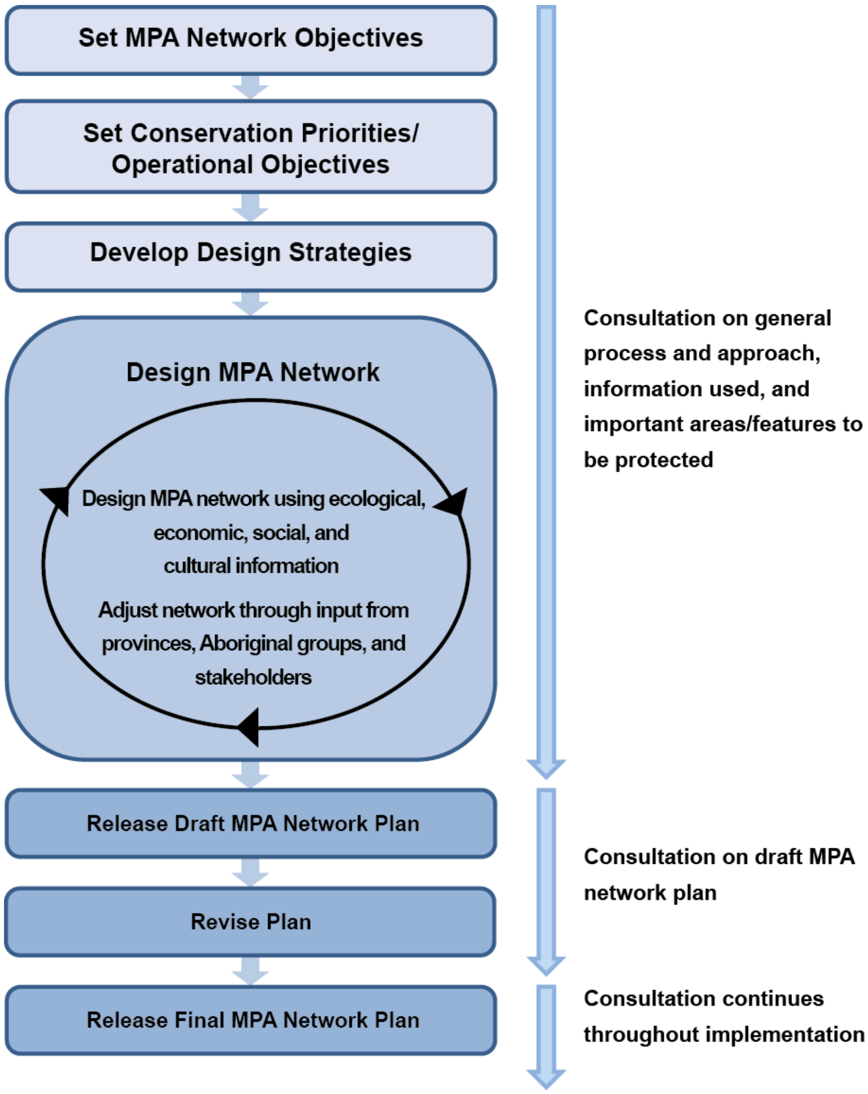

Figure 1. General process steps for the development of an MPA network plan for the Scotian Shelf Bioregion.

Feedback and input from the provinces, First Nations and other Indigenous groups, stakeholders, and the general public has been collected to date from a combination of targeted bilateral meetings, working group meetings, participation in conferences, multi-stakeholder meetings, and other fora, including public open houses. A brief feedback form was also developed and put on the DFO website to collect feedback on identified coastal Ecologically and Biologically Significant Areas (EBSAs). First Nations in Nova Scotia continue to be consulted using the *Mi'kmaq – Nova Scotia – Canada Terms of Reference (ToR) for a Consultation Process* and First Nations in New Brunswick have been consulted using the *Mi'gmag,* *Wolastoqiyik, New Brunswick and Canada Interim Consultation Protocol*. Those First Nations and Indigenous organizations in the region that are not part of these protocols are also being consulted.

The development of the MPA network plan for the Scotian Shelf Bioregion will facilitate DFO Maritimes Region's contribution to the 2020 national target (see Section 1.0), as it will help to ensure that contributing sites are a part of a broader, scientifically informed MPA network design. However, the ultimate end goal of the network planning process is to have an effective network of MPAs in place that provides meaningful, long-term protection of biodiversity, ecosystem functions, and special natural features. The final percentage of the Scotian Shelf Bioregion to be captured in the comprehensive MPA network will be determined through the network planning process, with plan implementation extending beyond 2020.

1.2 PLANNING AREA

The DFO Maritimes Region boundary represents the MPA network planning area for the Scotian Shelf Bioregion. The planning area includes the waters of Scotian Shelf and Slope, the Bay of Fundy, the Canadian portion of Georges Bank and the Gulf of Maine, and the deep-water area out to the extent of the Canadian Exclusive Economic Zone (Figure 2). Due to differences in available data, the planning area has been divided into coastal and offshore components. The coastal component includes the Atlantic coast of Nova Scotia (roughly defined as the area inshore of the 100 m isobath) and the Bay of Fundy, while the offshore component encompasses the remaining waters. For the offshore area, systematic, long-term surveys such as the DFO Research Vessel Survey provide region-wide datasets that permit a data-driven approach to MPA network design using the conservation planning decision support software, *Marxan*. In contrast, information available for the coastal component is patchy and more descriptive in nature. Thus, the process to identify coastal contributions to the network will largely focus on EBSAs that have been identified along the Atlantic Coast of Nova Scotia (Hastings *et al.* 2014) and in the Bay of Fundy (Buzeta 2014).

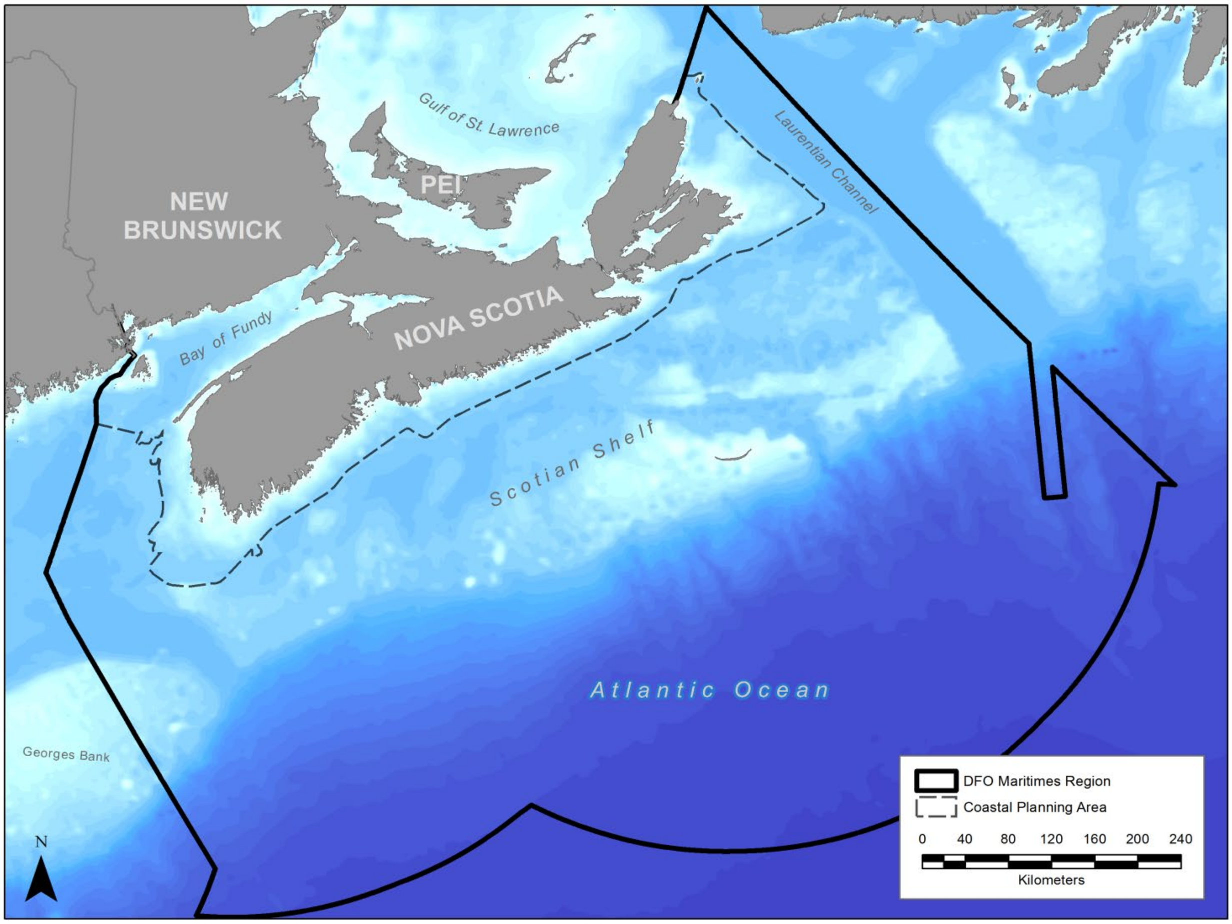

Figure 2. The DFO Maritimes Region boundary represents the Scotian Shelf Bioregion MPA network planning area, and has been divided into coastal and offshore components.

2.0 STRATEGIC OBJECTIVES, CONSERVATION PRIORITIES AND OPERATIONAL OBJECTIVES FOR THE SCOTIAN SHELF BIOREGIONAL MPA NETWORK

Strategic objectives, conservation priorities, and operational objectives have been developed for the Scotian Shelf bioregional MPA network with input from the MPA Network Technical Working Group, which is made up of scientists and conservation practitioners from DFO, Canadian Wildlife Service, and Parks Canada Agency. Feedback from other government departments, First Nations and other Indigenous groups, stakeholders, and academics also helped shape the objectives and priorities presented in this section.

2.1 STRATEGIC OBJECTIVES

The strategic objectives for the Scotian Shelf bioregional MPA network are:

1. Protect unique, rare, or sensitive ecological features in the bioregion
2. Protect representative examples of identified ecosystem and habitat types in the bioregion
3. Help maintain ecosystem structure, functioning, and resilience within the bioregion
4. Contribute to the recovery and conservation of depleted species

5. Help maintain healthy populations of species of Indigenous, commercial, and/or recreational importance

2.2 CONSERVATION PRIORITIES

Identifying conservation priorities is an important step in systematic conservation planning because it specifies what a protected area network will aim to protect (Margules and Pressey 2000, Rondinni and Chiozza 2010). Conservation priorities can be individual populations or species, groups of species, habitats, communities, ecological processes, or other ecological features. Conservation priorities can be categorized as either coarse-filter features, such as broad-scale seascape, ecosystem, or habitat types, or fine-filter features, which are individual species or other smaller scale ecological features (e.g., cold-water coral reefs) (Lieberknecht *et al.* 2010). Comprehensive MPA networks should capture representative examples of broad-scale ecosystem or habitat types in a region (coarse-filter) as well as smaller scale special natural features and priority species (fine-filter).

The conservation priorities for the Scotian Shelf bioregional MPA network were selected with the help of the Technical Working Group. Conservation priorities selection considered: the ecological components of the strategic objectives; the conservation priorities used by Horsman *et al.* (2011) in the previous regional MPA network analysis; past work to identify and describe EBSAs (e.g., Doherty and Horsman 2007, Buzeta 2014, Hastings *et al.* 2014, DFO 2014a); and feedback from other government departments, First Nations and other Indigenous groups, stakeholders, and academics.

The specific coastal and offshore conservation priorities for the Scotian Shelf bioregional MPA network are listed in Appendix A. The conservation priorities for the bioregional MPA network have been organized into coarse-filter (representative) and fine-filter features, with the latter being further subdivided into the three categories of: biogenic habitats, areas of high biodiversity, and areas important for depleted species (see Appendix A).

It is important to note that the list of conservation priorities will be adapted over time as more information becomes available and ecological conditions change. As well, certain potential offshore conservation priorities were not included in the MPA network design analysis due to data limitations (see Section 5).

2.3 OPERATIONAL OBJECTIVES

An operational objective has been crafted for each conservation priority for the Scotian Shelf bioregional MPA network. Operational objectives specify the desired state for each conservation priority and were developed through the Technical Working Group (see Appendix A). Since they specify the desired state for a conservation priority, operational objectives can also influence design strategies. For example, an operational objective that states the desire to “recover” a feature is stronger than one that states the desire to “maintain” a feature. Strong operational objectives will usually lead to higher targets.

3.0 REVIEW OF METHODS FOR SETTING CONSERVATION TARGETS

Setting conservation targets is a key step in systematic protected area network planning (Margules and Pressey 2000). Targets specify how much of a conservation feature a protected area network will aim to protect (Possingham *et al.* 2006, Ardron *et al.* 2010). Therefore, targets have a strong influence on the size and configuration of protected area networks (Vimal *et al.* 2011, Delavenne *et al.* 2012). Setting targets provides a clear basis for conservation decisions and allows for the measurement of success during the implementation phase of protected area network development (Rondinni 2010). Targets also increase accountability and transparency in the process (Cowling *et al.* 2003).The achievability of targets due to factors such as potential economic impacts should not be considered during their formulation as trade-offs will be made later in the process (Pressey *et al.* 2003).

Most conservation planning decision support software packages (e.g., *Marxan*) require the setting of targets for conservation features (Ardron *et al.* 2010). However, the scientific basis that supports target setting is often weak and the importance of having a clear rationale for targets can be overlooked. It is, therefore, crucial to understand the concept of targets as being closely linked to the conditions needed for biodiversity persistence. Rondinini and Chiozza (2010) explained this through the concept of ecological thresholds. The likelihood of species extinction escalates significantly when the loss of their habitat exceeds a given threshold, the same way that ecosystem functioning may deteriorate substantially when the number of species in it falls below a given threshold. Therefore, knowing such thresholds and setting targets above them could theoretically secure biodiversity persistence.

Broad conservation goals may remain relevant over the long-term, but targets typically have a shorter lifespan and should be revised and adapted over time as more information becomes available (Pressey *et al.* 2003). As noted above, one of the benefits of setting targets is the explicit guidance they provide for conservation initiatives but they can also imply a false level of precision, so the inherent uncertainty and limitations of targets must be acknowledged from the outset (Pressey *et al.* 2003).

Approaches to target setting for conservation planning vary from simple, policy-driven approaches where a single target is set for all conservation features to analytical methods that estimate the specific area requirements for individual species, habitats or ecosystems. Thus, targets can be fixed across all conservation features or differ depending on the characteristics of each feature (Gerhartz Abraham 2015). It is important to note that there is no single ideal method for setting conservation targets (Rondinni 2010).

3.1 POLICY-DRIVEN APPROACH

The CBD target of protecting 10% of coastal and marine areas by 2020 is a widely referenced international policy-driven target (CBD 2011) that has been adopted by Canada and other signatories. Fixed targets such as this are politically important but they lack ecological credibility because they are not based on the requirements of species and other ecological features (Noss 1996, Carwardine *et al.* 2009). Thus, achieving such targets will not necessarily ensure biodiversity persistence. Jessen *et al.* (2011) recommend that 30% of each of Canada’s marine bioregions should be strictly protected to help ensure the long-term health of marine ecosystems. Lubchenco and Grorud-Colvert (2015) suggest 20–50% of the world’s oceans should be protected in MPAs. The CBD target should, therefore, be viewed as an interim target or a starting point for a country or region (Lieberknecht *et al.* 2010). Pressey *et al.* (2003) suggest that the overall percentage of a country or region that should be protected “should emerge from, rather than constrain, the achievement of targets for individual features”. In other words, a comprehensive protected area network design process should determine the ultimate amount of area that needs to be protected within a region.

As a general rule, relatively low, policy-driven targets should not be applied broadly to a range of conservation priorities in comprehensive regional-scale systematic MPA network planning processes. However, it is common practice to set a fixed minimum target for all broad-scale coarse-filter features in a region when more rigorous methods are not feasible (Lieberknecht *et al.* 2010).

3.2 EXPERT OPINION APPROACH

Expert opinion can also be used as a basis for setting conservation targets (e.g., Cowling *et al.* 2003, Pressey *et al.* 2003, Smith *et al.* 2009). This approach is often used in data-poor situations. Biases associated with expert opinion approaches can result from research interests of the participants, if not properly accounted for. Expert judgement is prevalent in all approaches to setting conservation targets.

3.3 EVIDENCE-BASED APPROACHES

There is a need for more scientifically defensible approaches for setting conservation targets (Lieberknecht *et al.* 2010). Evidence-based approaches to target setting rely on an adequate understanding and mapping of the distribution and viability of conservation features. Rondinini and Chiozza (2010) describe four evidence-based approaches to target setting:

1. *Species–area relationship*: This approach is based on the relationship between habitat area and the number of species that an area can support. Generally, as more area is set aside for protection, the rate of increasing ecological benefits for the given species community or biome will begin to flatten; somewhere in this flattening section is where a target should be set. The method relies on published data to parametrize the species area-curve based on the equation S=c*Az (*where S is the number of species, A is the area, c is a constant, and z is the factor to be estimated*; Rondinini and Chiozza 2010). Since species accumulation rate is not necessarily constant across all habitat types, a generalized rate can produce inaccurate estimates of the percentage target for certain habitats.

2. *Habitat-specific species–area relationship*: This approach identifies habitat-specific targets based on the fit of a species-area curve from the equation S=c*Az (Desmet and Cowling 2004). Unlike the species-area relationship method, the habitat-specific value of z is estimated based on habitat-specific inventory data. However, the method relies on adequate data quality and quantity to accurately inference the number of species represented in a given area partitioned to each habitat (Rondinini and Chiozza 2010).

3. *Heuristic principles*: Heuristic approaches use approximations that rely on a number of assumptions, and are suitable for use when more rigorous methods are not available or feasible given available data or capacity (Rondinini 2010). Heuristic methods can accommodate a variety of specific goals (e.g., conservation of biodiversity patterns, processes, ecosystem services) and make use of biodiversity data of variable quality and quantity, so they are the most flexible methods for setting targets (Rondinini 2010). Some examples include rules of thumb, transformation of ordinal scales into quantitative thresholds, and educated guesses (Rondinini 2011), which require planners to interpret qualitative knowledge of specific conservation features.

4. *Spatially-explicit population viability analysis*: Species-specific targets can be based on population viability analysis (PVA) where the amount of habitat required to conserve a species is estimated (Rondinini *et al.* 2006, Justus *et al.* 2008, Rondinini and Chiozza 2010). Spatially explicit PVAs attempts to predict measures of viability of species based on demographic data (e.g., censuses, mark-recapture studies, surveys and observations of reproduction and dispersal events, presence/absence data) and habitat data. The method is usually viewed as the most scientifically valid since it explicitly deals with species persistence. However, the vast amount of high-quality and long-term data required to perform a PVA limits its application in most conservation planning exercises. Therefore, the method is less applicable in situations considering multi species and other conservation features (Rondinini and Chiozza 2010).

It is important to highlight that all of the methods described above, other than the heuristic approaches, are species/habitat focused, which limits their ability to reflect the broader ecological objectives of MPA networks intended to conserve entire ecosystems and their associated biodiversity and ecosystem functioning. So, in many cases, heuristic principles must be applied because targets for many important conservation features cannot always be set through standard area-based methods. However, there is no standard methodology to apply heuristic principles to target setting. The choice of a method for defining quantitative, heuristic targets should be guided based on the type of biodiversity feature and data availability. Ideally, a combination of different methods may be the most suitable approach to capture the multi-scalar nature of biodiversity; however, in practice, the choice of method will ultimately depend on the type of biodiversity feature and data availability for the particular planning area.

4.0 DESIGN STRATEGIES FOR THE SCOTIAN SHELF BIOREGION: METHODS AND RESULTS FOR THE COASTAL COMPONENT

A design strategy has been developed for each conservation priority to guide MPA network design in the Scotian Shelf Bioregion. Design strategies must specify: (1) the types of areas or features to be conserved; and (2) the relative targets for those areas or features. For the coastal planning area, design strategies were developed based on expert opinion with input from the MPA Network Technical Working Group.

For the coarse-filter coastal conservation priorities, the types of areas to be conserved are representative examples of the various coastal and nearshore habitats present in the region. Two groups of coarse-filter coastal conservation priorities were identified based on available habitat classification systems:

1. Eco-units: this classification provides a means of coarsely subdividing the Bay of Fundy and the nearshore waters along the Atlantic coast of Nova Scotia into nine areas that share similar subtidal oceanographic and substrate characteristics (Greenlaw, paper in prep; Figure 3).
2. Coastline classes: this classification system subdivides the Bay of Fundy coastline and the Atlantic coast of Nova Scotia into one of three major substrate types – hard, mixed or soft substrate (Greenlaw *et al.* 2012; Figure 4).

Each eco-unit or coastline class is considered a separate conservation priority.

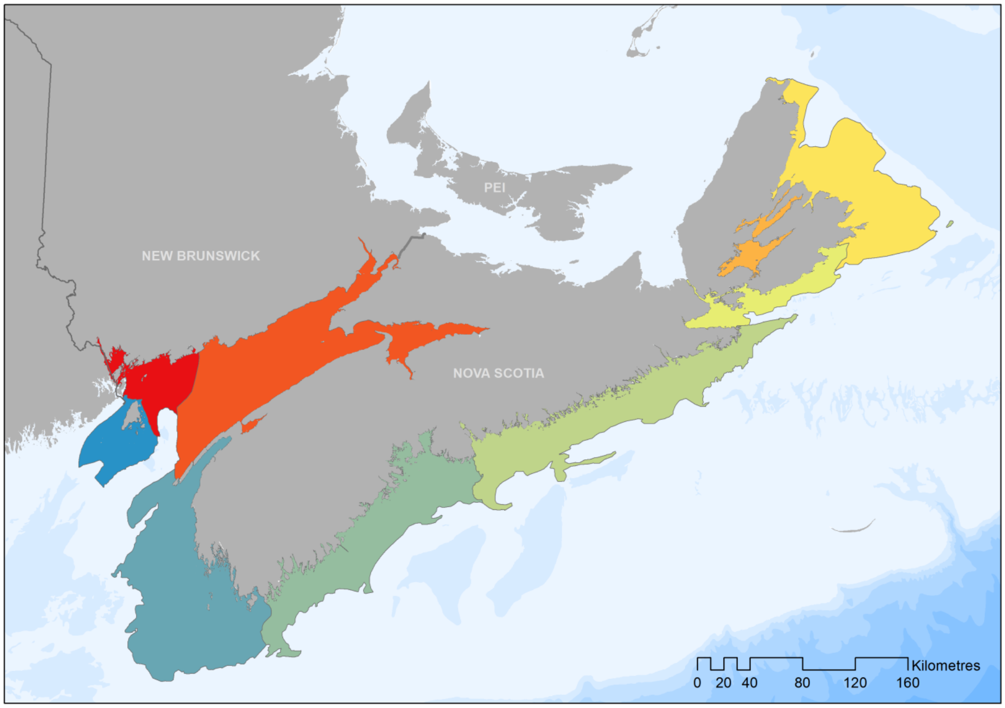

Figure 3. Coastal eco-units, represented by nine coloured polygons, share similar subtidal oceanographic and substrate characteristics (from Greenlaw, paper in prep).

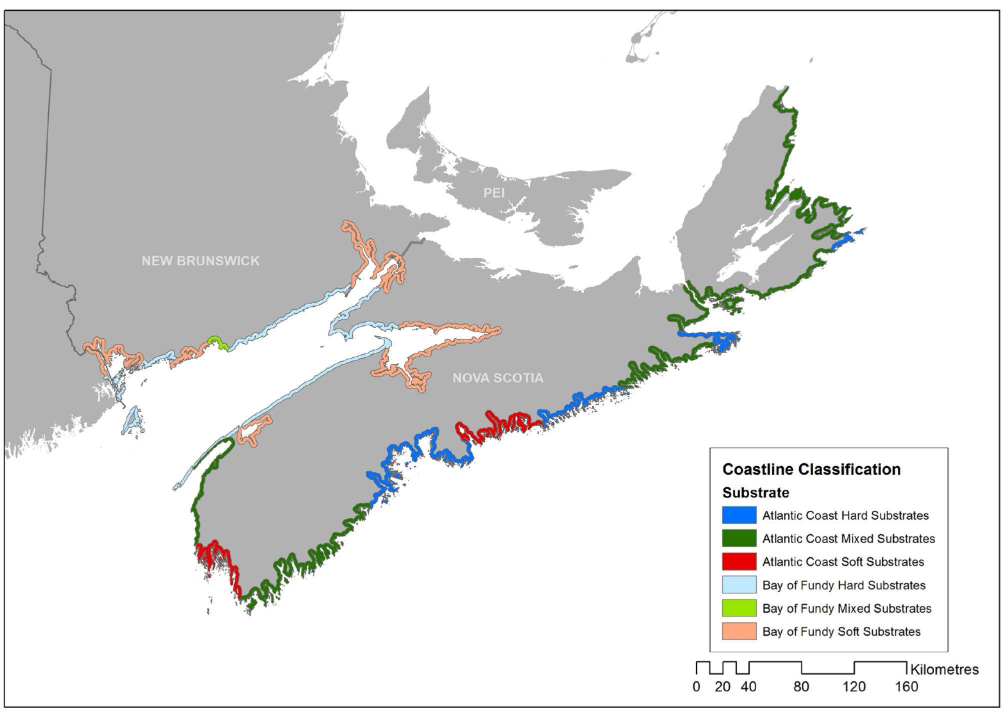

Figure 4. Coastline classes for the Bay of Fundy and the Atlantic Coast of Nova Scotia, grouped by the major substrate present (adapted from Figure 3 of Greenlaw et al. 2012).

For most of the fine-filter coastal conservation priorities, the types of areas to be conserved were determined by examining the ecological, biological, and biophysical features described for each Bay of Fundy (Buzeta 2014) and Atlantic Coast (Hastings *et al.* 2014) EBSAs (Figure 5), and considering only those features that would benefit from marine spatial protection.

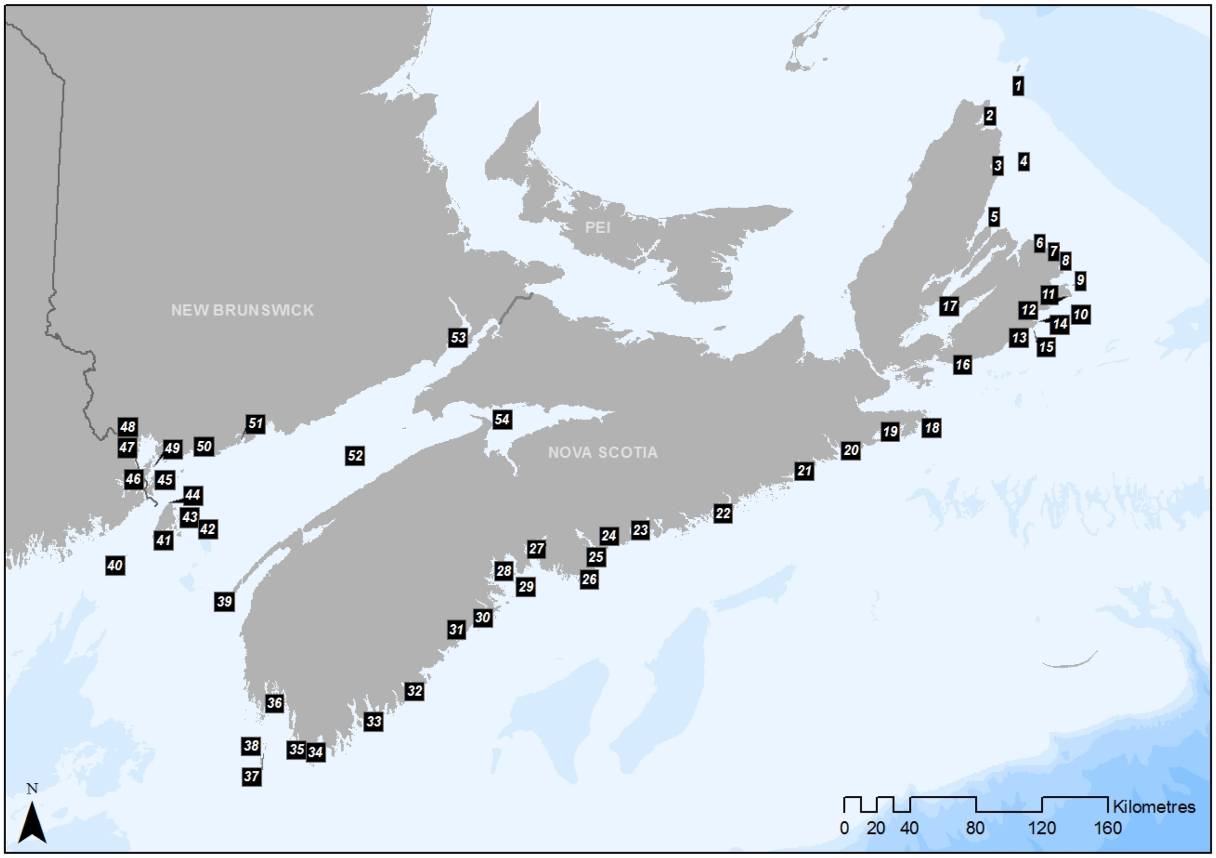

Figure 5. Coastal Ecologically and Biologically Significant Areas in the Scotian Shelf Bioregion. The black numbered boxes indicate the general location of each of the 54 coastal EBSAs in the region. For a description of the EBSAs numbered 1–38, refer to Hastings et al. 2014; for EBSAs 39–54, refer to Buzeta 2014.

The list of types of areas to be conserved and associated targets for each coastal conservation priority is provided in Table 2 (see Appendix B for the full list of features considered in the development of the coastal network design strategies).

Table 2. Design strategies for coastal conservation priorities

Coastal Conservation Priority Category	Type of Area to be Conserved	Target (Amount)
Representative features	1) Eco-units 2) Coastline classes for the Bay of Fundy and Atlantic Coast of Nova Scotia	1) Protect at least two representative example areas and at least 10% total area in each eco-unit 2) Protect at least two representative example of each coastline class found along the Bay of Fundy and Atlantic Coast of Nova Scotia
Highly natural ecosystems	Areas recognized as highly natural or intact ecosystems	Protect at least one example in each eco-unit where relevant
Areas of high productivity	Areas with naturally occurring nutrient-rich surface waters, areas with enhanced productivity, or areas with persistent or recurring upwelling	Protect at least one example in each eco-unit where relevant
Areas of high biodiversity	Areas recognized as being highly biodiverse	Protect at least one example in each eco-unit where relevant
Complex or unique geomorphology	Complex or unique geomorphological features that support biodiversity or ecological function	Protect at least one example in each eco-unit where relevant
Persistent unique or rare oceanographic characteristics	Areas with steep temperature gradients, strong stratification, strong tidal currents, enhanced mixing, or highly fluctuating surface salinity	Protect at least one example in each eco-unit where relevant
Biogenic habitats (marine plants and macro-algae)	Significant concentrations[2] of eelgrass, saltmarsh, kelp, rockweed, and other macro-algae	Protect at least one example area of adequate size[3] in each eco-unit where relevant (protect at least two examples in the Bras d'Or eco-unit)
Biogenic habitats (invertebrates)	1) Significant concentrations[2] of Horse Mussels (*Modiolus modiolus* beds), stalked tunicates (*Boltenia ovifera*), and habitat-forming sponges (e.g., *Haliclona oculata* and *Myxilla* spp.) 2) Oyster beds (*Crassostrea virginica*)	1) Protect all known significant concentrations 2) Protect at least one example area of adequate size[3] in each eco-unit where relevant (protect at least two examples in the Bras d'Or eco-unit[4]).

The targets for the coarse-filter conservation priorities (eco-units and coastline classes) were written to ensure that an example of each classification is included in the network. The eco-unit was also used as the base unit for the fine-filter conservation priority targets, which ensures replication in the coastal network design.

For fine-filter conservation priorities, the wording chosen for the targets reflects the current limitations of data and information available for much of the coastal planning area within the region. As further information becomes available, it may be possible to add greater specificity to the target wording.

For highly natural ecosystems, areas of high productivity, areas of high biodiversity, complex or unique geomorphology, and persistent unique or rare oceanographic characteristics, the proposed target was to protect at least one example in each eco-unit where relevant. The target for some invertebrate biogenic habitats (i.e., Horse Mussel beds, stalked tunicates, and habitat-forming sponges) was to protect all known significant concentrations (with significant areas identified and described through science advice). This more strongly worded target was designed with consideration for the functional importance and vulnerability of these features

[2] To be determined by expert advice.
[3] Area must be of adequate size to ensure the function of the feature is protected. Adequate size will be determined by expert advice.
[4] Due to its isolation, the Bras d'Or lakes eco-unit is considered separately from the rest of the coastal planning area. Protecting at least two examples ensures replication for these features within the lakes.

(Kenchington 2014). For oyster beds and erect bryozoan turf, the target was to protect at least one example area of adequate size in each eco-unit where relevant (and to protect at least two examples in the Bras d'Or eco-unit). For significant concentrations of eelgrass, saltmarsh, kelp and macro-algae, the proposed target was to protect at least one example area of adequate size for each type present in each eco-unit (and to protect at least two examples of each type in the Bras d'Or eco-unit).

The EBSAs, or parts of an EBSA, that capture multiple fine and/or coarse-filter conservation priorities will be prioritized for consideration into the coastal network.

The Bras d'Or Lake and mid-inner Bay of Fundy eco-units have a high level of substructure/diversity and are globally unique. Since the entire Bras d'Or Lakes eco-unit is identified as one EBSA and only a small number of EBSAs are identified within the mid-inner Bay of Fundy eco-unit, site selection in these areas applied to the coastal component of the network may warrant further refinement of existing boundaries or identification of new EBSAs at a finer scale.

In addition to the ecological, biological, and biophysical features captured in Table 2, the EBSAs described in Buzeta (2014) and Hastings *et al.* (2014) also encompass many more species-specific features. Those species-specific features that would benefit from spatial protection were also considered in the coastal site-prioritization process. For reasons of practicality, no design strategies were developed for these features; rather, their presence was taken into account as a secondary assessment of conservation value for each EBSA.

The species-specific features considered are areas important for sensitive life-history stages of species (e.g., spawning areas, overwintering areas, migratory bottlenecks, etc.). This includes areas important for sensitive life-history stages of birds, fish, invertebrates, turtles, and cetaceans as well as depleted species and culturally important species. The types of features included as species-specific considerations are described in Table 3, and listed in detail in Appendix B.

Table 3. Categories of species-specific considerations and the types of areas included.

Species-specific Considerations	Types of Areas
Areas important for depleted species (Species listed by the Committee on the Status of Endangered Wildlife in Canada [COSEWIC])	Spawning, juvenile, nursery, overwintering, foraging, or aggregation areas for depleted species Critical Habitat (CH) areas that meet the Other Effective Area-based Management Measures criteria[5]
Areas important for sensitive life-history stages for culturally important species	Spawning, juvenile, nursery, overwintering, feeding, migratory bottleneck areas
Areas important for sensitive life-history stages for marine mammals and turtles	Foraging, calving, nursery, migratory bottleneck areas
Areas important for sensitive life-history stages for birds	Foraging areas
Areas important for sensitive life-history stages for marine invertebrates	Spawning, juvenile, nursery, overwintering, migratory bottleneck areas, bivalve beds (e.g., clam, scallop)
Areas important for sensitive life-history stages for fish	Spawning, juvenile, nursery, overwintering, feeding, migratory bottleneck areas

[5] Operational Guidance for Identifying 'Other Effective Area-Based Conservation Measures' in Canada's Marine Environment

5.0 DESIGN STRATEGIES FOR THE SCOTIAN SHELF BIOREGION: METHODS AND RESULTS FOR THE OFFSHORE COMPONENT

This section explains the methods used to develop design strategies for the offshore component of the Scotian Shelf bioregional MPA network, and presents the resultant design strategies. The methods were applied to all of the offshore conservation priorities outlined in Appendix A (Table A2). However, sufficient spatial data do not exist for certain conservation priorities (e.g., soft corals, Porbeagle Shark) so not all features can be included in MPA network design analyses at this time. For each design strategy, the type of area to be conserved and a target range is presented. Notable strengths, uncertainties, and challenges encountered when applying the method to each category of conservation priorities are also highlighted in this section. The data used to map each area or feature to be conserved are not under review in this process. The majority of data layers that have been used in this process have undergone peer review (e.g., DFO 2012, DFO 2014a, DFO 2016a).

In an effort to test the effects that design strategies may have on the total area requirements and spatial configuration of an MPA network, a series of exploratory MPA network design analyses were completed using the conservation planning software *Marxan* (see Appendix C for detailed methods and results). A suite of analyses using different target combinations were generated and compared to a baseline analysis. These investigative analyses used an earlier version of the targets for the offshore component of the Scotian Shelf Bioregion. It must be emphasized that the exploratory MPA network design outputs discussed presented in Appendix C are for illustrative purposes only and are not proposed MPA network scenarios.

5.1 IDENTIFYING THE TYPES OF AREAS TO BE CONSERVED FOR OFFSHORE CONSERVATION PRIORITIES

The type of area to be conserved for each conservation priority must be specified before setting conservation targets. The areas to be conserved are spatial representations of the various conservation priorities and operational objectives (see Appendix A). For coarse-filter conservation priorities, where the general objective is to capture a representative example each of these broad-scale feature (e.g., shelf bank geomorphic unit), the conservation priority *is* the type of area to be conserved.

For fine-filter features, the types of areas to be conserved are smaller-scale but highly significant or important for a particular feature or species rather than its full distribution. For example, for large gorgonian corals, the areas to be conserved are significant concentrations of these species instead of their entire distribution. Since the areas to be conserved for fine-filter priorities are smaller and highly important, the targets for these features are expected to be higher than those for coarse-filter features. For certain conservation priorities, there may be multiple types of areas to be conserved. The areas or features to be conserved for all offshore conservation priorities are presented in Sections 5.3 and 5.4.

Detailed, spatially-explicit life-history information does not exist for most conservation priorities, so data availability often dictates the types of areas to be conserved. For instance, for Atlantic Cod, the ideal features to be conserved might be spawning and nursery areas, but available data do not allow for the precise mapping of these areas. In this case, the best available data are from the DFO Research Vessel Survey. These point data can be used to generate relative distribution maps, which can be used to delineate areas of high biomass that are assumed to be important habitats (Horsman and Shackell 2009, DFO 2014a).

Tulloch *et al.* (2016) notes that modelling methods have significantly improved over the last decade but are still under-utilized in conservation planning. For most cetaceans, broad species distribution models (SDMs) represent the best available information. In cases where highly important habitats for a particular species have not been identified, SDM outputs can be used in MPA network design; however, targets should be tempered due to the fact that the area to be conserved could be a large and broadly defined, and thus more comparable to a coarse-filter feature.

5.2 SETTING TARGETS FOR OFFSHORE CONSERVATION PRIORITIES

The approach used to set targets for the offshore conservation priorities of the Scotian Shelf bioregional MPA network draws on several of the methods described in the previous section. This approach is intended to be practical, logic-based and qualitative. The method is a hybrid, in the sense that each conservation priority is first assigned a fixed minimum target that is increased, where necessary, based on the key characteristics or conservation needs of the conservation priority (Figure 6). Scientific expert opinion has also been incorporated into the process as key decisions and the final target ranges have been reviewed by regional subject matter experts. As a final step, each target may be further refined based on pragmatic considerations (e.g., existing management measures, data quality); however, this part of the process is not addressed in this paper. It is important to note that the achievability of targets due to pragmatic factors such as potential economic impacts should not be considered during their initial development as trade-offs will occur later in the network design process (Pressey *et al.* 2003). As with any target setting exercise, considerable uncertainty exists around the targets that have been proposed. More robust targets could be developed in the future by refining this method or through additional research on the specific area requirements of each conservation priority.

A minimum target of 10% was set for all conservation priorities to ensure that they each receive some level of representation within the MPA network. Even the largest coarse-filter features, such as the Abyssal Plain or Continental Rise Geomorphic Units, were assigned a minimum target of 10% because these deep sea ecosystems are poorly studied and almost certainly more heterogeneous than they appear (e.g., Grassle and Maciolek 1992). Protecting relatively large swaths of these deep-water areas will help account for some of the uncertainty regarding their ecological structure and composition. It is recognized, however, that the minimum target of 10% may not be sufficient for many conservation priorities.

The second step in setting targets for the conservation priorities was to determine if, and by how much, the target for each conservation priority should be increased based on its key characteristics or conservation needs. A tailored approach to adjusting targets was developed for each conservation priority category (with the exception of areas of high species richness) based on one or more of the following factors: size, uniqueness/rarity, vulnerability, and current status. Not all of these factors were applied to all conservation priority categories (Table 4). For example, size was the only factor considered for coarse-filter conservation priorities because the objective for these features is simply to capture a representative example of each within the MPA network. On the other hand, many of the fine-filter features are unique/rare, vulnerable, or depleted, so the targets for these conservation priorities require closer examination and, in many instances, will be higher. Approaches where minimum targets are set for coarse-filter features and higher targets are set for fine-filter features are commonly used in systematic conservation planning (Pressey *et al.* 2003, Lieberknecht *et al.* 2010). Unique scoring systems were developed to set targets for the biogenic habitat and depleted species conservation priorities. Applying the scoring systems required judgements and assumptions to be made.

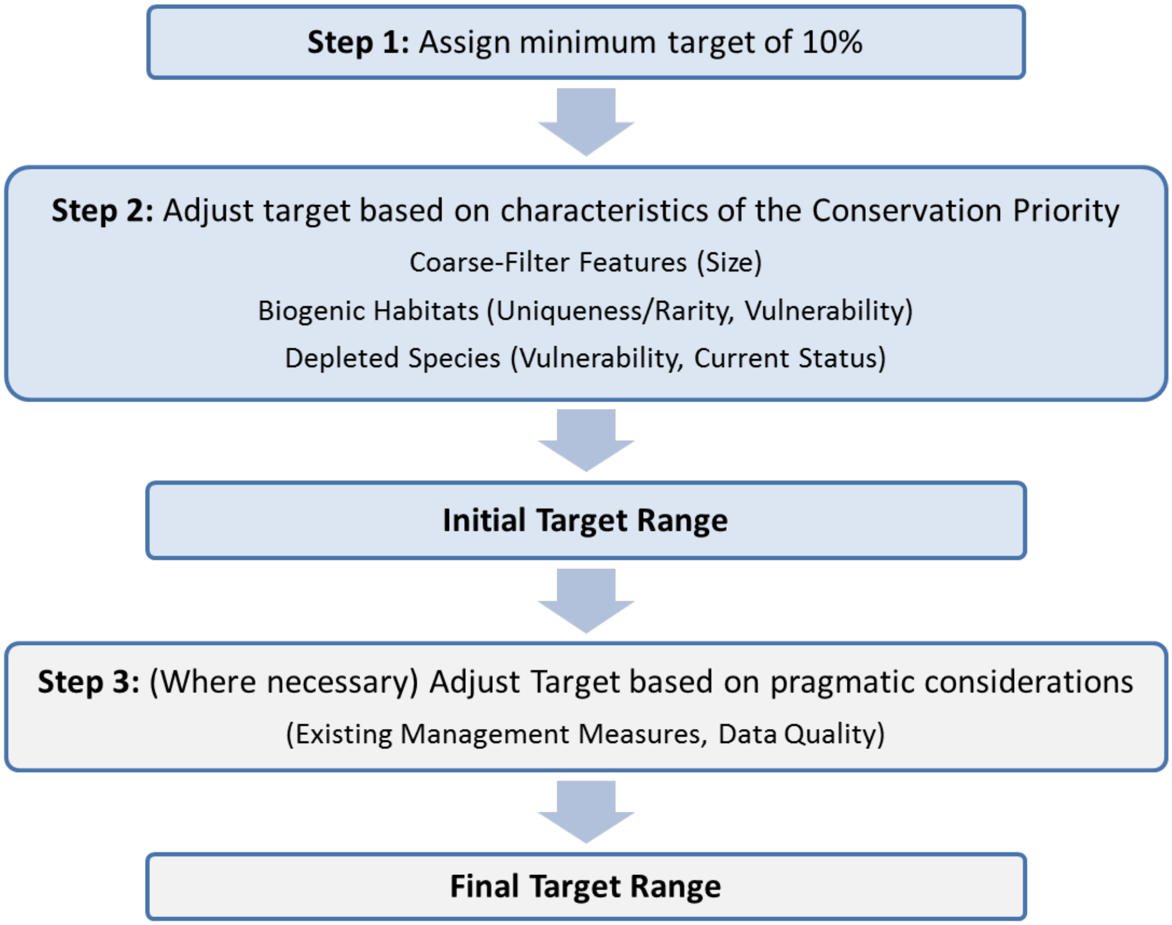

Figure 6. General target setting process for the conservation priorities of the Scotian Shelf Bioregion. Steps 1 and 2 are addressed in this paper.

The adjusted targets at the end of the second step in the process should also reflect the specific intent of the operational objective for a particular conservation priority. As a result, the conservation priorities with stronger operational objectives should generally have higher targets. For example, in most cases, an operational objective that states the desire to "recover" a feature should be higher than one where the desire is to "maintain" a feature.

The adjusted targets may be further refined through the consideration of several secondary factors but these are not addressed in this paper. First, targets may be adjusted based on any existing management or conservation measures for a conservation priority. For example, targets may be lowered for conservation priorities that have stringent and effective non-spatial measures are already in place (Lieberknecht *et al.* 2010). It can, however, be difficult to determine the effectiveness of existing management measures. Effective MPA network design requires the interpretation of broader goals through the filter of available data on the biodiversity of a region (Lieberknecht *et al.* 2010). Thus, the quality and reliability of the spatial data used to represent a conservation priority is also important to consider when setting targets because unreliable data should not have a major influence on an MPA network design (Lieberknecht *et al.* 2010). Targets could be lowered for conservation priorities that have been mapped using less reliable or precise data. An alternative to adjusting targets would be to fine-tune certain settings in the decision support software (Marxan) to lower the weighting on certain conservation priorities. The targets presented in this paper were not adjusted based on these two secondary factors.

Table 4. Primary factors or characteristics considered when adjusting targets for the different conservation priority categories ("x" indicates that the factor was applied to the conservation priority).

	Conservation Priority Categories			
		Fine-filter Features		
Primary Factors (Characteristics)	*Coarse-filter Features*	Areas of High Species Richness	Biogenic Habitats	Depleted Species
Size	**x**	-	-	-
Uniqueness/Rarity	-	-	**x**	-
Vulnerability	-	-	**x**	**x**
Current Status	-	-	-	**x**

5.2.1 Setting Targets for Coarse-filter Features

For this process, the targets for coarse-filter features were based solely on the size of the feature, which is a common practice when setting conservation targets (Pressey *et al.* 2003). Size is simply defined as the total area covered by the feature to be conserved. Under this approach, smaller coarse-filter features will be assigned a higher target than larger features. This is based on the assumption that smaller features are more susceptible to changes or disturbances, including catastrophic events. With coarse-filter features, the aim is simply to capture representative examples of each feature within the MPA network; so, in most cases, the targets for coarse-filter features will be lower than fine-filter features. However, very small coarse-filter features can still have high targets.

With sufficient biological data, species-area relationships could be explored to develop evidence-based targets for representative features (Rondinini and Chiozza 2010). However, the data needed to apply such techniques are not currently available, so a simpler approach has been adopted for this process.

Targets for coarse-filter features in this process were scaled proportionally based on their relative overall size. Specifically, we used a method described in Lieberknecht *et al.* (2010) in which the distribution of targets for coarse-filter features of the same general kind would fall within a continuum roughly proportional to the square root of their respective total areas (see equation).

$$(x_p / y_p) \approx (x_t / y_t)^{0.5}$$

Where x and y are two features within a given feature class, p represents the area protected of a given feature, and t represents the total area of a given feature in the network.

It is important to bear in mind that the approach suggested in Lieberknecht *et al.* (2010) can be appropriate when there is a greater emphasis on protecting rare or unusual coarse-filter features or when it is unrealistic to protect very large areas, but this will ultimately depend on the conservation objectives of the network. For instance, if the objective is to reflect the natural relative abundance of all coarse-filter features across the network, then it is not recommended to set higher targets for rarer coarse-filter features. However, this type of approach is rarely implemented. Numerous examples exist where targets for coarse-filter features have been scaled based on their overall abundance (e.g., Ardron 2008).

In future iterations of this process, other factors such as uniqueness, vulnerability or naturalness could also be considered in setting targets for coarse-filter features. However, sufficient information is not readily available to systematically evaluate such factors and attempting to do so would add more complexity and subjectivity to the process.

5.2.2 Setting Targets for Fine-filter Features

Fine-filter features in this process fall within three sub-categories: biogenic habitats, areas of high species richness, and depleted species.

5.2.2.1 Biogenic Habitats

The primary factors or key characteristics considered when refining the targets for biogenic habitat conservation priorities were uniqueness/rarity and vulnerability. A scoring system was developed for this sub-category of conservation priorities where separate uniqueness/rarity and vulnerability scores were generated and then combined (using the square-root of the sum of squares, divided by the number of factors) to determine a target score.

Kenchington (2014) produced an overview of benthic EBSAs in the Scotian Shelf Bioregion, which included a general evaluation of the different biogenic habitat types against established EBSA criteria. This work included an estimate of the uniqueness/rarity of each biogenic habitat type resulting in a high, medium, or low ranking. These results were used as the basis for assigning uniqueness/rarity scores for biogenic habitat features in this process (Table 5).

International guidance from the Food and Agriculture Organization (FAO) on describing Vulnerable Marine Ecosystems (VMEs) (FAO 2009) was used as a basis determining the vulnerability scoring system for biogenic habitat conservation priorities (Table 5). The FAO VME criteria were originally developed to assess the vulnerability of deep-sea ecosystems to fishing, so they have been generalized for use in the current process. More specifically, the Functional Significance of the Habitat and Structural Complexity criteria were removed because all biogenic habitats are functionally significant and structurally complex by definition, which is one of the reasons they are considered conservation priorities. For each biogenic habitat type, a score of 1–3 was assigned for each of the criteria used (Life-History Traits and Fragility) and a composite score was calculated (using the square-root of the sum of squares, divided by the number of factors) to determine the final vulnerability score. The FAO (2009) outlined four life-history traits that signify a vulnerable species: slow growth rates, late age of maturity, low or unpredictable recruitment, and long lived. Three of these were considered in the current process. Age of maturity is rarely known for habitat-forming species so this trait was not considered (Cordes *et al.* 2001). Kenchington (2014) also described the vulnerability of the different biogenic habitats in the Scotian Shelf Bioregion, so these results were compared to the vulnerability scores produced using the simplified VME criteria.

In this initial application, the ranks/scores assigned to the three Life-History Traits were developed using broad categories based on available literature. For example, for the long-lived trait, large gorgonian corals were given a high ranking (3) because colonies of these species are known to live for hundreds of years (Bennecke *et al.* 2016). The method could be refined by defining meaningful thresholds for what constitutes low, medium and high scores for each of the three life-history traits being considered. Keeping with the long-lived example, a threshold of < 10 (low), 10–30 (medium), > 30 (high) could be considered but should be based on evidence and confirmed by experts.

The target score for each biogenic habitat conservation priority was calculated by combining the uniqueness/rarity score with the vulnerability score (using the square-root of the sum of squares, divided by the number of factors). Scores assigned for each criterion were confirmed with subject matter experts. Target scores were then translated into a target range using the five equal target score bins presented in Table 6.

Table 5. Method for scoring biogenic habitat conservation priorities in the Scotian Shelf Bioregion (uniqueness/rarity criteria modified from Kenchington 2014; vulnerability criteria modified from FAO 2009).

Primary Factor		Scoring Criteria
Uniqueness/rarity		High uniqueness/rarity (as defined in Kenchington 2014) = 3
		Medium uniqueness/rarity (as defined in Kenchington 2014) = 2
		Low uniqueness/rarity (as defined in Kenchington 2014) = 1
Vulnerability	Life-history traits	Has a minimum of 2 of the 3 following traits: slow growth rates, long lived, low or unpredictable recruitment = 3
		Has 1 of the 3 following traits: slow growth rates, long lived, low or unpredictable recruitment = 2
		Has none of the following traits: slow growth rates, long lived, low or unpredictable recruitment = 1
	Fragility	High potential for damage or mortality resulting from physical disturbance = 3
		Moderate potential for damage or mortality resulting from physical disturbance = 2
		Low potential for damage or mortality resulting from physical disturbance = 1

Table 6. Table of target scores and corresponding target ranges.

Target Score	Target	Target Range
1–1.4	Low	10–20%
1.41–1.8	Low-Medium	20–40%
1.81–2.2	Medium	40–60%
2.21–2.6	Medium-High	60–80%
2.61–3	High	80–100%

5.2.2.2. Areas of High Species Richness

The need to protect marine biodiversity is widely recognized through federal policy and international agreements (CBD 2009). Biodiversity protection is the primary goal of Canada's national MPA network (Government of Canada 2011) and the *Oceans Act* (1996) lists the protection of areas of high biodiversity as one of five criteria for establishing MPAs. Protecting areas of high biodiversity has been a widely applied, cost-effective strategy for conserving biodiversity in terrestrial and, to some extent, marine settings (Marchese 2015). Although conservation planning has evolved to consider much more than the number of species in a region, protecting areas of high species richness is still recognized as a key component of a comprehensive biodiversity protection strategy. Persistent areas of high biodiversity are important ecosystem features that provide integrity and resilience to marine ecosystems, which are under pressure from local activities and broad scale changes (ICES 2012, Ward-Paige and Bundy 2016).

Attempting to customize the conservation targets for the areas of high species richness conservation priorities is a challenge because it is difficult to differentiate among them based on any of the primary factors. For instance, they are all large features (mostly between 35,000 km^2 and 38,000 km^2) so considering size would not help with assigning relative targets. Also, the areas of high species richness for different taxa may be distinct from adjacent areas but they do not qualify as unique or rare because they are too numerous. For example, for demersal fishes, there are close to thirty areas of high species richness in the bioregion. Further, it would be difficult to assess the vulnerability or current status of these features because they are made up of many different species with unique characteristics. Despite these realities, areas of high species richness must be represented within the bioregional MPA network. In this regard they are similar to coarse-filter features. For this reason, a fixed target range of 20–40% has been set for all areas of high species richness conservation priorities. The Technical Working Group agreed on this general target range for this group of conservation priorities. This range is also generally consistent with recommendations to protect at least 30% of Canadian bioregions (Jessen *et al.* 2011).

5.2.2.3 Depleted Species

It is widely accepted that the habitat needs of depleted species should be considered in systematic conservation planning (Margules and Pressey 2000). The primary factors considered when setting targets for depleted species were vulnerability and current status. Thus, for each depleted species, a separate score was determined for both of these factors and a combined target score was calculated (using the square-root of the sum of squares, divided by the number of factors). Size and uniqueness/rarity were not considered because nearly all of the depleted species in the region have large area requirements and were considered common before they became depleted. So, considering these other factors would inappropriately penalize these species. Some of the more pragmatic considerations (e.g., existing management measures for a particular species) will be addressed later in the process.

5.2.2.4 Depleted Fishes

For this process, the Intrinsic Vulnerability Index (IVI) developed by Cheung *et al.* (2007) was used as the basis for determining the inherent vulnerability of the different depleted fish species in the bioregion. The IVI was used to rank the vulnerability of global fish species to exploitation based on life-history traits. In general, fishes that are large bodied, long lived, have a higher age at maturity, and lower growth rates are considered most vulnerable (Jennings *et al.* 1999). Overall, IVI scores range from ten to 90, while the scores for depleted species in the Scotian Shelf Bioregion range from 29 (American Plaice) to 78 (Atlantic Wolffish) (Table 7). For the purposes of this exercise, vulnerability ranks of high (3), medium (2) or low (1) were assigned based on three ranges of IVI scores determined by natural breaks in the overall distribution of IVI values (Table 9).

Table 7. Intrinsic vulnerability index scores from Cheung et al. (2007) for depleted fish species in the Scotian Shelf Bioregion.

Depleted Fish Species	IVI Score
Atlantic Wolfish	78
Blue Shark	77
Shortfin Mako Shark	76
Roundnose Grenadier	75
Winter Skate (Eastern Scotian Shelf)	72*
Smooth Skate	72*
Roughhead Grenadier	70
Porbeagle Shark	66
White Shark	64
Spiny Dogfish	62*
Redfish (Unit 2)	58*
Thorny Skate	57
Basking Shark	54
Cusk	54
Atlantic Cod	52
White Hake	41
Ocean Pout	31
American Plaice	29

**IVI score was determined at the family level.*

The second factor considered in determining targets for depleted fish species is current status. This factor is based on the COSEWIC assessment, the DFO Precautionary Approach Framework (PAF), or (in rare cases) other reliable information. COSEWIC listings are used instead of Species at Risk Act (SARA) (2002) listings because COSEWIC is an independent, science-based process that does not take into account political, social or economic factors (COSEWIC 2009a). In cases where a species has been assessed by COSEWIC and through the DFO PAF, the most recent assessment will be used. Species that are not listed by COSEWIC or assessed under the PAF but are at a biomass level less than < 40% of the long-term mean for 5 of the last 10 years will be assigned a score of 2 for this factor. Table 8 provides the most recent status assigned to each species and the scoring method for current status is outlined in Table 9. The target scores were converted to target ranges based on Table 6.

Table 8. Current status of depleted fish species (using most recent COSEWIC and SARA assessments).

Depleted Fish Species	Status
Atlantic Wolfish	Special Concern (COSEWIC and SARA)
Blue Shark	Special Concern (COSEWIC)
Roundnose Grenadier	Endangered (COSEWIC)
Winter Skate (ESS)	Endangered (COSEWIC)
Smooth Skate	Special Concern (COSEWIC)
Roughhead Grendadier	Special Concern (COSEWIC)
Porbeagle Shark	Endangered (COSEWIC)
White Shark	Endangered (COSEWIC and SARA)
Spiny Dogfish	Special Concern (COSEWIC)
Redfish (Unit 2)	Threatened (COSEWIC)

Depleted Fish Species	Status
Thorny Skate	Special Concern (COSEWIC)
Basking Shark	Special Concern (COSEWIC)
Cusk	Endangered (COSEWIC)
Atlantic Cod	Endangered (COSEWIC)
White Hake	Threatened (COSEWIC)
Ocean Pout	Not listed but has shown significant decline (Clark and Emberley 2011)
American Plaice	Threatened (COSEWIC)

Table 9. Method for scoring depleted fish species conservation priorities in the Scotian Shelf Bioregion (IVI scores from Cheung et al. 2007).

Primary Factor	Scoring Criteria
Vulnerability	High Intrinsic Vulnerability Index score from 59–90 = 3
	Medium Intrinsic Vulnerability Index score from 37–58 = 2
	Low Intrinsic Vulnerability Index score from 10–36 = 1
Current Status	Listed as Endangered by COSEWIC or in Critical Zone under PAF (minimum of 5 of the last 10 years) = 3
	Listed as Threatened by COSEWIC or not assessed by COSEWIC or DFO but has shown significant decline* = 2
	In the Cautious Zone under PAF (minimum of 5 of the last 10 years) or listed as Special Concern by COSEWIC = 1

**Species that have been at < 40% of long-term mean biomass for 5 of the last 10 years.*

5.2.2.5 Depleted Cetaceans and Sea Turtles

With the exception of Harbour Porpoise (COSEWIC 2006a), all of the cetacean and sea turtle conservation priorities are inherently vulnerable due to common life-history traits such as low fecundity, late maturity, and slow growth rates. For this reason, the cetaceans (other than harbour porpoise) and sea turtles have been assigned a high vulnerability score. The current status of cetaceans and sea turtles is based on the COSEWIC status. Table 10 provides a summary of the scoring methods for vulnerability and current status of these conservation priorities.

Table 10. Method for scoring cetaceans and sea turtle conservation priorities in the Scotian Shelf Bioregion.

Primary Factor	Scoring Criteria
Vulnerability	All cetaceans* and turtles assigned high vulnerability score = 3
Current Status	Listed as Endangered by COSEWIC = 3
	Listed as Threatened by COSEWIC or not assessed by COSEWIC but have shown significant decline* = 2
	Listed as Special Concern by COSEWIC = 1

**With the exception of harbour porpoise, which is not considered inherently vulnerable.*

5.3 RESULTS FOR COARSE-FILTER FEATURES

Ecosystem or habitat (i.e., coarse-filter) representation is recognized by DFO (2013) and the CBD (2007) as an essential property of effective MPA networks. For a regional-scale MPA network to achieve representation it must include adequate examples of the full range of ecosystem, habitat, or community types that occur in the region (Noss *et al.* 1999, DFO 2013). To consider ecosystem or habitat representation in the MPA network design, an ecological classification system must be selected or developed. Each ecosystem or habitat type within a particular classification system is considered a coarse-filter feature that will be targeted within an MPA network design process. Several ecological classifications have been developed for the Scotian Shelf Bioregion (e.g., Day and Roff 2000, Kostylev and Hannah 2007, Fader *unpublished*, DFO 2016a). The Kostylev and Hannah (2007) classification and the recently developed hierarchical marine ecological classification by DFO (2016a) will be used as the primary basis for considering coarse-filter representation in this exercise. Other classifications may be considered in future iterations. Seabird, demersal fish, and invertebrate functional groups will also be considered coarse-filter features in this exercise because they are intended to represent broad-scale ecological processes.

Size was the only factor considered in developing targets for coarse-filter features. As a general rule, smaller features received larger targets and vice versa. The size-based scoring method developed by Lieberknecht *et al.* (2010) (Section 5.2.1) was used in this process. To apply the this approach, a “starting target” must be selected for the largest conservation priority (i.e., Slope, Rise and Abyss Oceanographic Unit), which dictates the relative targets of the other coarse-filter features. Different starting targets were explored (e.g., 10%, 5% and 3%) to test the effects they would have on the targets of other coarse-filter conservation priorities. With a 10% starting target, several coarse-filter feature targets were above 50%, which is not necessary or realistic because coarse-filter features generally have relatively low targets. A starting target of 3% yielded more practical results; so, for the current process, it has been used to set the low end of the coarse-filter feature target range. However, using 3% as the starting point resulted in nearly half of the coarse-filter targets being below 10%, so these were all increased to 10% to satisfy the minimum target requirement (see Section 5.2). A starting target of 10% was used to generate the high end of the target range.

There are several small (< 1000 km^2) coarse-filter features that will receive relatively high targets using the Lieberknecht *et al.* (2010) approach. These features could have a significant influence on the MPA network design so they should only be included when they are acknowledged as ecologically distinct features and not an artifact of the habitat classification analysis. Small features for which there is not a high degree of confidence regarding their ecological significance should not be assigned targets because they will have a seed effect in the network design analysis. One example may be from the fish functional group category of coarse-filter priorities, where the small pelagic piscivore group on the eastern Scotian Shelf is only 429 km^2 so it received a target of 72%. This feature would have a significant influence on the design so should only be included if it is known to be an ecologically distinct feature.

The targets for the different types of coarse-filter features are presented in the following subsections. Targets for all coarse-filter features can be viewed together in Section 5.5 (Table 11).

5.3.1 Design Strategies for Oceanographic Units

Types of areas to be conserved: As part of a hierarchical marine ecological classification, DFO (2016a) has classified the Maritimes Region into distinct oceanographic units based on known conditions (e.g., temperature and salinity) and processes (e.g., currents). Each oceanographic unit represents a separate area or feature to be conserved. Initial targets are proposed based on their size using the Lieberknecht *et al.* (2010) approach.

Table 11. *Targets for oceanographic units in the Scotian Shelf Bioregion.*

Area to be Conserved[6]	Targets (Low)	Targets (High)
Gulf of Maine	10	30
Baccaro and LaHave banks	11	38
LaHave and Emerald basins	10	26
Western and Sable Island banks	10	31
Eastern Scotian Shelf	10	22
Laurentian Slope	10	34
Slope, Rise and Abyss	10	10

5.3.2 Design Strategies for Geomorphic Units

Types of areas to be conserved: Geomorphic units, as defined in DFO (2016a), are geomorphological features assumed to have distinctive biological communities. Geomorphic units are the level below oceanographic units in the DFO (2016a) hierarchical marine ecological classification system. Each geomorphic unit represents a separate area or feature to be conserved within this group of coarse-filter features. The target for each unit is based on its size using the Lieberknecht *et al.* (2010) approach.

Table 12. Targets for geomorphic units in the Scotian Shelf Bioregion.

Area to be Conserved[7]	Targets (Low)	Targets (High)
Abyssal Plain	10	11
Continental Rise	10	10
Shelf Bank	10	14
Shelf Basin	10	32
Shelf Channel	12	39
Shelf Flat	10	19
Shelf Topo. Complex	10	30
Shelf Topo. Complex Bank	10	25
Shelf Topo. Complex Basin	16	54
Slope	11	35
Slope Channel	10	26

5.3.3 Design Strategies for Scope for Growth Classes

Kostylev and Hannah (2007) developed a habitat model based on observed *scope for growth* and *natural disturbance* conditions in the Scotian Shelf Bioregion. Their results were used by Horsman *et al.* (2011) in a preliminary MPA network analysis and noted by King *et al.* (2013) as a suitable classification system for use in MPA network design in the bioregion. Separate scope for growth and natural disturbance classifications were created based on this model.

Types of areas to be conserved: Capturing different scope for growth classes should ensure a wide range of community types is included in the network. Each scope for growth class represents a separate area or feature to be conserved within this group of coarse-filter features.

[6] Bras d'Or Lake, Bay of Fundy and SW NS, and Atlantic Inshore are oceanographic units that were described in DFO (2016a), but will not be considered in the offshore approach as they fall within the coastal planning area.

[7] Bay of Fundy Basin, Flat, and Inlet, and Inner Shelf Bank, Flat and Inlet are geomorphic units that were described in DFO (2016a), but will not be considered in the offshore approach as they fall within the coastal planning area.

The target for each unit is proposed below based on its size using the Lieberknecht *et al.* (2010) approach.

Table 13. Targets for scope for growth classes in the Scotian Shelf Bioregion.

Area to be Conserved	Targets (Low)	Targets (High)
Very low scope for growth	10	15
Low scope for growth	10	10
Moderate scope for growth	10	13
High scope for growth	10	20
Very high scope for growth	10	19

5.3.4 Design Strategies for Natural Disturbance Classes

Types of areas to be conserved: Capturing different natural disturbance classes should ensure a wide range of community types is included in the network. Each natural disturbance class represents a separate area or feature to be conserved within this group of coarse-filter features. The target for each class is based on its size using the Lieberknecht *et al.* (2010) approach.

Table 14. Targets for scope for natural disturbance classes in the Scotian Shelf Bioregion.

Area to be Conserved	Targets (Low)	Targets (High)
Very low natural disturbance	10	28
Low natural disturbance	10	22
Medium natural disturbance	10	17
High natural disturbance	10	27

5.3.5 Design Strategies for Functional Groups

5.3.5.1 Groundfish Functional Groups

Types of areas to be conserved: The areas or features to be conserved for these coarse-filter features are *important habitats* (or *core areas*), which were identified and mapped by Bundy *et al.* (2017) using DFO Research Vessel Survey data. The mapping approach was similar to that of Horsman and Shackell (2009).

Table 15. Targets for groundfish functional groups in the Scotian Shelf Bioregion.

Area to be Conserved	Targets (Low)	Targets (High)
Small and Medium Benthic Piscivores (East)	10	10
Small and Medium Benthic Piscivores (West)	12	17
Large Benthic Piscivores (East)	10	11
Large Benthic Piscivores (West)	10	17
Small and Medium Pelagic Piscivores (East)	10	21
Small and Medium Pelagic Piscivores (West)	0	0
Small Benthic Benthivores (East)	10	13
Small Benthic Benthivores (West)	10	22
Medium Benthic Benthivores (East)	10	11
Medium Benthic Benthivores (West)	10	17
Large Benthic Benthivores (East)	10	12
Large Benthic Benthivores (West)	10	16

Area to be Conserved	Targets (Low)	Targets (High)
Small, Medium, and Large Pelagic Planktivores (East)	10	14
Small, Medium, and Large Pelagic Planktivores (West)	10	18
Small, Medium, and Large Benthic Zoopiscivore (East)	10	15
Small, Medium, and Large Benthic Zoopiscivore (West)	10	17
Small, Medium, and Large Pelagic Zoopiscivore (East)	10	24
Small, Medium, and Large Pelagic Zoopiscivore (West)	10	33

5.3.5.2 Invertebrate Functional Groups

Types of areas to be conserved: The areas or features to be conserved for these representative features are *important habitats* (or *core areas*), which were identified and mapped by Bundy *et al.* (2017) using DFO Research Vessel Survey data. The mapping approach was similar to that of Horsman and Shackell (2009).

Table 16. Targets for invertebrate functional groups in the Scotian Shelf Bioregion.

Area to be Conserved	Targets (Low)	Targets (High)
Small Benthic Benthivores (East)	10	10
Small Benthic Benthivores (West)	10	15
Medium Benthic Benthivores (East)	10	10
Medium Benthic Benthivores (West)	10	15
Small, Medium, and Large Zoopiscivores (East)	10	31
Small, Medium, and Large Zoopiscivores (West)	10	16
Benthic Colonial Filter Feeders (East)	10	18
Benthic Colonial Filter Feeders (West)	0	0
Benthic Non-Colonial Filter Feeders (East)	10	10
Benthic Non-Colonial Filter Feeders (West)	10	20
Detritivores (East)	10	14
Detritivores (West)	10	27

5.3.5.3 Seabird Functional Groups

Types of areas to be conserved: The areas to be conserved for these representative features are important habitats for each seabird functional group, which were identified and mapped using the seabird sightings data described in Allard *et al.* (2014).

Table 17. Targets for seabird functional groups in the Scotian Shelf Bioregion.

Area to be Conserved	Targets (Low)	Targets (High)
Surface-Seizing Planktivores	10	27
Surface Shallow-Diving Piscivore/Generalists	10	11
Surface Shallow-Diving Coastal Piscivores	10	24
Pursuit-Diving Piscivores	10	13
Shallow Pursuit Generalists	10	10
Pursuit-Diving Planktivore	10	14
Plunge-Diving Piscivores	10	10
Ship-Following Generalists	10	13

5.4 RESULTS FOR FINE-FILTER FEATURES

5.4.1 Design Strategies for Areas of High Species Richness

As explained in Section 5.2.2, a target range of 20–40% was selected for all conservation priorities in the areas of high species richness category because it was difficult to differentiate among these features based on any of the primary factors (e.g., size, vulnerability). The area or feature to be conserved for these conservation priorities are areas that fell within the top quantile for species richness during the DFO Research Vessel Surveys (e.g., Ward-Paige and Bundy 2016) and other surveys.

Table 18. Targets for areas of high species richness in the Scotian Shelf Bioregion.

Area to be Conserved	Target Range
Areas of high fish species richness	20–40%
Areas of high invertebrate species richness	20–40%
Areas of high small fish species richness	20–40%
Areas of high ichthyoplankton species richness	20–40%
Areas of high small invertebrate species richness	20–40%

5.4.2 Design Strategies for Biogenic Habitats

The Scotian Shelf bioregional MPA network aims to protect high density areas for habitat forming species, such as corals, sponges, and other taxa. These biogenic habitats support other species and are sensitive to disturbance (Kenchington 2014), so they have very high conservation value. In this process, the areas or features to be conserved for offshore biogenic habitats are “significant concentrations” of the different species or species groups described below.

Significant concentrations of large gorgonian corals, sea pens, *Vazella pourtalesi* sponges, and other sponges were delineated by Kenchington *et al.* (2016) using a kernel density analysis. Additional kernel density analyses were recently completed by Beazley *et al.* (2017) for other biogenic habitat-forming species, such as horse mussels and stalked tunicates. These layers will be included in future MPA network design analyses. Where a kernel density analysis has been completed, the results will serve as the primary areas to be conserved for biogenic habitat conservation priorities. Kenchington *et al.* (2016) and Beazley *et al.* (2016, 2017) have also developed SDMs for some of the biogenic habitat priorities. These models predict the broad distribution of the different taxa based on environmental variables but do not highlight significant concentrations. In cases where a kernel density layer has not be developed for a species group, the SDM layer can be used as a substitute but targets for these features were tempered because they do not point to significant concentrations.

The specific targets for biogenic habitat conservation priorities were based on uniqueness/rarity and vulnerability factors. Certain biogenic habitats in the region are recognized as unique (e.g., *V. pourtalesi* sponge grounds) while others are quite common (e.g., soft corals). These features may also be highly vulnerable (e.g., large gorgonian corals) or quite resilient (e.g., soft corals). Unique biogenic habitats that are considered highly vulnerable were assigned high targets while other conservation priorities in this group received lower targets. Initial targets were developed for all of the species in this subsection but sufficient data were not available for certain priorities so they were not included in the exploratory network analysis (e.g., *Lophelia pertusa* reefs, tube-dwelling anemone fields). These features will be included in future iterations of this process when adequate data are available. The factor scoring for this group of conservation priorities has been reviewed by regional experts. It is important to note that, under the *Policy for Managing the Impact of Fishing on Sensitive Benthic Areas*[8], a case could be made that all biogenic habitats that are considered vulnerable should be assigned a high target. As a result, a minimum target of 30% was assigned to all biogenic habitats.

5.4.2.1 *Vazella pourtalesi* (Sponge) Concentrations

Type of area to be conserved: Significant concentrations of *Vazella pourtalesi* (Russian Hat sponges) were defined by Kenchington *et al.* (2016) using kernel density analysis.

Target range: High (80–100%).

Table 19. Targets for significant concentrations of Vazella pourtalesi (Russian Hat sponges) in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	**3**	**High.** Russian Hat sponges have been documented in other parts of the world but the dense concentrations found in and around Emerald Basin are thought to be globally unique (Fuller *et al.* 2008, Kenchington 2014, DFO 2015a). A maximum density of 16 sponges /m^2 has been identified (Fuller 2011, Kenchington *et al.* 2015).
Vulnerability	3	*Life-history traits* (Fuller *et al.* 2008, Kenchington 2014) Slow growth: Yes [presumed to be slow but will be verified through future research (Kenchington pers. comm.) Low or sporadic recruitment: Unknown [presumed to be low but will be verified through future research (Kenchington pers. comm.) Long lived: **Yes**
	3	*Fragility:* **High** (Fuller *et al.* 2008).
	3	Combined Vulnerability Score
Target Score = 3.00		**Target Range = High 80–100%**

5.4.2.2 Large Gorgonian Coral Concentrations

Type of area to be conserved: Significant concentrations of large gorgonian corals were defined by Kenchington *et al.* (2016) using kernel density analysis.

Target range: High (80–100%).

Table 20. Targets for significant concentrations of large gorgonian corals in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	**3**	**High.** Significant concentrations of large gorgonian corals are considered rare in the Maritimes Region. Distribution is likely limited by larval supply (Metaxas and Davis 2005, Mortensen and Buhl- Mortensen 2004).

[8] The DFO *Policy for Managing the Impact of Fishing on Sensitive Benthic Areas*.

Consideration	Score	Rationale
Vulnerability	3	*Life-history traits* (Fuller *et al.* 2008, Watanabe *et al.* 2009, Mortensen and Buhl-Mortensen 2005, Lacharite and Metaxas 2013) Slow growth: **Yes** (Bennecke *et al.* 2016) Low or sporadic recruitment: **Yes.** Significant mortality early in the benthic stage of gorgonian corals is thought to limit the abundance of adult colonies (Mortensen and Buhl- Mortensen 2004, Metaxas and Davis 2005, Lacharite and Metaxas 2013, Bennecke and Metaxas 2017). Long lived: **Yes.** The largest colonies of gorgonian corals are estimated to be hundreds of years old (Watanabe *et al.* 2009, Bennecke *et al.* 2016).
	3	*Fragility:* **High**
	3	Combined Vulnerability Score
Target Score = 3.00		**Target Range = High (80–100%)**

5.4.2.3 Small Gorgonian Coral Concentrations

Type of area to be conserved: Due to data limitations, Kenchington *et al.* (2016) did not complete a kernel density analysis for small gorgonian corals so significant concentrations of this species group have not been defined. However, Beazley *et al.* (2016) has developed a SDM for small gorgonians, which will be used as the area to be conserved for this species. The full target should not be applied because discrete, significant concentrations have not been identified. If truly significant concentrations are identified in the future, they could be included at the full target level. Based on benthic surveys, small gorgonians appear to be common in their own habitat in the bioregion (soft, muddy sediment) but do not tend to form dense patches like sea pens or sponges (Beazley pers. comm.).

Target range: Medium (40–60%).

Table 21. Targets for significant concentrations of small gorgonian corals in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	**2**	Small gorgonian corals are less common than sea pens and sponges in the bioregion but more common than large gorgonian corals (Beazley pers. comm.).
Vulnerability	3	*Life-history traits* (Fuller *et al.* 2008) Slow growth: **Yes** Low or sporadic recruitment: **Yes.** Significant mortality early in the benthic stage of gorgonian corals is thought to limit the abundance of adult colonies (Mortensen and Buhl- Mortensen 2004, Metaxas and Davis 2005). Long lived: **Yes.** Considered slow growing and long lived, but data is limited. Age of *Acanella arbuscula* from growth rings was estimated to be 30 years, radiocarbon dating of same individual placed it at < 100 years (Sherwood *et al.* 2009).
	3	*Fragility:* **High**
	3	Combined Vulnerability Score
Target Score = 2.55		**Target Range = (Medium-High 60–80%)**

5.4.2.4 Sea Pen Fields (*Pennatulacea*)

Type of area to be conserved: Significant concentrations of sea pens were defined by Kenchington *et al.* (2016) using kernel density analysis.

Target range: Medium-High (60–80%).

Table 22. Targets for significant concentrations of sea pens in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	**1**	**Low.** Sea pens are common in the Maritimes Region but dense sea pen fields provide structural complexity in otherwise low-relief areas (Kenchington 2014).
Vulnerability	3	*Life-history traits:* Sea pens are considered to be a highly vulnerable species (Kenchington 2014). Slow growth: **Yes.** (de Moura Neves *et al.* 2015). Low or sporadic recruitment: Unknown. Long lived: **Yes.** Sea pens are long lived with the ability to reach up to 50 years in age (Kenchington 2014).
	3	*Fragility:* **Yes.** Sea pens meet the FAO VME fragility criterion (Fuller *et al.* 2008).
	3	Combined Vulnerability Score
Target Score = 2.24		**Target Range = Medium-High (60–80%)**

5.4.2.5 Other Sponge Concentrations

Type of area to be conserved: Significant concentrations of *Porifera* (sponges) were defined by Kenchington *et al.* (2016) using kernel density. Concentrations dominated by *V. pourtalesi* were removed from the kernel density results and included as a separate conservation priority. For this exercise, it is assumed that the other sponge conservation priority is made up of the more common and less vulnerable sponges in the bioregion.

Target range: Low-Medium (20–40%).

Table 23. Targets for significant concentrations of other sponges in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	**1**	**Low.** Kenchington (2014). Sponges are common and widespread in the region so have been assigned a low uniqueness score.
Vulnerability	2	*Life-history traits:* Sponges are sessile filter-feeders that can have slow growth rates so certain species can be quite vulnerable (Kenchington 2014). However, other sponge species grow fast and are shorter-lived. Slow growth: **Yes** (Kenchington 2014) Long lived: Unknown. Low or sporadic recruitment: Unknown.
	2	*Fragility:* **Yes.** Upright forms are considered fragile.
	2	Combined Vulnerability Score
Target Score = 1.58		**Target Range = Low-Medium (20–40%)**

5.2.2.6 *Lophelia pertusa* (Coral) Reefs

Type of area to be conserved: The only known *Lophelia pertusa* reef in the bioregion has been mapped and is currently protected from bottom contact fishing. This conservation priority was not included in the exploratory MPA network analysis.

Target range: High (80–100%).

Table 24. *Targets for Lophelia pertusa reefs in the Scotian Shelf Bioregion.*

Consideration	Score	Rationale
Uniqueness/rarity	**3**	**High.** The only known living *Lophelia pertusa* reef in the Maritimes Region is located in the Stone Fence area on the eastern edge of the Scotian Shelf so this feature is regionally unique. *Lophelia* colonies have been recorded in at least two other areas in the region, including the Gully MPA, but no other reefs have been discovered.
Vulnerability	3	*Life-history traits* (Larsson *et al.* 2014). Slow growth: **Yes** Low or sporadic recruitment: **Yes.** Very limited distribution in the bioregion would suggest low recruitment. Long lived: **Yes**
	3	*Fragility:* **Yes** (Fuller *et al.* 2008).
	3	Combined Vulnerability Score
Target Score = 3.00		**Target Range = High (80–100%)**

5.2.2.7 Horse Mussel Beds (*Modiolus modiolus*)

Type of area to be conserved: The type of area to be conserved for this species is horse mussel beds. Horse mussels are known to occur in the offshore (Murillo *et al.* 2018) and some small significant concentrations were recently identified by Beazley *et al.* (2017). However, this conservation priority was not included in the exploratory MPA network analysis due to timing. An SDM has also been developed for this species so it could be included in future network design analyses.

Target range: High (80–100%).

Table 25.*Targets for significant concentrations of Horse Mussels in the Scotian Shelf Bioregion.*

Consideration	Score	Rationale
Uniqueness/ rarity	**3**	**High.** Horse Mussels are common and relatively widespread in the Scotian Shelf bioregion but distinct beds have only been identified in the Bay of Fundy so these features are considered rare or potentially unique (Kenchington 2014). The total area covered by horse mussel beds is very small (less than 12 km^2) (Kostylev *et al.* 2009, Todd *et al.* 2014).
Vulnerability	3	*Life-history traits:* Horse Mussel beds are considered to be highly vulnerable in the Bay of Fundy (Kenchington 2014). Slow growth: **Yes**. Slow growth rates and, on average, reach maturity at 4 years (Kenchington *et al.* 2006, Kenchington 2014, DFO 2015b). Low or sporadic recruitment: **Yes**. Irregular reproduction patterns (Kenchington *et al.* 2006). Long lived: **Yes**. The species can live for approximately 100 years.
	2	*Fragility:* To be confirmed through expert review.
	2.78	Combined Vulnerability Score
Target Score = 2.78		**Target Range = High (80–100%)**

5.2.2.8 Stalked Tunicate Fields (*Boltenia ovifera*)

Stalked tunicate fields (of the species *Boltenia ovifera*) occur at high densities in several areas along the Atlantic coast of Nova Scotia (Francis *et al.* 2014) and in the Bay of Fundy (Kenchington *et al.* 2007) but also occur in the offshore.

Type of area to be conserved: Significant concentrations of stalked tunicates *(Boltenia ovifera)* were defined by Beazley *et al.* (2017) using kernel density analysis. However, this data layer was not available when the exploratory MPA network analysis presented in Appendix C was completed. An initial SDM has also been developed for this species by Beazley *et al.* (2017) and could be included in future iterations of this process.

Target range: High (80–100%).

Table 26.Targets for significant concentrations of Stalked Tunicates (Boltenia ovifera) in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	**3**	Kenchington (2014) classifies Stalked Tunicate fields as highly unique in the Maritimes Region.
Vulnerability	2	*Life-history traits:* Kenchington (2014) classifies Stalked Tunicate fields as medium-high in terms of vulnerability. They are sessile and appear to be habitat specialists (preferring hard substrata for settlement and attachment) (DFO 2015b). Slow growth: Unknown. Low or sporadic recruitment: Unknown. Long lived: Unknown. Plough (1969) suggested that the minimum lifespan in the Gulf of Maine is 3 years but these results are not definitive.
	3	*Fragility:* **Yes.** The species is fragile with poor regeneration abilities (Murillo *et al.* 2011, Francis *et al.* 2014).
	2.78	Combined Vulnerability Score
Target Score = 2.78		**Target Range = High (80–100%)**

5.2.2.9 Soft Coral Gardens (*Alcyonacea*)

Type of area to be conserved: Significant concentrations will be identified based on an SDM that is in development. This conservation priority was not included in the exploratory MPA network design analysis presented in Section 6 because the spatial layer is not complete.

Target range: Low (10–20%).

Table 27.Targets for significant concentrations of soft corals in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	1	Soft corals are not considered unique in the Maritimes Region (Kenchington 2014).

Consideration	Score	Rationale
Vulnerability	1	*Life-history traits:* Soft corals are not considered vulnerable in the Maritimes Region (Kenchington 2014). Soft corals are sessile, long-living species that have a relatively fast growth and recruitment rate (DFO 2006, Edinger *et al.* 2011). They are able to withstand repeated disturbance (Kenchington 2014). Slow growth: **No**. Low or sporadic recruitment: **No**. Long lived: **Yes.**
	1	*Fragility:* To be confirmed through expert review.
	1	Combined Vulnerability Score
Target Score = 1		**Target Range = Low (10–20%)**

5.2.2.10 Crinoid Beds (*Conocrinus lofotensis*)

Type of area to be conserved: Significant concentrations will be identified based on an SDM that is in development. This conservation priority was not included in the exploratory MPA network design analysis presented in Section 6 because the spatial layer is not complete.

Target range: Medium-High (60–80%).

Table 28.Targets for significant concentrations of Crinoids (Conocrinus lofotensis) in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	**2**	The degree of uniqueness of Crinoids beds is not known in the Maritimes Region (Kenchington 2014) but significant concentrations are considered distinct from other areas.
Vulnerability	2	*Life-history traits:* Kenchington (2014) states that Crinoid beds are highly vulnerable because they are sessile, fragile and can live up to 20 years. However, they have a relatively high growth rate and regeneration ability (Murillo *et al.* 2011). Slow growth: **No.** Low or sporadic recruitment: To be determined through literature review and consultation with experts. Long lived: **High**.
	3	*Fragility:* **Yes**.
	2.29	Combined Vulnerability Score
Target Score = 2.29		**Target Range = Medium-High (60–80%)**

5.2.2.11 Tube-dwelling Anemone Fields (*Pachycerianthus borealis*)

Type of area to be conserved: Significant concentrations will be identified based on an SDM that is in development. This conservation priority was not included in the exploratory MPA network design analysis presented in Section 6 because the spatial layer is not complete.

Target range: Medium (40–60%).

Table 29.Targets for significant concentrations of Tube-dwelling Anemones (Pachycerianthus borealis) in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Uniqueness/ rarity	**2**	The uniqueness of Tube-dwelling Anemones has been categorized as medium (Kenchington 2014). Significant concentrations are considered distinct from other areas.
Vulnerability	2	*Life-history traits:* The vulnerability of Tube-dwelling Anemones has been categorized as medium (Kenchington 2014) Tube-dwelling Anemones are a sessile, filter feeding species. Little is known about their life history, but one report has stated a lifespan between 11 to 20 years (Fuller *et al.* 2008). Slow growth: To be determined through literature review and consultation with experts. Low or sporadic recruitment: To be determined through literature review and consultation with experts. Long lived: **Yes**.
	2	*Fragility:* **Medium**
	2	Combined Vulnerability Score
Target Score = 2		**Target Range = Medium (40–60%)**

5.4.3 Design Strategies for Depleted Species

The initial list of offshore depleted species for the Scotian Shelf Bioregion (Appendix A, Table A2) includes any species that is listed as Endangered, Threatened, or Special Concern by COSEWIC. For fishes, the list also includes species that are in the Critical or Cautious zone under the DFO Precautionary Approach Framework or at biomass levels that are less than forty percent of the long-term mean (i.e., ocean pout). Many of the depleted species in the initial list were not included in the MPA network analysis due to a lack of sufficient data. Where appropriate, these species may still be considered at the individual MPA design and establishment stage of this process.

All of the depleted species on the initial list are mobile and many have quite large area requirements (e.g., North Atlantic Right Whale, Leatherback Sea Turtle). The MPA network will not aim to protect the entire range of these species. Rather, the focus will be on spatially discrete areas where a species aggregates in high densities either year round or at certain times of the year. If these important areas have not been identified, the targets cannot be fully applied. In cases where broad distribution information (e.g., a SDM) is the best available information, a lower target can be assigned to ensure that the depleted species receives some representation within the MPA network. Certain depleted species may not aggregate in specific areas in the bioregion or their aggregation areas may be quite broad. These species are less suitable for spatial approaches to protection but may still be included in the network design analysis but at a lower target. The area to be conserved for most depleted species will be important habitats but in certain cases it will be a proportion of the broader distribution. Vulnerability and current status were the two factors used to develop targets for depleted species.

5.4.3.1 Cetaceans

Based on demography, COSEWIC status, and spatial correlation analysis of SDM results (Gomez *et al.* 2017) five cetacean species were identified as conservation priorities for the Scotian Shelf bioregional MPA network: Northern Bottlenose Whale, North Atlantic Right Whale, Blue Whale, Fin Whale, and Harbour Porpoise. Collectively, these species may also serve as indicator or umbrella species for other cetaceans in the bioregion. For example, Fin Whale is an indicator species for Sei Whale, Minke Whale, and Humpback Whale (Gomez *et al.* 2017). Protecting the five priority species could, therefore, offer protection and enhanced monitoring for many other cetaceans in the bioregion.

Of the five priority cetacean species, important habitats have only been identified for Northern Bottlenose Whale and North Atlantic Right Whale. In fact, official Critical Habitat has been designated for both of these species under the *Species at Risk Act*. Important habitats have not been identified for the other cetacean species, which represents a significant data gap in this process. In cases where important habitats have not been defined, modelled species distributions developed by Gomez *et al.* (2017) may be used as a substitute but targets should be reduced. Applying the full target to a large area to be conserved would have a major influence on the configuration and extent of the MPA network.

The areas to be conserved for cetaceans are, therefore, either Critical Habitats or predicted species distributions. The species distribution modelling approach is described in Gomez *et al.* (2017). Target scores for cetaceans were based on vulnerability and current status. Most cetaceans are considered highly vulnerable due to their inherent physiological characteristics. The current status was simple to score for this group because they are all listed under COSEWIC.

Northern Bottlenose Whale

Type of area to be conserved: Critical Habitat areas designated under the *Species at Risk Act* (the Gully, Shortland Canyon, and Haldimand Canyon I [987 km^2]). Most of the population resides in these three large canyons on the shelf edge (Whitehead and Hooker 2012).

Target range: High (80–100%).

Table 30.Targets for Northern Bottlenose Whale Critical Habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** The Northern Bottlenose Whale is a long-lived species with individuals living for approximately 30–40 years (DFO 2010b). Females give birth to a single calf and it is suggested that the breeding cycle is 2 years; however, this has not been examined in detail (DFO 2010b, Harris *et al.* 2013). Males in the populations off Iceland reach maturity between 7–9 years, while females reach maturity at 8–12 years off Labrador (DFO 2010b).
Current Status	3	This population of Northern Bottlenose Whale is listed as **Endangered** by COSEWIC and under SARA (DFO 2010b).
Target Score = 3.00		**Target Range = High (80–100%)**

North Atlantic Right Whale

Type of area to be conserved: Critical Habitat areas designated under the *Species at Risk Act* (Grand Manan Basin and Roseway Basin [4036 km^2]).

Target range: High (80–100%).

Table 31.Targets for North Atlantic Right Whale Critical Habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** North Atlantic Right Whales (NARW) are large bodied, long lived, have low fecundity, aggregate spatially, migrate thousands of kilometers, and feed at the ocean surface so they are considered highly vulnerable (Brown *et al.* 2009). NARW have low reproductive rates and a 14-month gestation period is suggested (Cole *et al.* 2013). The life span of this species is unknown, although the oldest individual on record was estimated to be 90 years of age (Smedbol 2007). It is approximated that females reach maturity around nine years of age while the age of maturity for males is unknown (Smedbol 2007). Individual Right Whales are highly mobile during their migrations, departing and returning to different habitats within their north-temperate region between May to October (Brilliant *et al.* 2015).
Current Status	3	The NARW is listed as **Endangered** by COSEWIC and under SARA (Brown *et al.* 2009).
Target Score = 3.00		**Target Range = High (80–100%)**

Blue Whale

Type of area to be conserved: Important habitats have not been identified for this species so the full target will not be applied. Gomez *et al.* (2017) have developed an SDM for this species that will be used as the area to be conserved but the target will be significantly reduced.

Target range: High (80–100%).

Table 32.Targets for Blue Whale Critical Habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** Blue Whales mate and calve from late fall to mid-winter. They reach sexual maturity between 5–15 years of age (Sears and Calambokidis 2002). Blue Whales have low calving (a single calf every 2–3 years) and recruitment rates (Sears and Calambokidis 2002, COSEWIC 2012a). Blue Whales are thought to live between 70–80 years (Sears and Calambokidis 2002). The species is highly migratory moving from the subtropics to northern North Atlantic waters.
Current Status	3	The Blue Whale is listed as **Endangered** by COSEWIC and under SARA.
Target Score = 3.00		**Target Range = High (80–100%)**

Fin Whale

Type of area to be conserved: Important habitats have not been delineated for this species so the full target will not be applied. Gomez *et al.* (2017) have developed spring and summer SDMs for this species that will be used as the area to be conserved but the target will be significantly reduced. It should be noted that fin whales are known to aggregate in areas of upwelling and convergent fronts where high density of prey can be found (Breeze *et al.* 2002). These areas may include the shelf edge between Emerald and LaHave banks, shelf basins and the outer Bay of Fundy (Breeze *et al.* 2002, Woodley and Gaskin 1996). If surveys confirm the importance of these areas, they could be used as the areas to be conserved in future iterations of this process. Fin Whale aggregations have also been noted in coastal waters around the Sambro Ledges and Canso Ledges (Hastings *et al.* 2014).

Target range: Medium-High (60–80%).

Table 33.Targets for important Fin Whale habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** Fin Whales reach sexual maturity at 5–15 years of age and physical maturity at 25 years of age (COSEWIC 2005). It is estimated that the potential interbirth interval is 2.24 years (12-month gestation, weaning 6–7 months, and 6 month resting period) (COSEWIC 2005). Maximum life span may be as high as 100 years (COSEWIC 2005). The Fin Whale is a migratory species moving from southern wintering grounds to high-latitude productive areas where they spend the summer feeding (COSEWIC 2005).
Current Status	1	This species is listed by COSEWIC (last assessed May 2005) and under SARA as **Special Concern**.
Target Score = 2.23		**Target Range = Medium-High (60–80%)**

Harbour Porpoise

Type of area to be conserved: Important habitats have not been delineated for this species so the full target will not be applied. Gomez *et al.* (2017) have developed summer and fall SDMs for this species that will be used as the area to be conserved but the target will be significantly reduced.

Target range: Low (10–20%).

Table 34.Targets for important Harbor Porpoise habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	1	**Low.** Harbour Porpoises reach sexual maturity at a relatively early age (estimated at 3.44 years) and have high fecundity (COSEWIC 2006a). Reproduction is seasonal, limited to a few months in the summer (COSEWIC 2006a). It is estimated that the species is short lived, with few individuals living past their teens (COSEWIC 2006a). Highly mobile species. May aggregate in specific areas for days or weeks and then rapidly move to other suitable habitat.
Current Status	1	Listed by COSEWIC as **Special Concern** (last assessed April 2006). Not designated under SARA.
CV Score = 1.00		**Target Range = Low (10–20%)**

Sowerby’s Beaked Whale

Type of area to be conserved: Available data did not support the development of an SDM for this species (Gomez *et al.* 2017), so it was not included in the exploratory MPA network design scenarios presented in Section 6.

Target range: Medium-High (60–80%).

Table 35. Targets for important Sowerby's Beaked Whale habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** Assumed to be long lived, slow growing, late to mature and produce few offspring.
Current Status	1	Listed as **Special Concern** by COSEWIC (2006a).
Target Score = 2.23		**Target Range = Medium-High (60–80%)**

5.4.3.2 Turtles

Due to data limitations, neither turtle species have been included in the exploratory MPA network design scenarios presented in Section 6. However, the approach to setting targets was still applied.

Leatherback Turtle

Type of area to be conserved: Critical Habitat for this species has been proposed but it is very broadly defined so applying the full target to this feature would have a strong influence on the extent and configuration of the MPA network.

Target range: High (80–100%).

Table 36. Targets for Leatherback Turtle Critical Habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** Leatherback Turtles are long-distance pelagic migrators that can cover over 10,000 km/year (COSEWIC 2012b). While feeding, they exhibit a slow, sinuous swimming behaviour (Dodge *et al.* 2014). Slow to mature. Exact age at maturity is uncertain, estimated between 16–29 years (COSEWIC 2012b). Females nest in the tropics on average six times in one nesting period, with nesting periods occurring every two to three years (Breeze *et al.* 2002).
Current Status	3	This species is listed as **Endangered** by COSEWIC (last assessed May 2012) and under SARA.
CV Score = 3.00		**Target Range = High (80–100%)**

Loggerhead Turtle

Type of area to be conserved: Sufficient data not available.

Target range: High (80–100%).

Table 37. Targets for important Loggerhead Turtle habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** Loggerhead Turtles nest in the tropics on a 2–3 year interval, laying 112 eggs in each three to four clutches (COSEWIC 2010a). The species reaches sexual maturity around 16–34 years, with longevity being approximately 46 years (COSEWIC 2010a). Loggerhead sea turtles are highly migratory.
Current Status	3	COSEWIC has listed this species as **Endangered** (last assessed April 2010). This species is not listed under SARA.
Target Score = 3.00		**Target Range = High (80–100%)**

5.4.3.3 Sharks

Due to data limitations, none of the shark species have been included in the exploratory MPA network design scenarios presented in Section 6. However, the approach to setting targets was still applied as these species could be included in future iterations of this process if information on important habitats for these species becomes available.

Porbeagle Shark

Type of area to be conserved: Sufficient data are not available. This species is widely distributed inshore and offshore, with distribution limited only by salinity and temperature, preferring cooler and saltier water masses (Campana *et al.* 2015b).

Target range: High (80–100%).

Table 38.Targets for important Porbeagle Shark habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 66 (Cheung *et al.* 2007). Porbeagle Sharks have a low fecundity, late age of sexual maturation, and low natural mortality (Zwanenburg *et al.* 2006). Females mature at 13 years and males mature at 8 years. Porbeagle life span is between 25 and 46 years and generation time is about 18 years (Campana *et al.* 2002). This species is highly mobile.
Current Status	3	COSEWIC has listed this species as **Endangered** (last assessed April 2010). This species is not listed under SARA.
CV Score = 3.00		**Target Range = High (80–100%)**

White Shark

Type of area to be conserved: Sufficient data are not available. This species is widely distributed across Atlantic Canadian waters with no known areas of particularly important habitat. It is thought to be a highly migratory species based on satellite tracking from other jurisdictions (COSEWIC 2006c).

Target range High (80–100%).

Table 39.Targets for important White Shark habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 64 (Cheung *et al.* 2007). Male White Sharks reach sexual maturity between ages 8–10 and females reach maturity between 12–18 years; longevity is estimated to be between 23–60 years. White Shark fecundity increases with size of the female, with a litter that generally varies between 2 and 10. Length of reproductive cycle is unknown but assumed to have about 3 years between pregnancies. Survival of pups is said to be low (COSEWIC 2006c).
Current Status	3	This species is listed as **Endangered** by COSEWIC (last assessed May 2012) and under SARA.
CV Score = 3.00		**Target Range = High (80–100%)**

Blue Shark

Type of area to be conserved: Sufficient data are not available. Blue Sharks have a wide distribution, preferring temperatures between 10–25°C (Nakano and Stevens 2008). They are likely the most common large shark in Canadian waters (Zwananburg *et al.* 2006).

Target range: Medium-High (60–80%).

Table 40.Targets for important Blue Shark habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 77 (Cheung *et al.* 2007). Blue Sharks are considered highly migratory with a single well-mixed population in the North Atlantic (Campana *et al.* 2011). Blue Sharks are a viviparous species, with males reaching maturity at 4–6 years and female at 5–7 years (Campana *et al.* 2015a). Generation time between each litter is approximately 8.1 years (COSEWIC 2006d). Assumed lifespan is between 16–20 years of age (COSEWIC 2006d).
Current Status	1	COSEWIC has listed this species as **Special Concern** (last assessed April 2006 – re-assessment scheduled for April 2016). This species is not listed under SARA.
Target Score = 2.23		**Target Range = Medium-High (60–80%)**

Basking Shark

Type of area to be conserved: Sufficient data are not available. They are widely distributed on the Scotian Shelf and in the Bay of Fundy (DFO 2008). Basking Sharks are highlight migratory, following individual paths rather than travelling in a group or along regular routes. It is suggested that Basking Sharks embark on transoceanic migration (Gore *et al.* 2008). Dense aggregations of Basking Sharks have been noted at the entrance to the Bay of Fundy (COSEWIC 2009b) so this species will be considered in the coastal MPA network design process.

Target range: Low-Medium (20–40%).

Table 41.Targets for important Basking Shark habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	2	**Medium.** IVI score: 54 (Cheung *et al.* 2007). Basking Sharks have a late age of maturity, low fecundity, long gestation period, long periods between gestations, surface behaviour, and naturally small populations (COSEWIC 2009b).
Current Status	1	COSEWIC has listed this species as **Special Concern** (last assessed November 2009). This species is not listed under SARA.
CV Score = 1.58		**Target Range = Low-Medium (20–40%)**

Shortfin Mako Shark

Type of area to be conserved: Sufficient data are not available to map important habitats for this species. The Shortfin Mako Shark is a highly migratory species that can be found in Atlantic Canadian waters during summer and fall, preferring temperatures between 17–22°C (COSEWIC 2017).

Target range: Medium-High (60–80%).

Table 42.Targets for important Shortfin Mako Shark habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 76 (Cheung *et al.* 2007). The Shortfin Mako Shark is considered a low productivity species (COSEWIC 2017). The estimated age at which half the individuals reach maturity is 8 years and 18 years for females. Shortfin mako is a viviparous species that usually has 11 pups every three years.
Current Status	1	COSEWIC has listed this species as **Special Concern** (last assessed in 2017). This species is not listed under SARA.
Target Score = 2.23		**Target Range = Medium-High (60–80%)**

5.4.3.4 Demersal Fishes

For all but one depleted demersal fish species, the areas or features to be conserved by the Scotian Shelf bioregional MPA network are termed *important habitats*. These areas have been defined through an analysis of the DFO research vessel survey data using the method described by Horsman and Shackell (2009). This method simply creates a relative distribution map (based on biomass caught in the survey) for each species and identifies the areas of highest biomass as important habitats. Thus, the spatial data layer that goes into the network design analysis does not represent the full distribution of a species. Summer survey data were used for the current exercise but historical fall and spring data are also available. The vulnerability and current status factors were considered in developing targets for depleted demersal fishes.

Atlantic Cod

Atlantic Cod is a widely distributed demersal fish species that occurs in a variety of habitats throughout the Scotian Shelf Bioregion.

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]). For Atlantic Cod, important habitats were identified for three distinct populations (Western Scotian Shelf, Eastern Scotian Shelf, Sydney Bight). Targets were set for each population.

Target range: Medium-High (60–80%).

Table 43.Targets for important Atlantic Cod habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	2	**Medium.** IVI score: 52 (Cheung *et al.* 2007).
Current Status	3	COSEWIC has list the Scotian Southern population and the Laurentian South population of Atlantic Cod as **Endangered** (last assessed April 2010). This species is not listed under SARA.
CV Score = 2.55		**Target Range = Medium-High (60–80%)**

Redfish (Unit 2)

Redfish within Unit 2 are widely distributed within the Gulf of St. Lawrence and Laurentian Channel. This management unit includes two species: Deepwater Redfish (*Sebastes mentella*) and Acadian Redfish (*Sebastes fasciatus*).

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]).

Target range: Low-Medium (20–40%).

Table 44.Targets for important Redfish (Unit 2) habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	2	**Medium.** IVI score: 58 (Cheung *et al.* 2007). Redfish have a long lifespan (up to 75 years), slow growth, and recruitment range between 5 and 12 years (Branton 1999, COSEWIC 2010b). Redfish are viviparous, with a fecundity between 1,500 and 107,000 larvae (COSEWIC 2010b).
Current Status	1	The latest COSEWIC assessment listed Acadian Redfish and Deepwater Redfish as Threatened (last assessed April 2010). These species are not listed under SARA. However, DFO Science recently assessed these species and found that Deepwater Redfish is now in the Healthy Zone under the Precautionary Approach Framework (DFO 2018) but Acadian Redfish is in the **Cautious Zone**, so this species was assigned a current status score of 1.
Target Score = 1.58		**Target Range = Low-Medium (20–40%)**

Eastern Scotian Shelf Winter Skate

On the Eastern Scotian Shelf, Winter Skate are found at relatively shallow (< 100m) depths on central and northeastern banks such as Western and Banquereau banks, the Gully, on the western margin of the Laurentian Channel, and in the central region of the Laurentian Channel between 200–400m (Scott 1982, COSEWIC, 2015, Ward-Paige and Bundy 2016).

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]).

Target range: High (80–100%).

Table 45.Targets for important Winter Skate habitat (Eastern Scotian Shelf) in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 72 (Cheung *et al.* 2007). This species has a slow rate of growth and a generation time of 18 years (COSEWIC 2015). They have a late age of maturity and low rate of reproduction (COSEWIC 2015). Maximum calculated age has been found to be between 19.5 and 20.5 years (Frisk and Miller 2005). Winter Skate deposit 40–70 eggs annually (COSEWIC 2015). It is suggested that Sable Island Bank may be a spawning area (Simon and Frank 2000).
Current Status	3	COSEWIC has listed the Eastern Scotian Shelf population as Endangered (last assessed May 2015). This species has not been listed by SARA.
Target Score = 3.00		**Target Range = High (80–100%)**

American Plaice

Type of area to be conserved: Important summer habitat areas (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]). American Plaice is a widespread spawner but concentrations are found on Sable Island, Banguereau, Western and Browns banks (Ollerhead 2007, COSEWIC 2009c).

Target range: Low-Medium (20–40%).

Table 46. Targets for important American Plaice habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	1	**Low.** IVI score: 29 (Cheung *et al.* 2007). Age of maturity for American Plaice has declined over the past several decades from 10–11 years to 6–8 years (COSEWIC 2009c). Fecundity is highly variable over time and across areas (COSEWIC 2009c). This species is a batch spawner with as many as 10 batches. American Plaice can tolerate a wide range of environmental conditions (COSEWIC 2009c).
Current Status	2	COSEWIC has listed this species as **Threatened** (last assessed April 2009). This species is not listed under SARA.
Target Score = 1.58		**Target Range = Low-Medium (20–40%)**

Cusk (*Brosme brosme*)

Cusk is a large, relatively slow-growing, bottom-living fish that does not form large aggregations (COSEWIC 2012c).

Type of area to be conserved: The DFO research vessel survey does not sample the full extent of Cusk habitat in the Scotian Shelf Bioregion (DFO 2014b) so these data were not used to map important habitats for this species. A SDM developed by DFO (2014b) has been used as the area to conserve for this species in this process. The model does not identify important habitats, so targets for this species may need to be tempered.

Target range: Low-Medium (20–40%).

Table 47. Targets for important Cusk habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	2	**Medium.** IVI score: 54 (Cheung *et al.* 2007). Cusk are relatively late to mature (around age 10) but have high fecundity (DFO 2014b). Cusk do not undergo extensive local movements, seasonal or spawning migrations (COSEWIC 2012c). There is limited adult migration across deep water regions, limited inter-site exchange of pelagic eggs and larvae due to site-specific circulatory retention and poor survival during drift phases across deep basins (COSEWIC 2012c).
Current Status	1	Cusk was listed as Endangered by COSEWIC in 2012 (COSEWIC 2012c) but is currently in the **Cautious Zone** under the Precautionary Approach Framework (DFO 2016b).
Target Score = 1.58		**Target Range = Low-Medium (20–40%)**

White Hake

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]). In the Scotian Shelf Bioregion, White Hake can be found along the shelf edges, especially along the Laurentian Channel and near the Gully. This species is also found in LaHave and Emerald basins, and in deep waters around Georges Bank extending into the Bay of Fundy (Breeze *et al.* 2002, COSEWIC 2013, Simon and Cook 2013, Ward-Paige and Bundy 2016). Concentrations of spawning fish have been found on Emerald and Western banks during July (Ollerhead 2007).

Target range: Medium (40–60%).

Table 48.*Targets for important White Hake habitat in the Scotian Shelf Bioregion.*

Consideration	Score	Rationale
Vulnerability	2	**Medium.** IVI score: 41 (Cheung *et al.* 2007). White Hake are a slow-swimming long lived (about 20 years) demersal species that are highly fecund (Bundy and Simon 2005, Roy *et al.* 2012, COSEWIC 2013).
Current Status	2	COSEWIC has listed this species as **Threatened** (last assessed November 2013). This species has not been assessed by SARA.
Target Score = 2.00		**Target Range = Medium (40–60%)**

Smooth Skate

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]). On the eastern shelf, concentrations of this species are found in the Laurentian Channel and on Banquereau and Sable Island banks (COSEWIC 2012d, Ward-Paige and Bundy 2016). Smooth Skate is also found on Georges Bank, in Roseway Basin, and in the Bay of Fundy (Simon *et al.* 2011, COSEWIC 2012d, Ward-Paige and Bundy 2016).

Target range: Medium-High (60–80%).

Table 49.Targets for important Smooth Skate habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 72 (Cheung *et al.* 2007). Smooth Skates are long lived, slow growing, and slow to reproduce (40–100 large egg capsules per year) (COSEWIC, 2012d).
Current Status	1	COSEWIC has listed this species as **Special Concern** (last assessed May 2012). This species is not listed under SARA.
Target Score = 2.23		**Target Range = Medium-High (60–80%)**

Atlantic Wolffish

Atlantic Wolffish are widely distributed across the Scotian Shelf, Georges Bank, and into the Bay of Fundy.

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]). Concentrations have been noted on the western Scotian Shelf, in the area of Roseway, LaHave, and Browns banks, Bay of Fundy, and on the eastern Scotian Shelf (Simon *et al.* 2012, Collins *et al.* 2015, DFO 2015c, Ward-Paige and Bundy 2016).

Target range: Medium-High (60–80%).

Table 50.Targets for important Atlantic Wolffish habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 78 (Cheung *et al.* 2007). Atlantic Wolffish are a large demersal non-schooling fish that prefers hard substrates (McRuer *et al.* 2000). The species is considered sedentary but can make migrations between offshore and inshore for spawning (COSEWIC 2012e). The species is not considered highly fecund but there is a high egg survival rate (McRuer *et al.* 2000).

Consideration	Score	Rationale
Current Status	1	COSEWIC has listed this species as **Special Concern** (last assessed November 2012). This species is not listed under SARA.
Target Score = 2.23		**Target Range = Medium-High (60–80%)**

Thorny Skate

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]).

Target range: Low-Medium (20–40%).

Table 51.Targets for important Thorny Skate habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	2	**Medium.** IVI score: 57 (Cheung *et al.* 2007). Thorny Skates are a slow growing, late-maturing species with a lifespan between 16–20 years (COSEWIC 2012f). Thorny Skate fecundity is estimated at 40.5 eggs per year with a success of 38% (COSEWIC 2012f).
Current Status	1	COSEWIC has listed this species as **Special Concern** (last assessed May 2012). This species is not listed under SARA.
Target Score = 1.58		**Target Range = Low-Medium (20–40%)**

Spiny Dogfish

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]). Spiny Dogfish tend to concentrated on the western Scotian Shelf (Bundy 2004). Abundance of this species is highest in the deeper waters in the approaches to the Bay of Fundy and off southwest Nova Scotia (Ward-Paige and Bundy 2016).

Target range: Medium-High (60–80%).

Table 52.Targets for important Spiny Dogfish habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 62 (Cheung *et al.* 2007). Spiny Dogfish are a slow growing, low fecundity, ovoviviparous species that are thought to live to approximately 40 years (McRuer and Hurlbut 1996). They are thought to have low productivity as females mature between 11–17 years and, therefore, many do not make it to that age (DFO 2014b).
Current Status	1	COSEWIC has listed this species as **Special Concern** (last assessed April 2010). This species has not been listed under SARA.
Target Score = 2.23		**Target Range = Medium-High (60–80%)**

Ocean Pout

Type of area to be conserved: Important summer habitat (defined based on DFO research vessel survey data using method used in Horsman and Shackell [2009]).

Target range: Low-Medium (20–40%).

Table 53.Targets for important Ocean Pout habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	1	**Low.** IVI score: 31 (Cheung *et al.* 2007).
Current Status	2	Below 40% of long-term mean (Clark and Emberley 2011).
Target Score = 1.58		**Target Range = Low-Medium (20–40%)**

Roundnose Grenadier

Type of area to be conserved: Important habitat has not been defined at this time so this species was not included in the initial MPA network design analysis. It will be included in future iterations of this process.

Target range: High (80–100%).

Table 54.Targets for important Roundnose Grenadier habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 75 (Cheung *et al.* 2007).
Current Status	3	COSEWIC (2008) has listed this species as **Endangered**. This species has not been listed under SARA.
Target Score = 3.00		**Target Range = High (80–100%)**

Roughhead Grenadier

Type of area to be conserved: Important habitat has not been defined at this time so this species was not included in the initial MPA network design analysis. It will be included in future iterations of this process.

Target range: Medium-High (60–80%).

Table 55.Targets for important Roughhead Grenadier habitat in the Scotian Shelf Bioregion.

Consideration	Score	Rationale
Vulnerability	3	**High.** IVI score: 70 (Cheung *et al.* 2007).
Current Status	1	COSEWIC (2007) has listed this species as **Special Concern**. This species has not been listed under SARA.
Target Score = 2.23		**Target Range = Medium-High (60–80%)**

5.5 SUMMARY OF OFFSHORE CONSERVATION TARGETS

The final list of targets for the conservation priorities for the Scotian Shelf bioregional MPA network are presented below (Table 56 and Table 57). Many of the conservation priorities described in the previous section were not included in the exploratory analyses (Appendix C) due to data limitations (e.g., Porbeagle Shark, Blue Whale).

Table 56. Preliminary conservation targets for coarse-filter offshore conservation priorities of the Scotian Shelf bioregional MPA network.

Oceanographic Units Conservation Priorities	Targets (Low)	Targets (High)
Gulf of Maine	10	30
Baccaro and LaHave banks	11	38
LaHave and Emerald basins	10	26
Western and Sable Island banks	10	31
Eastern Scotian Shelf	10	22
Laurentian Slope	10	34
Slope, Rise and Abyss	10	10

Geomorphic Units Conservation Priorities	Targets (Low)	Targets (High)
Abyssal Plain	10	11
Continental Rise	10	10
Shelf Bank	10	14
Shelf Basin	10	32
Shelf Channel	12	39
Shelf Flat	10	19
Shelf Topo. Complex	10	30
Shelf Topo. Complex Bank	10	25
Shelf Topo. Complex Basin	16	54
Slope	11	35
Abyssal Plain	10	11

Scope for Growth Classes Conservation Priorities	Targets (Low)	Targets (High)
Very low scope for growth	10	15
Low scope for growth	10	10
Moderate scope for growth	10	13
High scope for growth	10	20
Very high scope for growth	10	19

Natural Disturbance Classes Conservation Priorities	Targets (Low)	Targets (High)
Very low natural disturbance	10	28
Low natural disturbance	10	22
Medium natural disturbance	10	17
High natural disturbance	10	27

Groundfish Functional Groups Conservation Priorities	Targets (Low)	Targets (High)
Small and Medium Benthic Piscivores (East)	10	10
Small and Medium Benthic Piscivores (West)	12	17
Large Benthic Piscivores (East)	10	11
Large Benthic Piscivores (West)	10	17
Small and Medium Pelagic Piscivores (East)	10	21
Small and Medium Pelagic Piscivores (West)	0	0
Small Benthic Benthivores (East)	10	13
Small Benthic Benthivores (West)	10	22
Medium Benthic Benthivores (East)	10	11
Medium Benthic Benthivores (West)	10	17
Large Benthic Benthivores (East)	10	12
Large Benthic Benthivores (West)	10	16
Small, Medium, and Large Pelagic Planktivores (East)	10	14
Small, Medium, and Large Pelagic Planktivores (West)	10	18
Small, Medium, and Large Benthic Zoopiscivore (East)	10	15
Small, Medium, and Large Benthic Zoopiscivore (West)	10	17
Small, Medium, and Large Pelagic Zoopiscivore (East)	10	24
Small, Medium, and Large Pelagic Zoopiscivore (West)	10	33

Invertebrate Functional Groups Conservation Priorities	Targets (Low)	Targets (High)
Small Benthic Benthivores (East)	10	10
Small Benthic Benthivores (West)	10	15
Medium Benthic Benthivores (East)	10	10
Medium Benthic Benthivores (West)	10	15
Small, Medium, and Large Zoopiscivores (East)	10	31
Small, Medium, and Large Zoopiscivores (West)	10	16
Benthic Colonial Filter Feeders (East)	10	18
Benthic Colonial Filter Feeders (West)	0	0
Benthic Non-Colonial Filter Feeders (East)	10	10
Benthic Non-Colonial Filter Feeders (West)	10	20
Detritivores (East)	10	14
Detritivores (West)	10	27

Seabird Functional Groups

Seabird Functional Groups Conservation Priorities	Targets (Low)	Targets (High)
Surface-Seizing Planktivores	10	27
Surface Shallow-Diving Piscivore/Generalists	10	11
Surface Shallow-Diving Coastal Piscivores	10	24
Pursuit-Diving Piscivores	10	13
Shallow Pursuit Generalists	10	10

Seabird Functional Groups Conservation Priorities	Targets (Low)	Targets (High)
Pursuit-Diving Planktivore	10	14
Plunge-Diving Piscivores	10	10
Ship-Following Generalists	10	13

Table 57. Summary of preliminary conservation target ranges for fine-filter offshore conservation priorities of the Scotian Shelf bioregional MPA network.

Areas of High Species Richness Conservation Priorities	Uniqueness/ Rarity	Vulnerability	Current Status	Score	Target Range
Areas of high fish species richness	NA	NA	NA	NA	Low-Medium (20–40%)
Areas of high invertebrate species richness	NA	NA	NA	NA	Low-Medium (20–40%)
Areas of high small fish species richness	NA	NA	NA	NA	Low-Medium (20–40%)
Areas of high small invertebrate species richness	NA	NA	NA	NA	Low-Medium (20–40%)
Areas of high ichthyoplankton species richness	NA	NA	NA	NA	Low-Medium (20–40%)

Biogenic Habitats Conservation Priorities	Uniqueness/ Rarity	Vulnerability	Current Status	Score	Target Range
Vazella pourtalesi (sponge) concentrations	3	3	NA	3	High 80–100%
Large gorgonian coral concentrations	3	3	NA	3	High 80–100%
Small gorgonian coral concentrations	2	2	N/A	2	Medium-High 60–80%
Other sponge concentrations	1	2	N/A	1.58	Low-Medium 20–40%
Sea pen fields	1	3	N/A	2.24	Medium-High 60–80%
Lophelia pertusa (coral) reefs	3	3	N/A	3	High 80–100%
Horse Mussel beds	3	2.54	N/A	2.78	High 80–100%
Stalked tunicate fields	3	2.54	N/A	2.78	High 80–100%
Soft coral gardens	1	1	N/A	1	Low 10–20%
Crinoid beds	2	2.54	N/A	2.29	Medium-High 60–80%
Tube-dwelling Anemone fields	2	2	N/A	2	Medium 40–60%

Depleted Species Conservation Priorities	Uniqueness/ Rarity	Vulnerability	Current Status	Score	Target Range
Northern Bottlenose Whale	N/A	3	3	3	High 80–100%
North Atlantic Right Whale	N/A	3	3	3	High 80–100%
Blue Whale	N/A	3	3	3	High 80–100%
Fin Whale	N/A	3	1	2.23	Medium-High 60–80%
Sowerby's Beaked Whale	N/A	3	1	2.23	Medium-High 60–80%
Harbour Porpoise	N/A	1	1	1	Low 10–20%
Leatherback Turtle	N/A	3	3	3	High 80–100%
Loggerhead Turtle	N/A	3	3	3	High 80–100%
Porbeagle Shark	N/A	3	3	3	High 80–100%
White Shark	N/A	3	3	3	High 80–100%
Blue Shark	N/A	3	1	2.23	Medium-High 60–80%
Basking Shark	N/A	2	1	1.58	Low-Medium 20–40%
Shortfin Mako Shark	N/A	3	1	2.23	Medium-High 60–80%
Atlantic Cod	N/A	2	3	2.55	Medium-High 60–80%
Redfish (Unit 2)	N/A	2	2	2	Low-Medium 20–40%
Winter Skate	N/A	3	3	3	High 80–100%
American Plaice	N/A	1	2	1.58	Low-Medium 20–40%
Cusk	N/A	2	1	1.58	Low-Medium 20–40%
White Hake	N/A	2	2	2	Medium 40–60%
Smooth Skate	N/A	3	1	2.23	Medium-High 60–80%
Atlantic Wolffish	N/A	3	1	2.23	Medium-High 60–80%
Thorny Skate	N/A	2	1	1.58	Low-Medium 20–40%
Spiny Dogfish	N/A	3	1	2.23	Medium-High 60–80%
Roundnose Grenadier	N/A	3	3	1.58	High 80–100%
Roughhead Grenadier	N/A	3	1	2.23	Medium-High 60–80%
Ocean Pout	N/A	1	2	1.58	Low-Medium 20–40%

6.0 DISCUSSION AND NEXT STEPS

6.1 OFFSHORE APPROACH

The general approach to setting offshore conservation targets presented in this paper is useful in data driven MPA network design processes where there is insufficient knowledge, data or capacity to adopt a more science-based method (e.g., population viability analysis, species/habitat-area relationship). It is a systematic, repeatable, transparent, and logic-based approach that assumes certain conservation priorities require greater representation in network design than others based on factors that are important in the context of nature conservation (i.e., size, uniqueness/rarity, vulnerability, current status). The approach is also practical, cost-effective, and relatively simple to apply. It allows for the use of available data, including those from different sources and of varying quality. Expert opinion is also easily incorporated into this method. It does not require large amounts of feature-specific data (e.g., compared to population viability analysis). Finally, the approach is adaptable as it can be easily altered based on regional variation and available information.

One major limitation of the approach is that it does not answer the question of how much area is required for each conservation priority to persist over time. More empirical research on the requirements for persistence of the priorities is needed to generate targets that are more biologically and/or ecologically meaningful. There is also a degree of subjectivity in scoring the different factors but this weakness can be addressed through the development of clear, evidence-based decision rules. This was done for certain factors and conservation priority categories (e.g., vulnerability scoring for depleted fishes) so the degree of subjectivity was reduced from earlier versions of this approach. Developing a tailored scoring method for each priority category significantly improved the approach from the initial version. Regardless of the methods, all scoring decisions should be vetted by subject matter experts.

6.1.1 Setting Targets for Offshore Coarse-Filter Conservation Priorities

Setting a minimum target of 10% for all coarse-filter features is an appropriate precautionary rule to ensure significant examples of all features are captured within the MPA network. The largest conservation priorities in the bioregion are the deep-water coarse-filter features (e.g., Abyssal Plain Geomorphic Unit), which are also data poor so very little is known about the ecological communities they support. Protecting large examples of these features could help account for some of the uncertainty regarding their ecological structure and composition.

Size was the only factor considered when setting targets for coarse-filter conservation priorities. The Lieberknecht *et al.* (2010) proportional approach was used where the starting target for the largest coarse-filter feature was set at 3%. The results served as the low end of the target range for coarse-filter priorities. Ten and 5% starting targets were also tried to test the effects they would have on the other coarse-filter targets. The 10% option led to relatively high targets (several above 50%), which would greatly increase the overall area requirements for the network. Although still arbitrary, the 3% starting target yielded more practical results, so it was adopted. However, it resulted in nearly half of the coarse-filter targets being below 10% so these had to be increased to 10% to satisfy the minimum target requirement (see Section 5.2). Because it is a proportional approach, applying the Lieberknecht *et al.* (2010) method also produced some very high targets for the smallest coarse-filter features. Setting targets for small features creates a seed effect when using *Marxan*, where the tool builds around areas that it must select to meet specified targets. If these small coarse-filter features are truly distinct, they should receive a high target. However, if they are artifacts of the habitat classification, they should not be assigned targets due to the strong influence they will have on the network design analysis. In this exercise, a target was not set for the *western Scotian Shelf small, medium and large pelagic piscivore fish functional group* because it is a very small feature (429 km^2) that was assigned a target of 72%. Using this target would have a strong influence on the MPA network analysis and the authors were not confident it is a truly distinct feature. The layer was still included in the analysis but its target was set to zero. Doing this still allowed the feature to be selected but removed the potential seed effect it could have on the overall design.

The relatively simple, size-based approach to setting targets for coarse-filter features was preferred at this time but the method could be refined in the future based on several factors. Not all coarse-filter features are the same so targets for these features could be adjusted based on factors such as uniqueness/rarity or vulnerability. Certain smaller-scale habitat types may be unique within the region and warrant higher targets. Even larger coarse-filter features may be unique on a broader scale. For example, the entire Bay of Fundy is globally unique, which may justify a higher target for this feature. It would be a challenge to systematically evaluate the vulnerability of all coarse-filter features.

In an ideal situation, the representative examples of coarse-filter features captured within an MPA network will be intact and highly natural. Thus, naturalness is a factor that could be considered in future iterations of this approach. With adequate data, past and current human pressures could be mapped to help determine areas of relatively high naturalness. Indeed, a next step in this process is to begin to build socioeconomic considerations into the MPA network design. Commercial fisheries landings data from the last decade could be used to develop an initial input layer to represent the potential cost to commercial fisheries. Including this human use layer in future *Marxan* analyses will encourage the selection of areas where there has been less fishing pressure in recent years. To some extent, these areas will be more natural than intensively fished areas.

Threats could also be considered when setting targets for coarse-filter priorities. Features that are under threat could be assigned higher targets than those not under threat. However, if this approach was applied, an intensively fished bank habitat would receive a higher target than a remote, untouched habitat. Targeting areas that are under threat would inevitably lead to more conflict with rights holders and stakeholders as these same areas are often important for fishing and other ocean industries.

6.1.2 Setting Targets for Offshore Fine-Filter Conservation Priorities

When setting targets for fine-filter features, the type of area to be conserved is an important consideration. For all of these features, the ideal area to be conserved (data permitting) is not the full distribution of the feature but a highly important subset of its distribution. For example, the MPA network does not aim to protect every individual *Vazella pourtalesi* sponge in the Scotian Shelf Bioregion. Rather, it aims to protect significant concentrations of this species because these areas are not only important for the long-term persistence of this sponge species, but they also provide habitat for many other species. Therefore their ecological value is very high. In this and other cases, the data for fine-filter conservation priorities have already been analyzed to delineate significant or important areas, so targets for these features should be relatively high.

When the data do not permit the delineation of important habitats for fine-filter priorities, broader distribution data can be used as a substitute but targets should be reduced significantly. Otherwise, very high targets will be applied to large features, which will have a dramatic effect on the overall network design.

Overall, the approaches used to set targets for the three categories of fine-filter priorities were adequate. Setting a fixed target of 20–40% for the five areas of high species richness priorities was deemed appropriate because it was difficult to differentiate among these features based on any of the factors. More research is needed to investigate the ecological processes associated with areas of high species richness and to develop a better rationale for focused protection for these hotspots versus those areas of lower, but nonetheless important, diversity (Marchese 2015).

The tailored approach to setting targets for biogenic habitat conservation priorities is sound but could be improved by developing evidence-based decision rules for the different life-history traits under the vulnerability factor (e.g., slow growth, sporadic recruitment, long lived). Regional experts recommended specifying meaningful thresholds (or bins) for what constitutes low, medium, and high scores for each of the three life-history traits being considered. This would help minimize subjectivity in the process. The authors will continue to work with regional experts to add rigor to this approach.

The simplified approach for depleted species based on vulnerability and current status was found to be effective. More research is needed to determine how much habitat each species needs to persist over the long term. It would also be useful to know where critical life-history stages (e.g., spawning, calving, nursing) occur for all depleted species. Understanding larval dispersal, species migration and other movements would also greatly inform MPA network design. However, taking a step back, we recognize that too much emphasis cannot be placed on endangered and threatened species as doing so will not ensure a healthy functioning ecosystem (see Lieberknecht, *et al.* 2010). The approach applied in this exercise did not fall into this trap as these fine-filter features are buffered through the inclusion of an extensive suite of coarse-filter features.

Several secondary factors should be considered for all targets before beginning the iterative *Marxan* analysis that will inform the design of the bioregional MPA network. For instance, it will be important to consider existing management measures that may already be in place for depleted species or other features. If effective measures are already in place, targets could be lowered for a particular feature. Data quality and reliability is another secondary factor that could be considered for certain features. Systematic techniques or clear decision rules for considering these and other potential secondary factors could be developed and applied in the future.

6.2 COASTAL APPROACH

The design strategies for the coastal components of the MPA network were developed using a simple, logical, expert-opinion driven approach. The wording chosen for the targets reflects the current limitations of data and information available for much of the coastal planning area within the region. As further information becomes available, it may be possible to add specificity to the target wording. For example, if a minimum "significant spatial extent" value can be determined that would adequately protect and maintain the ecosystem function of eelgrass beds, this minimum size requirement can be specified in the target for protecting that biogenic habitat type.

The current list of ecological features considered for the development of coastal design strategies identifies only salmon and eel as features that address the conservation priority for culturally significant species. It is acknowledged that this list is neither comprehensive nor final. The conservation priority for culturally important species provides an opportunity to engage with indigenous groups and incorporate Indigenous Traditional Knowledge (ITK) into MPA network planning. These efforts may result in changes to the conservation priority wording, adjustments to the list of types of areas to be conserved and associated targets, and additional information on species and EBSAs that can be incorporated into the tables of ecological features (Appendix B).

The current limited state of knowledge about coastal marine features presents a challenge in terms of prioritizing coastal EBSAs for inclusion in the MPA network. Even with the design strategies to guide the site selection process, areas with high ecological value may still be overlooked due to lack of available information. For example, some EBSAs described by Hastings *et al.* (2014) for the Atlantic Coast of Nova Scotia are known to be important for various birds, but little or no information currently exists to describe the marine environment in these EBSAs. More work is also needed to characterize important areas for invertebrates throughout the Bay of Fundy and the Atlantic Coast of Nova Scotia. For example, the current EBSA descriptions do not consistently report clam beds or lobster spawning areas. As well, the types of areas to be conserved for invertebrate biogenic habitat may require updating if other significant concentrations of biogenic habitat-forming species become known (e.g., erect bryozoan beds as described in Kenchington (2014). Likewise, there may be areas outside of the 54 existing EBSAs that would qualify for EBSA designation, and/or that may contain features that would provide valuable contributions to coastal targets. In some cases additional information may exist that can be incorporated to address these gaps; in other cases additional research may be required. The Bras d'Or Lakes and Minas Basin are examples of large EBSAs that require more research to understand the biodiversity and ecological processes that occur within them.

In addition to the challenges posed by information gaps, it is important to note that some of the existing research dates from more than thirty years ago. It will be important to update and validate existing information for priority sites as network planning moves forward. More generally, as on-going research, monitoring, and gathering of ITK provides new insights about coastal marine areas in the region, there will be a need to consider and incorporate this information as part of the regular cycle of MPA Network Plan review and revision.

6.3 COMBINING THE COASTAL AND OFFSHORE PROCESSES

As previously noted, different approaches have been used to develop MPA network design strategies for the coastal and offshore components of the Scotian Shelf Bioregion. Different approaches will also be used to select sites and design the overall MPA network is these different parts of the bioregion. The iterative *Marxan* analysis applied in the offshore will not be permitted to select areas within the coastal and Bay of Fundy planning area. The inshore extent of the DFO research vessel survey will be used as the technical boundary that separates the Atlantic coast and offshore area, while the boundary between the offshore and the Bay of Fundy lies near the mouth of the bay seaward of Grand Manan and Brier Island. Setting this hard technical boundary will prevent overlap in the two site selection processes. Once network sites have been identified in the respective areas, the sites may be manually adjusted, where appropriate, to bridge the gap between coastal and offshore sites.

6.4 OTHER MPA NETWORK DESIGN CRITERIA

Even when there is reliable information on the distribution of conservation priorities, it is still difficult to determine the total area required to guarantee the integrity and persistence of a particular feature. At present, identifying how to secure the long-term persistence of species, ecosystems and the ecological and evolutionary processes that maintain them remains one of the most difficult questions in conservation planning. However, setting targets is not the only way to address biodiversity conservation objectives. Other considerations in MPA network design, including connectivity, adequate and viable sites, and replication play a crucial role in maintaining biodiversity and ecological processes, and must be considered in network planning (Gaines *et al.* 2010, Green *et al.* 2014, Berglun *et al.* 2012).

In MPA network planning, replicability can be achieved through the setting of multiple representation targets. In this sense, an MPA network design would require that features be protected in multiple separate patches, spaced apart from one another. Lieberknecht *et al.* (2010) claimed that the replication of features can spread risk against damaging events and long-term change affecting individual sites and enhance connectivity in the network. Also, it is argued that habitat replication increases the likelihood of capturing variations in communities and species (Green *et al.* 2014). Referring to this, Watson *et al.* (2011) claimed that this creates a redundancy effect that may be desirable to provide the MPA network with the necessary resilience to ensure that conservation priorities survives in the face of natural catastrophes, disease epidemics, or the chronic ecological and genetic effects of small population size. However, one shortcoming of using this criterion is the assumption that the distribution of features that are replicated have similar potential for sustaining a population over a period of time.

Adequacy has been acknowledged by the international and scientific community as a core principle of reserve network design and conservation biology (Dudley 2008, Smith *et al*. 2009, CBD 2009, Wilson *et al.* 2010). Adequacy relates to the viability of the sites within a network, ensuring they are of appropriate size and have the level of protection needed to guarantee the integrity of the features therein (CBD 2009). A single reserve may fail to attain ecological integrity if it is not self-sufficient as a location and will depend on its connectivity to other parts of the ocean for recruitment of its component species (Roff and Zacharias 2011). As such, adequacy is often closely linked to connectivity. Both terms are encompassed within the concept of maintaining the ecological and evolutionary processes that generate and sustain biodiversity at various spatial and temporal scales (Soulé *et al.* 2004, Dudley 2008, Pressey *et al.* 2007, Watson *et al.* 2011).

Achieving connectivity in MPA network design has become one of the most desired goals in conservation planning. However, although many scientists have discussed the importance and implications of including connectivity in network planning (Almany *et al.* 2009; Gaines *et al.* 2010, Green *et al.* 2014), few have explored practical ways to incorporate robust connectivity indicators in systematic conservation approaches. Incorporating information on connectivity within a systematic conservation planning framework enables networks of priority areas to be designed with the goal of maintaining genetic and demographic linkages, which can contribute to the resilience of populations to the effects of climate change (Watson *et al.* 2010). Yet, quantifying connectivity requires an understanding of larval dispersal, a biological aspect poorly known for most of species for which protection is needed. Also, since connectivity requirements varies from priority to priority, explicitly addressing this concept can be challenging for planers using a systematic approach, since it cannot be fully incorporated using spatial prioritization tools such as *Marxan* (Lötter *et al.* 2010).

Explicit considerations of these concepts go beyond the scope of this paper. However, DFO recognizes that a robust MPA network design will require the use of best available science to ensure these principles are addressed in the overall MPA network plan. A comprehensive analysis of the MPA network design addressing these criteria will be explored in the future.

Socioeconomic considerations will be addressed in the next phase of the iterative MPA network design process. The inclusion of socioeconomic criteria improves social acceptability of protected areas by minimizing the impact on resource users and reducing conflicts (Adams *et al.* 2011), which can be key in accomplishing adequate levels of compliance. In systematic data driven processes, socioeconomic considerations are commonly addressed through the inclusion of potential costs in the analysis. Also, an important factor to consider that is rarely assessed when analyzing cost is equity (Halpern *et al.* 2013). An equitable distribution of costs between affected stakeholders has been argued to be a key component of conservation success (Klein *et al.* 2015).

It is important to bear in mind that striking a balance between biodiversity conservation and socioeconomic needs can be a difficult task given the inherent trade-offs between conservation and socioeconomic goals (Klein *et al.* 2015). Thus, there is a need to optimize trade-offs among objectives in order to maximize the benefits of conservation. Trade-offs in conservation are associated with gains and losses incurred by various actions and decisions regarding conservation and development (McShane *et al.* 2011). Elucidating trade-offs during MPA network development facilitates the negotiation of planning alternatives with stakeholders by compelling planners to modify biodiversity priorities or justify inequalities and economic losses created (Ban *et al.* 2013, Yates *et al.* 2015). Such trade-offs will be important to consider in coming stages of the MPA network design process for the Scotian Shelf Bioregion.

6.5 COMMITMENT TO A REGULAR CYCLE OF REVIEW

Looking ahead, it will be important to regularly update the coastal and offshore conservation priorities and design strategies as new information becomes available. Formally updating the MPA network design and associated plan on a 10-year cycle would seem appropriate.

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APPENDICES

APPENDIX A: CONSERVATION PRIORITIES AND OPERATIONAL OBJECTIVES FOR THE SCOTIAN SHELF BIOREGIONAL MPA NETWORK

Table A1. Conservation priorities and operational objectives for the coastal component of the Scotian Shelf bioregional MPA network.

	Coastal Conservation Priority Category	Operational Objective
Coarse -Filter	Representative features	Protect and maintain representative examples of coastal habitats found in the Bay of Fundy and Atlantic Coast of Nova Scotia, along with their associated biotic communities
Fine-Filter	Highly natural ecosystems	Protect and maintain areas recognized as high natural or intact ecosystems
	Areas of high productivity	Protect and maintain persistent areas of high productivity
	Areas of high biodiversity	Protect and maintain persistent areas of high biodiversity
	Complex or unique geomorphology	Protect and maintain areas with complex or unique geomorphological features that support biodiversity or ecological function
	Persistent unique or rare oceanographic characteristics	Protect and maintain persistent areas with unique or rare oceanographic characteristics
	Biogenic habitats (marine plants and macro-algae)	Protect and maintain significant concentrations of biogenic habitats formed by marine plants and macro-algae
	Biogenic habitats (invertebrates)	Protect and maintain significant concentrations of invertebrate biogenic habitat

Table A2. Conservation priorities and operational objectives for the offshore component of the Scotian Shelf bioregional MPA network. Asterisks indicate conservation priorities not included in exploratory MPA network design analyses.

		Offshore Conservation Priorities	Operational Objective
Coarse-Filter	Geomorphic Units	Abyssal Plain	Protect and maintain representative examples of identified geomorphic units and their associated biotic communities
		Continental Rise	
		Shelf Bank	
		Shelf Basin	
		Shelf Channel	
		Shelf Flat	
		Shelf Topo. Complex	
		Shelf Topo. Complex Bank	
		Shelf Topo. Complex Basin	
		Slope	
		Slope Channel	
	Oceanographic Units	Gulf of Maine	Protect and maintain representative examples of identified oceanographic units and their associated biotic communities
		Baccaro and LaHave banks	
		LaHave and Emerald basins	
		Western and Sable Island banks	
		Eastern Scotian Shelf	
		Laurentian Slope	
		Slope, Rise and Abyss	
	Scope for Growth	Very low scope for growth	Protect and maintain representative examples of identified Scope for Growth classes.
		Low scope for growth	
		Moderate scope for growth	
		High scope for growth	
		Very high scope for growth	
	Natural Disturbance	Very low natural disturbance	Protect and maintain representative examples of identified Natural Disturbance classes.
		Low natural disturbance	
		Medium natural disturbance	
		High natural disturbance	

		Offshore Conservation Priorities	Operational Objective
Coarse-Filter	Functional Groups	Fish - Large Benthic Benthivores	Protect and maintain identified core areas and associated habitat for all functional groups
		Fish - Small Benthic Benthivores	
		Fish - Medium Benthic Benthivores	
		Fish - Large Benthic Piscivores	
		Fish - Small and Medium Benthic Piscivores	
		Fish - Small, Medium, and Large Pelagic Planktivores	
		Fish - Small and Medium Pelagic Piscivores	
		Fish - Small, Medium, and Large Benthic Zoopiscivore	
		Fish - Small, Medium, and Large Pelagic Zoopiscivore	
		Invertebrates - Medium, Benthic Benthivores	
		Invertebrates - Small, Benthic Benthivores	
		Invertebrates - Detritivore	
		Invertebrates - Benthic, Colonial Filter Feeders	
		Invertebrates - Benthic, Non-colonial Filter Feeders	
		Invertebrates - Small, Medium and Large Zoopiscivores	
		Seabird Foraging Guild - Surface-seizing planktivores	
		Seabird Foraging Guild - Surface, shallow diving piscivore/generalist	
		Seabird Foraging Guild - Surface, shallow-diving coastal piscivores	
		Seabird Foraging Guild - Pursuit-diving piscivores	
		Seabird Foraging Guild - Shallow pursuit generalist	
		Seabird Foraging Guild - Pursuit diving planktivore	
		Seabird Foraging Guild - Plunge-diving piscovore	
Fine-Filter	Areas of High Species Richness	Areas of high fish species richness	Protect and maintain areas of high fish species richness in identified hotspots
		Areas of high invertebrate species richness	Protect and maintain areas of high invertebrate species richness in identified hotspots
		Areas of high ichthyoplankton species richness	Protect and maintain areas of high fish larvae species richness in identified hotspots
		Areas of high small fish species richness	Protect and maintain areas of high small fish species richness in identified hotspots
		Areas of high small invertebrate species richness	Protect and maintain areas of high small invertebrate species richness in identified hotspots

		Offshore Conservation Priorities	Operational Objective
Fine-Filter	Biogenic Habitats	*Vazella pourtalesi* (sponge) concentrations	Protect and maintain identified significant concentrations of *Vazella pourtalesi* and contribute to their recovery
		Large gorgonian coral concentrations	Protect and maintain identified significant concentrations of large gorgonian coral and contribute to their recovery
		Small gorgonian coral concentrations	Protect and maintain identified significant concentrations of small gorgonian coral and contribute to their recovery
		Sea pen fields	Protect and maintain significant concentrations of sea pens
		Other sponge concentrations	Protect and maintain significant concentrations of other sponges
		Lophelia pertusa (coral) reefs*	Protect and maintain identified significant concentrations of *Lophelia pertusa* and contribute to their recovery
		Horse mussel beds*	Protect and maintain significant horse mussel beds
		Stalked tunicate fields*	Protect and maintain significant concentrations of stalked tunicate fields
		Soft coral gardens*	Protect and maintain significant concentrations of soft coral gardens
		Crinoid beds*	Protect and maintain significant concentrations of crinoid beds
		Tube-dwelling anemone fields*	Protect and maintain significant concentrations of tube-dwelling anemone fields
	Depleted Species	North Atlantic Right Whale (NARW)	Protect NARW Critical Habitat and important habitat and NARWs while in their important habitat, and contribute to increasing population size (see SARA Recovery Strategy)
		Northern Bottlenose Whale (NBW)	Protect NBW Critical Habitat and important habitat and NBWs while in their important habitat, and contribute to increasing population size
		Blue Whale	Protect Blue Whale important habitat and Blue Whales while in their important habitat, and contribute to increasing population size
		Fin Whale	Protect Fin Whale important habitat and Fin Whales while in their important habitat, and contribute to increasing population size
		Harbour Porpoise	Protect Harbour Porpoise important habitat and Harbour Porpoises while in their important habitat, and contribute to increasing population size

		Offshore Conservation Priorities	Operational Objective
Fine-Filter	Depleted Species	Sowerby's Beaked Whale*	Protect Sowerby's Beaked Whale important habitat and Sowerby's Beaked Whales while in their important habitat, and contribute to increasing population size
		Leatherback Turtle*	Protect Leatherback Turtle Critical Habitat and important habitat and Leatherback Turtles while in their important habitat, and contribute to increasing population size
		Loggerhead Turtle*	Protect Loggerhead Turtle important habitat and Loggerhead Turtles while in their important habitat, and contribute to increasing population size
		Porbeagle Shark*	Protect Porbeagle Shark important habitat and Porbeagle Sharks while in their important habitat, and contribute to increasing population size
		White Shark*	Protect White Shark important habitat and White Sharks while in their important habitat, and contribute to increasing population size
		Blue Shark*	Protect Blue Shark important habitat and Blue Sharks while in their important habitat, and contribute to increasing population size
		Basking Shark*	Protect Basking Shark important habitat and Basking Sharks while in their important habitat, and contribute to increasing population size
		Shortfin Mako Shark*	Protect Blue Shark important habitat and Blue Sharks while in their important habitat, and contribute to increasing population size
		Atlantic Cod	Protect Atlantic Cod in their core areas and contribute to increasing population size (see PAF reference points for each population)
		Redfish (Unit 2)	Protect Redfish (Unit 2) in their core areas and contribute to increasing population size (see PAF reference points for each population)
		Winter Skate (Eastern Scotian Shelf)	Protect Winter Skate (ESS) in their core areas and contribute to increasing population size (see PAF reference points for each population)
		American Plaice	Protect American Plaice in their core areas and contribute to increasing population size (see PAF reference points for each population)
		Cusk	Protect Cusk in their core areas and contribute to increasing population size (see PAF reference points for each population)

		Offshore Conservation Priorities	Operational Objective
Fine-Filter	Depleted Species	White Hake	Protect White Hake in their core areas and contribute to increasing population size (see PAF reference points for each population)
		Smooth Skate	Protect Smooth Skate in their core areas and contribute to increasing population size (see PAF reference points for each population)
		Atlantic Wolfish	Protect Atlantic Wolffish in their core areas and contribute to increasing population size (see PAF reference points for each population)
		Thorny Skate	Protect Thorny Skate in their core areas and contribute to increasing population size (see PAF reference points for each population)
		Spiny Dogfish	Protect Spiny Dogfish in core areas and contribute to increasing population size (see PAF reference points for each population)
		Ocean Pout	Protect Ocean Pout in core areas and contribute to increasing population size (see PAF reference points for each population)
		Roundnose Grenadier*	Protect Roundnose Grenadier in core areas and contribute to increasing population size (see PAF reference points for each population)
		Roughhead Grenadier*	Protect Roughhead Grenadier in core areas and contribute to increasing population size (see PAF reference points for each population)

APPENDIX B: FEATURES OF THE ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS OF THE BAY OF FUNDY AND ATLANTIC COAST OF NOVA SCOTIA

The types of areas to be conserved for the coastal design strategies were identified by reviewing the ecological, biological, and biophysical features described for EBSAs identified in the Bay of Fundy (Buzeta, 2014), and the Atlantic Coast of Nova Scotia (Hastings *et al.* 2014) and considering only those features that would benefit from marine spatial protection. These features are listed below in Tables B1 (Bay of Fundy) and B2 (Atlantic Coast of Nova Scotia). The EBSA information for the bird-related features was updated in fall of 2016 through a review of the Canadian Wildlife Service's (CWS's) data holdings using methods as described in Hastings *et al.* (2014).

Table B1. Ecological, biological, and biophysical features described for Bay of Fundy EBSAs that have been considered in the development of the coastal design strategies. The information on bird-related features comes from CWS data holdings (October, 2016). The rest of the features are described in Buzeta (2014) unless otherwise noted. X: indicates the EBSAs that contain each listed feature; XX indicates EBSAs of particular importance for bird features; EN: listed by COSEWIC as endangered; T: listed by COSEWIC as threatened; SC: listed by COSEWIC as special concern.

Feature	Conservation Priority Category	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Highly natural / ecologically intact	Area of high naturalness										X		X				
Enhanced productivity (all trophic levels)	Area of high productivity					X	X										
Enhanced productivity: primary (phytoplankton)	Area of high productivity						X										
Enhanced productivity: secondary (copepods)	Area of high productivity					X	X			X							X
Enhanced productivity: secondary (Krill)	Area of high productivity					X	X			X							X
Enhanced productivity: secondary (unspecified)	Area of high productivity						X			X							X
Mudflat area[9] (of significance)	Area of high productivity												X	X	X		
Persistent or recurring upwellings	Area of high productivity		X			X	X			X							

[9] Mudflats, which support communities of benthic microalgae, are thought to be significant sources of primary productivity in the Bay of Fundy (Prouse *et al.* 1984).

Feature	Conservation Priority Category	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Diversity: benthic	Area of high biodiversity						X		X	X	X		X				X
Diversity: finfish	Area of high biodiversity				X												
Diversity: invertebrates (general)	Area of high biodiversity						X			X							
Diversity: marine birds	Area of high biodiversity				X		X			X							X
Diversity: marine mammal	Area of high biodiversity						X			X							X
Diversity: shorebirds	Area of high biodiversity				X		X			X							X
Diversity: sponges	Area of high biodiversity						X			X							X
Enhanced mixing (tidal, etc.)	Persistent, unique or rare oceanographic characteristics					X											
Highly fluctuating surface salinities	Persistent, unique or rare oceanographic characteristics							X									
Limited exchange with open ocean	Persistent, unique or rare oceanographic characteristics							X									
Strong tidal currents	Persistent, unique or rare oceanographic characteristics					X	X			X							X
Complex topography	Complex or unique geomorphology				X		X			X							
Unique geomorphological feature (isolated island)	Complex or unique geomorphology	X															
Habitat-forming sponges (significant)	Biogenic habitat (invertebrate)						X			X							
Horse mussel beds	Biogenic habitat (invertebrates)															X	
Stalked tunicate (*Boltenia ovifera*) fields	Biogenic habitat (invertebrates)						X			X							
Kelp beds	Biogenic habitat (marine plant, macroalgae)						X				X				X		X
Marine algae beds	Biogenic habitat (marine plant, macroalgae)				X		X										

Feature	Conservation Priority Category	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Rockweed areas (of significance)	Biogenic habitat (marine plant, macroalgae)						X			X							
Salt marsh area (of significance)	Biogenic habitat (marine plant, macroalgae)												X	X	X		

Table B2. Features described for Bay of Fundy EBSAs that have been included as secondary, species-specific considerations for the coastal site prioritization process. No design strategies have been developed for these features. The information on bird-related features comes from CWS data holdings (October, 2016). The rest of the features are described in Buzeta (2014) unless otherwise noted. X: indicates the EBSAs that contain each listed feature; XX indicates EBSAs of particular importance for bird features; EN: listed by COSEWIC as endangered; T: listed by COSEWIC as threatened; SC: listed by COSEWIC as special concern.

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Rare/unique persistent breeding/foraging occurrences: Arctic Tern	Important area bird	X															
Rare/unique persistent breeding/foraging occurrences: Atlantic Puffin	Important area bird	X															
Rare/unique persistent breeding/foraging occurrences: Black-legged Kittiwake	Important area bird						X				X						

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Rare/unique persistent breeding/foraging occurrences: Common Murre	Important area bird	X			X												
Rare/unique persistent breeding/foraging occurrences: Northern Gannet	Important area bird	X								X	X						
Rare/unique persistent breeding/foraging occurrences: Razorbill	Important area bird	X			X						X						
Rare/unique persistent moulting/foraging area: Bonaparte's Gull	Important area bird				X												
Significant breeding/foraging concentrations: auks (w/colonies); (60 km range)	Important area bird	XX			X	X											X
Significant breeding/foraging concentrations: Common Eider (w/colonies; adjacent shorelines up to 80 km with young)	Important area bird	X			XX		X				XX	X					
Significant breeding/foraging concentrations: Double-crested Cormorant (w/colonies); (5 km range)	Important area bird									X		X		X			X
Significant breeding/foraging concentrations: Great Blue Heron (w/colonies); (adjacent estuaries, marshes and intertidal flats)	Important area bird							X		X				X	X		
Significant breeding/foraging concentrations: large gulls (w/colonies); 60 km range)	Important area bird				XX		X			X	X	X			XX		XX
Significant breeding/foraging concentrations: Leach's Storm-petrel (w/colonies; 200–1000 km range)	Important area bird				X												
Significant breeding/foraging concentrations: terns (w/colonies); (20 km range)	Important area bird	XX															X

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Significant non-breeding/ foraging concentrations (staging/wintering): predatory benthivore (sea ducks; e.g., goldeneyes)	Important area bird				X		X		X	X							
Significant non-breeding/foraging concentrations (moulting): Common Eider	Important area bird	X			X						X	X					
Significant non-breeding/foraging concentrations (staging): plunge diving piscivore (Northern Gannet)	Important area bird		X				X				X						
Significant non-breeding/foraging concentrations (staging): pursuit diving piscivores (auks; e.g., Atlantic Puffin, Razorbill, murres)	Important area bird	X	X				X				X						X
Significant non-breeding/foraging concentrations (staging/wintering): grazers (geese; e.g., Atlantic Brant)	Important area bird			XX	XX												XX
Significant non-breeding/foraging concentrations (staging/wintering): grazers (geese; e.g., Canada Goose)	Important area bird													X	XX		
Significant non-breeding/foraging concentrations (staging/wintering): predatory benthivores (bay ducks; e.g., scaup)	Important area bird				X												
Significant non-breeding/foraging concentrations (staging/wintering): predatory benthivores (sea ducks; e.g., eiders)	Important area bird			X	X		X		X	X	X	X					X
Significant non-breeding/foraging concentrations (staging/wintering): predatory benthivores (sea ducks; e.g., mergansers)	Important area bird						X		X	X		X					

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Significant non-breeding/foraging concentrations (staging/wintering): predatory benthivores (sea ducks; e.g., scoters)	Important area bird				X		X		X	X		X		X			
Significant non-breeding/foraging concentrations (staging/wintering): predatory intertidal foragers (Purple Sandpiper)	Important area bird	X		XX	XX						XX	X					XX
Significant non-breeding/foraging concentrations (staging/wintering): predatory intertidal foragers (shorebirds; e.g., sandpipers, plovers)	Important area bird			XX	XX							X		XX	XX		X
Significant non-breeding/foraging concentrations (staging/wintering): pursuit diving planktivores (e.g., Dovekie)	Important area bird	X	X	X	X	X					X						X
Significant non-breeding/foraging concentrations (staging/wintering): shallow pursuit generalists (shearwaters; e.g., Great Shearwater, Sooty Shearwater)	Important area bird	X	X		X	X					X						X
Significant non-breeding/foraging concentrations (staging/wintering): surface seizing planktivores (phalaropes, storm-petrels)	Important area bird	X	X			X	X			X	X						X
Significant non-breeding/foraging concentrations (staging/wintering): surface shallow diving coastal piscivores (loons, grebes, cormorants)	Important area bird		X				X			X	X						

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Significant non-breeding/foraging concentrations (staging/wintering): surface shallow diving piscivores (gulls, terns; e.g., Herring Gull, Common Tern)	Important area bird	X	X	X	X	X	X			X	X	X					X
Rare/unique persistent breeding/foraging occurrences: Roseate Tern (EN)	Important area bird / depleted species	X															X
Significant breeding/foraging concentrations: Bald Eagle (prov. EN; adjacent estuaries, marshes and intertidal flats)	Important area bird / depleted species													X	X		
Significant breeding/foraging concentrations: Roseate Tern (EN; w/colonies; 20 km range)	Important area bird / depleted species	X															X
Significant non-breeding/foraging concentrations (staging): predatory intertidal forager (Piping Plover; EN)	Important area bird / depleted species				X									X			
Significant non-breeding/foraging concentrations (staging): predatory intertidal forager (Red Knot; EN)	Important area bird / depleted species				X									XX			

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Significant non-breeding/foraging concentrations (staging/wintering): predatory benthivore (Harlequin Duck; SC)	Important area bird / depleted species	X			XX						XX						XX
Juvenile/nursery: Atlantic Herring	Important area fish						X										
Juvenile/nursery: Pollock	Important area fish						X										
Migration route/use (bottleneck): Red Hake	Important area fish														X[10]		
Migration route/use (bottleneck): Winter Flounder	Important area fish														X[10]		
Migration route/use (bottleneck): Striped Bass	Important area fish / depleted species														X[10]		
Migration route/use (bottleneck): American Shad	Important area fish														X[10]		
Migration route/use (bottleneck): Atlantic Salmon	Important area fish / depleted species/ culturally important species														X[10]		
Migration route/use (bottleneck): American Eel	Important area fish / depleted species/ culturally important species														X[10]		
Migration route/use (bottleneck): Alewives	Important area fish														X[10]		
Migration route/use (bottleneck) - Blueback Herring	Important area fish														X[10]		
Migration route/use (bottleneck) - Spiny Dogfish	Important area fish														X[10]		
Migration route/use (bottleneck) - Atlantic Sturgeon	Important area fish														X[10]		
Migration route/use (bottleneck) - Atlantic Menhaden	Important area fish														X[10]		

[10] Dadswell 2010.

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Spawning: Atlantic Herring	Important area fish		X[11]												X		
Spawning: Atlantic Mackerel	Important area fish														X		
Spawning: Atlantic Silversides	Important area fish														X		
Spawning: Atlantic Menhaden	Important area fish														X		
Spawning: Windowpane Flounder	Important area fish														X[12]		
Spawning: Winter Flounder	Important area fish														X[13]		
Spawning: Haddock	Important area fish				X		X				X						
Spawning: Lumpfish	Important area fish						X			X					X		
Spawning: Pollock	Important area fish			X[11]													X[11]
Aggregation area: Atlantic Wolffish (SC)	Important area fish / depleted species						X			X							X
Feeding area: Basking Shark (SC)	Important area fish / depleted species					X	X				X						
Feeding area: Porbeagle Shark (EN)	Important area fish / depleted species						X			X	X						
Juvenile / nursery area: Redfish (stock not specified)	Important area fish / depleted species						X			X							
Juvenile/nursery area: Atlantic Cod (EN)	Important area fish / depleted species						X			X	X						
Spawning: Atlantic Cod (EN)	Important area fish / depleted species				X												
Striped Bass (multiple life-history stages) (EN)	Important area fish / depleted species														X		

[11] Buzeta *et al.* 2003.
[12] Huntsman 1922 as cited in Scott and Scott 1988; Bradford and Iles 1993.
[13] Bradford and Iles 1993.

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Juvenile/nursery area: American Eel (elver) (T)	Important area fish / depleted species/ culturally important species						X	X									
Juvenile/nursery: American Lobster	Important area invertebrate						X				X	X					
Soft-shelled clam beds	Important area invertebrate				X[14]							X[14]					
Spawning: American Lobster	Important area invertebrate			X										X			
Mud Piddock Clam beds (T)	Important area invertebrate / depleted species														X		
Feeding area: Atlantic White-sided Dolphin	Important area marine mammal / turtle																X[15]
Feeding area: Humpback Whale	Important area marine mammal / turtle						X			X							X[15]
Feeding area (inferred)[16]: Humpback Whale	Important area marine mammal / turtle										X[17]						
Feeding area: Minke Whale	Important area marine mammal / turtle		X				X			X							X[15]
Feeding area (inferred)[16]: Minke Whale	Important area marine mammal / turtle					X[17]											
Migration route/use (bottleneck): Harbour Porpoise (SC)	Important area marine mammal / turtle														X[18]		
Feeding area: Fin Whale (SC)	Important area marine mammal / turtle / depleted species		X				X			X							X[15]
Feeding area (inferred)[16]: Fin Whale (SC)	Important area marine mammal / turtle / depleted species					X[17]					X[17]						

[14] Community Coastal Resource Mapping 1999.
[15] Aecom 2011.
[16] For all *inferred* marine mammal feeding areas: AECOM (2011) states that whales and seals are attracted to these areas of the Bay of Fundy to feed, so aggregation areas in these locations are inferred to be feeding areas.
[17] Presence indicated from data in the Whale Sightings Database, Population Ecology Division, Fisheries and Oceans Canada Science Branch, Dartmouth, NS, January 2017.
[18] Stewart *et al.* 2011

Feature	Species-Specific Consideration	Machias Seal Island	Long Eddy (Grand Manan)	Flagg Cove, Whale Cove (Grand Manan)	South Grand Manan	Grand Manan Basin	Whole of Quoddy Region	Sam Orr's Pond (Quoddy)	Tongue Shoal (Quoddy)	Head Harbour Passage, West Isles Archipelago and The Passages (Quoddy)	The Wolves, Whitehorse Island, waters in between	Maces Bay	Musquash Estuary	Mary's Point, Grindstone Island, Chignecto Bay	Evangeline, Cape Blomidon, Minas Basin	Horse mussel reefs north of Digby	Brier Island, Digby Neck
Feeding area: Harbour Porpoise (SC)	Important area marine mammal / turtle / depleted species		X				X			X							X[15]
Feeding area (inferred)[16]: Harbour Porpoise (SC)	Important area marine mammal / turtle / depleted species					X[17]					X[17]						
Feeding area: North Atlantic Right Whale (EN)	Important area marine mammal / turtle / depleted species		X			X	X										X
Nursery area: North Atlantic Right Whale (EN)	Important area marine mammal / turtle / depleted species					X											
Right Whale Critical Habitat (EN)	Important area marine mammal / turtle / depleted species					X											

Table B3. Ecological, biological, and biophysical features described for Atlantic Coast EBSAs that have been considered in the development of the coastal design strategies. The information on bird-related features comes from CWS data holdings (October 2016) and the rest of the features are described in Hastings et al. (2014) unless otherwise noted. X: indicates the EBSAs that contain each listed feature; XX indicates EBSAs of particular importance for bird features; EN: listed by COSEWIC as endangered; T: listed by COSEWIC as threatened; SC: listed by COSEWIC as special concern.

Feature	Conservation Priority Category	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Highly natural/ ecologically intact	Area of high naturalness							X						X				X																					
Enhanced productivity (all trophic levels)	Area of high productivity	X																																					
Enhanced productivity (macro-algae)	Area of high productivity												X																		X	X	X				X		
Enhanced productivity (primary production - phytoplankton)	Area of high productivity																														X	X	X				X		
Enhanced productivity (secondary)	Area of high productivity																														X	X	X				X		
Enhanced productivity (unspecified)	Area of high productivity										X											X																	
Nutrient-rich surface waters	Area of high productivity	X																																					
Persistent or recurring upwellings	Area of high productivity	X												X[19]																									
Coastal lagoon	Area of high productivity																														X	X					X		

[19] Adam Drozdowski, DFO Science, personal communication, January 2017

Feature	Conservation Priority Category	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Diversity: coastal habitat types	Area of high biodiversity	X			X						X																			X	X								
Diversity: fishes	Area of high biodiversity																					X													X			X	
Diversity: invertebrates (general)	Area of high biodiversity																					X																	
Diversity: marine birds	Area of high biodiversity																																	X					
Diversity: shorebirds	Area of high biodiversity	X				X										X							X								X								
Bay that is unique in size and depth	Persistent unique or rare oceanographic characteristics										X		X									X																	
Enhanced mixing (tidal, etc.)	Persistent unique or rare oceanographic characteristics	X																																					

Feature	Conservation Priority Category	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Limited exchange with open ocean	Persistent unique or rare oceanographic characteristics																																						X
Steep temperature gradient	Persistent unique or rare oceanographic characteristics																																						X
Strong stratification	Persistent unique or rare oceanographic characteristics																																						X
Unique geomorphological feature (dense archipelago)	Complex or unique geomorphology																	X																					
Unique geomorphological feature (isolated island)	Complex or unique geomorphology												X																					X				X	
Stalked tunicate (*Boltenia ovifera*) fields	Biogenic habitat (invertebrates)													X																									
Eelgrass areas (of significance)	Biogenic habitat (marine plant, macroalgae)	X		X				X	X	X	X			X[20]		X	X	X[21]													X	X	X				X		X
Kelp beds	Biogenic habitat (marine plant, macroalgae)	X		X	X[22]					X				X[23]																									
Rockweed (significant area)	Biogenic habitat (marine plant, macroalgae)	X		X	X[22]																	X																	
Salt marsh area (of significance)	Biogenic habitat (marine plant, macroalgae)	X		X		X		X	X	X	X					X	X														X	X	X				X		X

[20] Wong *et al.* 2016.
[21] Melisa Wong, DFO Science, personal communication, October 2016.
[22] Sharp and Carter 1986.
[23] Filbee-Dexter 2016.

Table B4. Features described for Atlantic Coast EBSAs that have been included as secondary, species-specific considerations for the coastal site-prioritization process. The information on bird-related features comes from CWS data holdings (October 2016) and the rest of the features are described in Hastings et al. (2014) unless otherwise noted. X: indicates the EBSAs that contain each listed feature; XX indicates EBSAs of particular importance for bird features; EN: listed by COSEWIC as endangered; T: listed by COSEWIC as threatened; SC: listed by COSEWIC as special concern.

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'Or Lakes
Rare/unique persistent breeding/ foraging occurrences: American Oystercatcher	Important area bird	X				X																																	
Rare/unique persistent breeding/ foraging occurrences: Atlantic Puffin	Important area bird	X	X	X		X						X																						X					
Rare/unique persistent breeding/ foraging occurrences: Black-Crowned Night Heron	Important area bird	X			X																																		
Rare/unique persistent breeding/ foraging occurrences: Black-legged Kittiwake	Important area bird											X														X		X			X			X			X		
Rare/unique persistent breeding foraging occurrences: Northern Gannet	Important area bird	X	X																																				
Rare/unique persistent breeding/ foraging occurrences: Razorbill	Important area bird	X		X								X																		X	X			X					
Rare/unique persistent moulting/ foraging occurrences: Common Eider	Important area bird						X																																
Significant breeding/ foraging concentrations: Black-legged Kittiwake (w/colonies; 60 km range)	Important area bird																																	X					
Significant breeding/ foraging concentrations: Common Eider (w/colonies; adjacent shoreline up to 80 km with young)	Important area bird	X	X	X	X			X				X						X	X	X	X	X																	
Significant breeding/ foraging concentrations: Double-crested Cormorant (w/colonies); (5 km range)	Important area bird	X	X	X	X	X		X	X	X	X	X	X	X		X		X	X		X		X		X	X	X		X	X	X		X			X	X		X
Significant breeding/ foraging concentrations: Great Blue Heron (w/colonies); (adjacent estuaries, marshes and intertidal flats)	Important area bird	X		X	X			X		X	X				X			X	X																		X		X

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Significant breeding/ foraging concentrations: Great Cormorant (w/colonies; 20 km range)	Important area bird																	X X					X X	X X	X	X	X X	X X	X X	X	X X	X		X X		XX	X		
Significant breeding/ foraging concentrations: large gulls (w/colonies); 60 km range)	Important area bird	XX	X	X	X	X		X	X	X	X X	X	X	X	X		X	X X	X	X X	X	X	X		X	X			X	X X				X X		X	X		X
Significant breeding/ foraging concentrations: Leach's Storm-Petrel (w/colonies; 200-1000 km range)	Important area bird				X X															X X																			
Significant breeding/ foraging concentrations: terns (w/colonies); (20 km range)	Important area bird	X	X	X X		X		X			X X	X	X X	X			X	X X		X X	X				X X							X				X	X		X
Significant non-breeding/ foraging concentrations: generalist benthivores (dabbling ducks)	Important area bird	X		X X	X	X		X	X						X	X	X X														X	X	X						
Significant non-breeding/ foraging concentrations: grazer (Atlantic Brant)	Important area bird	X		X X		X X																																	
Significant non-breeding/ foraging concentrations: grazer (Canada Goose)	Important area bird	X		X				X X								X	X X														X	X	X						
Significant non-breeding/ foraging concentrations: plunge diving piscivore (Northern Gannet)	Important area bird	X	X			X	X	X		X		X		X	X	X				X			X	X	X	X		X	X	X	X	X	X	X	X		X	X	
Significant non-breeding/ foraging concentrations: predatory benthivore (bay ducks; e.g., scaup)	Important area bird	X		X		X		X		X	X																					X	X						
Significant non-breeding/ foraging concentrations: predatory benthivores (sea ducks; e.g., eiders)	Important area bird	X				X	X	X X	X	X	X	X		X	X X		X X	X X	X	X	X X	XX																	
Significant non-breeding/ foraging concentrations: predatory benthivores (sea ducks; e.g., golden-eyes)	Important area bird	X		X		X		X		X	X				X		X			X																	X		

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Significant non-breeding/ foraging concentrations: predatory benthivores (sea ducks; e.g., mergansers)	Important area bird	X		X				X		X	X						X					X										X	X						X
Significant non-breeding/ foraging concentrations: predatory benthivores (sea ducks; e.g., scoters)	Important area bird	X					X										X	X	X	X	X	X																	
Significant non-breeding/ foraging concentrations: predatory intertidal foragers (shorebirds, e.g., sandpipers, plovers)	Important area bird	X		X X		X X		X X	X X	X X						X X	X X														X X								
Significant non-breeding/ foraging concentrations: predatory intertidal forager; Purple Sand-piper	Important area bird	XX	X		X	X		X X										X X	X X		X	X	X						X	X X									
Significant non-breeding/ foraging concentrations: pursuit diving piscivores (auks; e.g., Atlantic Puffin, Razorbill, murres)	Important area bird	X	X																			X															X	X	
Significant non-breeding/ foraging concentrations: pursuit diving planktivore (Dovekie)	Important area bird																																		X		X	X	
Significant non-breeding/ foraging concentrations: shallow pursuit generalist (shearwaters; e.g., Great Shear-water, Sooty Shear-water)	Important area bird	X																												X					X			X	
Significant non-breeding/ foraging concentrations: surface seizing planktivores (phalaropes, storm-petrels)	Important area bird	X	X				X																												X			X	
Significant non-breeding/ foraging concentrations: surface shallow diving coastal piscivores (loons, grebes, cormorants)	Important area bird	X	X	X	X	X					X	X	X	X	X	X				X				X	X	X		X	X	X			X	X					
Significant non-breeding/ foraging concentrations: surface shallow diving piscivores (gulls,	Important area bird	X	X	X	X	X						X	X	X	X	X						X	X							X			X	X	X		X	X	

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
terns; e.g., Herring Gull, Common Tern)																																							
Significant breeding/ foraging concentrations: Piping Plover (EN; nesting beaches; adjacent intertidal areas)	Important area bird / depleted species	X		X		X		X	X	X						X	X															X	X				X		
Significant breeding/ foraging concentrations: Roseate Tern (EN; w/colonies; 20 km range)	Important area bird / depleted species	X	X	X X		X				X	X X	X	X X	X			X	X X		X X	X																		
Significant non-breeding/ foraging concentrations: predatory benthivore (Harlequin Duck; SC)	Important area bird / depleted species	X			X	X		X X					X					X X	X	X	X	X																	
Significant non-breeding/ foraging concentrations: predatory intertidal forager (Piping Plover; EN)	Important area bird / depleted species					X X		X X																															
Significant non-breeding/ foraging concentrations: predatory intertidal forager (Red Knot; EN)	Important area bird / depleted species	X				X X		X								X															X								
Feeding area (inferred)[24]: Atlantic Herring	Important area fish																																		X				
Feeding area (inferred)[24]: Witch Flounder	Important area fish																																		X			X	
Juvenile/nursery: Alewife	Important area fish	X																																					
Juvenile/nursery: Atlantic Herring	Important area fish	X																																					
Juvenile/nursery: Atlantic Tomcod	Important area fish										X																												
Juvenile/nursery: Cunner	Important area fish	X		X																																			

[24] For all *inferred* fish feeding areas (other than bluefin Tuna): these are fish aggregation areas as determined by data from DFO's summer Research Vessel survey. Feeding is inferred because Horsman and Shackell, (2009) state that the summer survey data reflect species' distribution during a period of rapid growth and feeding.

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Juvenile/nursery: Grubby	Important area fish																					X																	
Juvenile/nursery: Red Hake	Important area fish																					X																	
Juvenile/nursery: White Hake	Important area fish																					X																	
Juvenile/nursery: Lumpfish	Important area fish	X																																					
Juvenile/nursery: Ninespine Stickleback	Important area fish	X																																					
Juvenile/nursery: Northern Pipefish	Important area fish										X																												
Juvenile/nursery: Pollock	Important area fish	X																																					
Juvenile/nursery: Rock Gunnel	Important area fish	X																																					
Juvenile/nursery: Sand Lance	Important area fish	X									X											X																	
Juvenile/nursery: Three-Spined Stickleback	Important area fish	X		X																																			
Juvenile/nursery: Windowpane Flounder	Important area fish	X		X																																			
Juvenile/nursery: Winter Flounder	Important area fish	X																																					
Juvenile/nursery: Witch Flounder	Important area fish	X		X																																			
Larval area: American Plaice	Important area fish																																		X			X	
Larval area: Atlantic Herring	Important area fish																																		X				
Larval area: Atlantic Mackerel	Important area fish																																		X			X	
Larval area: Longhorn Sculpin	Important area fish																																		X				

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Migration route/use (bottleneck): Atlantic Mackerel	Important area fish																																					X[25]	
Migration route/use (bottleneck): Atlantic Herring	Important area fish																																					X[25]	
Migration route/use (bottleneck): Atlantic Cod (EN)	Important area fish																																					X[25]	
Overwintering: Atlantic Herring	Important area fish													X								X										X	X	X			X		
Spawning: Atlantic Herring	Important area fish	X						X								X	X															X	X						X
Spawning: Atlantic Mackerel	Important area fish												X																										
Aggregation area: Atlantic Cod (EN)	Important area fish / depleted species																					X																	
Aggregation area: Atlantic Wolffish (SC)	Important area fish / depleted species	X																				X																	
Aggregation area: Cusk (EN)	Important area fish / depleted species	X[26]																																					
Aggregation area: skates (SC)	Important area fish / depleted species	X																																					
Aggregation area: Thorny Skate (SC)	Important area fish / depleted species																					X																	

[25] Doherty and Horsman 2007.
[26] DFO 2006.

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'Or Lakes
Aggregation area: Winter Skate (T)	Important area fish / depleted species																					X												X					
Feeding area (inferred)[27]: American Plaice (T)	Important area fish / depleted species																																		X			X	
Feeding area (inferred)[27]: Atlantic Cod (EN)	Important area fish / depleted species																																		X			X	
Feeding area (inferred)[27]: Redfish (stock not specified)	Important area fish / depleted species																																					X	
Feeding area (inferred)[27]: Smooth Skate (SC)	Important area fish / depleted species																																		X				
Feeding area (inferred)[27]: Thorny Skate (SC)	Important area fish / depleted species																																		X				
Feeding area (inferred)[27]:White Hake (T)	Important area fish / depleted species																																		X			X	
Feeding area (inferred)[27]: Atlantic Wolffish (SC)	Important area fish / depleted species																																					X	
Feeding area (inferred) [28]: Bluefin Tuna (EN)	Important area fish /												X	X	X	X	X					X[29]																	

[27] For all *inferred* fish feeding areas (other than bluefin Tuna): these are fish aggregation areas as determined by data from DFO's summer Research Vessel survey. Feeding is inferred because Horsman and Shackell, (2009) state that the summer survey data reflect species' distribution during a period of rapid growth and feeding.
[28] Atlantic Bluefin Tuna aggregate to feed on prey (DFO 2011).
[29] COSEWIC 2011.

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
	depleted species																																						
Juvenile/nursery: American Plaice (EN)	Important area fish / depleted species																																		X				
Juvenile/nursery: Atlantic Cod	Important area fish / depleted species	X																																X					
Juvenile/nursery: White Hake	Important area fish / depleted species	X																															X	X					
Larval area: Atlantic Cod	Important area fish / depleted species																																		X			X	
Larval area: Redfish	Important area fish / depleted species																																		X			X	
Atlantic Salmon rivers (presence of salmon at any life stage)	Important area fish / depleted species/ culturally important species	X		X					X	X	X						X															X	X			X	X		X
American Oyster beds *(Crassostrea virginica*)	Important area invertebrate																																						X
Juvenile/nursery: American Lobster	Important area invertebrate	X		X																																			
Overwintering (probable): American Lobster	Important area invertebrate																																	X					
Scallop beds	Important area invertebrate																																	X					

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Spawning: American Lobster	Important area invertebrate												X																										

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'or Lakes
Feeding area (inferred)[30]: Atlantic White-sided Dolphin	Important area cetacean												X	X[31]								X														X[32]	X[32]		
Feeding area: Humpback Whale	Important area cetacean																																			X[32]	X[32]		
Feeding area (inferred)[30]: Humpback Whale	Important area cetacean	X																																					
Feeding area: Minke Whale	Important area cetacean																																			X[32]	X[32]		
Feeding area (inferred): Minke Whale	Important area cetacean												X									X																	
Feeding area (inferred)[30]: White-beaked Dolphin	Important area cetacean												X	X[31]								X																	
Feeding area: Fin Whale (SC)	Important area cetacean / depleted species													X								X														X[32]	X[32]		
Feeding area (inferred)[30]: Fin Whale (SC)	Important area cetacean / depleted species	X											X																										
Feeding area: Leatherback Turtle (EN)	Important area cetacean / depleted species												X																						X			X	

[30] For all *inferred* cetacean feeding areas: because whale distributions are generally linked to the distribution of their prey (Breeze *et al.* 2002), aggregation areas for whales are presumed to be used for feeding unless otherwise indicated.
[31] Simard *et al.* 2006; Peter Simard, Eckerd College, personal communication, January 2017.
[32] Hal Whitehead, Dalhousie University, personal communication, December 2017; Tonya Wimmer, Marine Animal Response Society, personal communication, January 2017.

Feature	Species-Specific Consideration	SW Scotian Shelf	Outer Tusket Islands	Lobster Bay	Bon Portage Island	Cape Sable Island	Green Point to Ram Island	Port Joli and Area	Medway Harbour Area	LaHave Islands	Mahone Bay	Pearl Island	St. Margaret's Bay	Sambro Ledges	Outer Halifax Harbour	Cole Harbour - Lawrencetown	Musquodoboit Harbour and Area	Eastern Shore Archipelago	Tobacco Island	Country Harbour Islands	Sugar Harbour Islands	Canso Ledges	Point Michaud and Basque Islands	Rocks off Forchu Head	Guyon Islands	Green Island	Harbour Rock	Islet off Baleine	Portnova Islands	Scatarie Island	Morien Bay	Big Glace Bay	Lingan Bay - Indian Bay	Bird Islands	Western Sydney Bight	Ingonish Bays	Aspy Bay	Cabot Strait (incl. St. Paul Island)	Bras d'Or Lakes
Feeding area: Pilot Whale	Important area cetacean																																			X[33]	X[33]		
Feeding area (inferred)[34]: Harbour Porpoise (SC)	Important area cetacean / depleted species												X									X														X[33]	X[33]		
Migration route/use (bottleneck): Pilot Whale	Important area cetacean																																					X	
Migration route/use (bottleneck): Minke Whale	Important area cetacean																																					X	
Migration route/use (bottleneck): Humpback Whale	Important area cetacean																																					X	
Migration route/use (bottleneck): Fin Whale	Important area cetacean																																					X	
Migration route/use (bottleneck): Leatherback Sea Turtle	Important area depleted species																																					X	

33 Hal Whitehead, Dalhousie University, personal communication, December 2017; Tonya Wimmer, Marine Animal Response Society, personal communication, January 2017.

34 For all *inferred* cetacean feeding areas: because whale distributions are generally linked to the distribution of their prey (Breeze *et al.* 2002), aggregation areas for whales are presumed to be used for feeding unless otherwise indicated.

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APPENDIX C: EXPLORATORY MARXAN ANALYSIS

The conservation planning software *Marxan* was used to test the effects of the preliminary offshore targets developed through the approach described in Section 5 by generating a series of exploratory MPA network design outputs. A suite of analyses using different target combinations were generated and compared to a baseline analysis (Table C1). The primary focus of the comparisons was to determine how different targets for the various types of conservation priorities influence the spatial configuration and total area required in a given MPA network scenario. It must be emphasized that the exploratory MPA network design outputs discussed in this Appendix are for illustrative purposes only and are not proposed MPA network scenarios. It is also important to note that the exploratory *Marxan* analyses presented below used the preliminary target ranges that were presented in the working paper for the November 2016 CSAS meeting rather than the targets presented in Tables 11 and 12 (Section 5) of this document. The final target ranges are different than those presented in the original working paper because the methods for developing design strategies have evolved since the initial approach was presented in 2016. The MPA network design scenario that is eventually proposed for this bioregion will be significantly different than the scenarios presented below because it will include coastal and Bay of Fundy sites and take into account: (a) existing MPAs, (b) potential socioeconomic costs, and (c) feedback from other government agencies, First Nations and Indigenous groups, and stakeholders. These considerations will have a significant influence on the configuration of the proposed MPA network design. This more comprehensive MPA network analysis will incorporate the advice from this process.

Table C1. Exploratory MPA network design scenarios used to evaluate the effects of targets. Scenario descriptions: B1 (Baseline 1): All features at bottom of target range; 1.1: Baseline 1 + Coarse-filter - High (Starting target at 10%); 1.2: Baseline 1 + Fine-filter – High; 1.3: Baseline 1 + Biogenic Habitats – High; 1.4: Baseline 1 + Depleted Species – High; 1.5: Baseline 1 + Areas of High Species Richness – High; 2.1: Only Coarse-Filter Features - High (Starting target at 10%); 2.2: Only Fine-Filter Features – High; 2.3: Only Biogenic Habitats – High; 2.4: Only Depleted Species – High; 2.5: Only Areas of High Species Richness – High.

	B1	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5
Coarse-Filter Features											
Oceanographic Units											
Gulf of Maine	10	29	10	10	10	10	29	0	0	0	0
Baccaro and LaHave banks	11	38	11	11	11	11	38	0	0	0	0
LaHave and Emerald basins	10	26	10	10	10	10	26	0	0	0	0
Western and Sable Island banks	10	31	10	10	10	10	31	0	0	0	0
Eastern Scotian Shelf	10	21	10	10	10	10	21	0	0	0	0
Laurentian Slope	10	34	10	10	10	10	34	0	0	0	0
Slope, Rise and Abyss	10	10	10	10	10	10	10	0	0	0	0

	B1	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5
Geomorphic Units											
Abyssal Plain	10	15	10	10	10	10	15	0	0	0	0
Continental Rise	10	14	10	10	10	10	14	0	0	0	0
Shelf Bank	10	20	10	10	10	10	20	0	0	0	0
Shelf Basin	13	45	13	13	13	13	45	0	0	0	0
Shelf Channel	16	55	16	16	16	16	55	0	0	0	0
Shelf Flat	10	26	10	10	10	10	26	0	0	0	0
Shelf Topo. Complex	12	41	12	12	12	12	41	0	0	0	0
Shelf Topo. Complex Bank	14	48	14	14	14	14	48	0	0	0	0
Shelf Topo. Complex Basin	22	74	22	22	22	22	74	0	0	0	0
Slope	15	49	15	15	15	15	49	0	0	0	0
Slope Channel	11	35	11	11	11	11	35	0	0	0	0
Scope for Growth Classes											
Very low scope for growth	10	29	10	10	10	10	29	0	0	0	0
Low scope for growth	10	20	10	10	10	10	20	0	0	0	0
Moderate scope for growth	10	26	10	10	10	10	26	0	0	0	0
High scope for growth	11	38	11	11	11	11	38	0	0	0	0
Very high scope for growth	10	28	10	10	10	10	28	0	0	0	0
Natural Disturbance Classes											
Very low natural disturbance	10	28	10	10	10	10	28	0	0	0	0
Low natural disturbance	10	22	10	10	10	10	22	0	0	0	0
Medium natural disturbance	10	17	10	10	10	10	17	0	0	0	0
High natural disturbance	10	27	10	10	10	10	27	0	0	0	0

	B1	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5
Fish Functional Groups											
Large Benthic Benthivores (East)	10	30	10	10	10	10	30	0	0	0	0
Large Benthic Benthivores (West)	11	36	11	11	11	11	36	0	0	0	0
Medium Benthic Benthivores (East)	10	30	10	10	10	10	30	0	0	0	0
Medium Benthic Benthivores (West)	12	40	12	12	12	12	40	0	0	0	0
Small Benthic Benthivores (East)	14	47	14	14	14	14	47	0	0	0	0
Small Benthic Benthivores (West)	25	82	25	25	25	25	82	0	0	0	0
Large Benthic Piscivores (East)	10	31	10	10	10	10	31	0	0	0	0
Large Benthic Piscivores (West)	12	39	12	12	12	12	39	0	0	0	0
Small and Medium Benthic Piscivores (East)	10	26	10	10	10	10	26	0	0	0	0
Small and Medium Benthic Piscivores	12	40	12	12	12	12	40	0	0	0	0
Small and Medium Pelagic Piscivores (East)	0	0	0	0	0	0	0	0	0	0	0
Small and Medium Pelagic Piscivores (West)	21	70	21	21	21	21	70	0	0	0	0
Small, Medium, and Large Pelagic Planktivores (East)	12	40	12	12	12	12	40	0	0	0	0
Small, Medium, and Large Pelagic Planktivores (West)	13	44	13	13	13	13	44	0	0	0	0
Small, Medium, and Large Benthic Zoopiscivore (East)	10	31	10	10	10	10	31	0	0	0	0
Small, Medium, and Large Benthic Zoopiscivore (West)	12	39	12	12	12	12	39	0	0	0	0
Small, Medium, and Large Pelagic Zoopiscivore (East)	25	84	25	25	25	25	84	0	0	0	0
Small, Medium, and Large Pelagic Zoopiscivore (West)	0	0	0	0	0	0	0	0	0	0	0

	B1	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5
Invertebrate Functional Groups											
Medium Benthic Benthivores (East)	10	23	10	10	10	10	23	0	0	0	0
Medium Benthic Benthivores (West)	39	100	39	39	39	39	100	0	0	0	0
Small Benthic Benthivores (East)	10	23	10	10	10	10	23	0	0	0	0
Small Benthic Benthivores (West)	10	30	10	10	10	10	30	0	0	0	0
Detritivores (East)	10	24	10	10	10	10	24	0	0	0	0
Detritivores (West)	11	35	11	11	11	11	35	0	0	0	0
Benthic Colonial Filter Feeders (East)	12	39	12	12	12	12	39	0	0	0	0
Benthic Colonial Filter Feeders (West)	30	98	30	30	30	30	98	0	0	0	0
Benthic Non-Colonial Filter (East)Feeders	10	23	10	10	10	10	23	0	0	0	0
Benthic Non-Colonial Filter Feeders (West)	10	30	10	10	10	10	30	0	0	0	0
Small, Medium, and Large Zoopiscivores (East)	12	39	12	12	12	12	39	0	0	0	0
Small, Medium, and Large Zoopiscivores (West)	11	36	11	11	11	11	36	0	0	0	0
Seabird functional groups											
Surface-Seizing Planktivores	10	25	10	10	10	10	25	0	0	0	0
Surface Shallow-Diving Piscivore/Generalists	10	25	10	10	10	10	25	0	0	0	0
Surface Shallow-Diving Coastal Piscivores	10	25	10	10	10	10	25	0	0	0	0
Pursuit-Diving Piscivores	10	25	10	10	10	10	25	0	0	0	0
Shallow Pursuit Generalists	10	25	10	10	10	10	25	0	0	0	0
Pursuit-Diving Planktivore	10	25	10	10	10	10	25	0	0	0	0
Plunge-Diving Piscivores	10	24	10	10	10	10	24	0	0	0	0
Ship-Following Generalists	10	25	10	10	10	10	25	0	0	0	0

	B1	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5
Fine-Filter Features											
Areas of High Species Richness											
Areas of high fish species richness	20	20	40	20	20	40	0	40	0	0	40
Areas of high invertebrate species richness	20	20	40	20	20	40	0	40	0	0	40
Areas of high ichthyoplankton species richness	20	20	40	20	20	40	0	40	0	0	40
Areas of high small fish species richness	20	20	40	20	20	40	0	40	0	0	40
Areas of high small invertebrate species richness	20	20	40	20	20	40	0	40	0	0	40
Biogenic Habitats											
Vazella pourtalesi concentrations	80	80	80	80	80	80	0	80	80	0	0
Large gorgonian coral concentrations	80	80	100	100	80	80	0	100	100	0	0
Small gorgonian coral concentrations	10	10	20	20	10	10	0	20	20	0	0
Sea pen fields	60	60	80	80	60	60	0	80	80	0	0
Other sponge concentrations	20	20	40	40	20	20	0	40	40	0	0

	B1	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5
Depleted Species											
Northern Bottlenose Whale	80	80	100	80	100	80	0	100	0	100	0
North Atlantic Right Whale	80	80	100	80	100	80	0	100	0	100	0
Blue Whale	10	10	20	10	20	10	0	20	0	20	0
Fin Whale	10	10	20	10	20	10	0	20	0	20	0
Harbour Porpoise	10	10	20	10	20	10	0	20	0	20	0
Atlantic Wolfish	60	60	80	60	80	60	0	80	0	80	0
Roundnose Grenadier	0	0	0	0	0	0	0	0	0	0	0
Winter Skate (Eastern Scotian Shelf)	80	80	100	80	100	80	0	100	0	100	0
Smooth Skate	60	60	80	60	80	60	0	80	0	80	0
Roughhead Grenadier	0	0	0	0	0	0	0	0	0	0	0
Spiny Dogfish	60	60	80	60	80	60	0	80	0	80	0
Redfish (Unit 2)[35]	40	40	60	40	60	40	0	60	0	60	0
Thorny Skate	20	20	40	20	40	20	0	40	0	40	0
Cusk	20	20	40	20	40	20	0	40	0	40	0
Atlantic Cod	60	60	80	60	80	60	0	80	0	80	0
White Hake	40	40	60	40	60	40	0	60	0	60	0
Ocean Pout	20	20	40	20	40	20	0	40	0	40	0
American Plaice	20	20	40	20	40	20	0	40	0	40	0

Marxan Software

Marxan was designed to solve the minimum set problem of achieving some minimum representation of biodiversity features for the smallest possible cost (McDonnell *et al.* 2002). This problem results from the reality that biodiversity conservation often competes against social, economic, and management constraints[36]. Using the simulated annealing optimization algorithm, *Marxan* answers the question of: what is the minimum number of sites and total area needed to meet the specified targets for all biodiversity features within a particular planning area (Smith *et al.* 2010, Stelzenmüller *et al.* 2013). For this, the system requires that: conservation

[35] Note that the target for this species has been reduced to Low-Medium because its status has improved. The exploratory Marxan analyses took place before the change in status.

[36] Stewart, R.R. and Possingham, H.P. 2002. A framework for systematic marine reserve design in South Australia: a case study. In, Inaugural World Congress on Aquatic Protected Areas, Cairns (unpublished).

features identified for protection are mapped; the bioregion is divided into a set of planning units; quantitative conservation targets are established for each conservation feature; and the amount of features within each of the selected planning unit is calculated (Game and Grantham 2008). Thus, *Marxan* develops a selection routine of conservation scenarios that meets the pre-set conservation targets. A scenario or efficient solution would be one that meets the targets with the lowest possible cost. This is achieved through the use of a mathematical objective function that gives a value for a collection of planning units based on the various costs of the selected set and the penalties for not meeting conservation targets (Ball and Possingham 2000). A solution containing zero planning units, though cheap to implement (total cost equals zero), would not meet any biodiversity feature targets and so the objective function value will be zero (Game and Grantham 2008). Having an objective function that gives any possible reserve system a cost value, allows the user to automate the selection of good reserve networks (at least according to the objective function) (Ball and Possingham 2000). *Marxan* works simply by continually testing alternate selections of planning units, aiming at improving the whole reserve system value. The objective function is a combination of the total cost of the reserve system and a penalty for any of the ecological targets that are not met. This objective function is designed so that the lower the value the better the solution (Game and Grantham 2008).

It is important to bear in mind that most decision support systems are designed to provide a range of optimal solutions to a given problem according to prescribed rules. Consequently, a selection will be made by the users who determine which one is most appropriate. Also, like other tools, the quality of the solutions in *Marxan* is a reflection of the quality of the data used (Martin *et al.* 2008).

Overall, *Marxan* is widely used by protected area network planners because it is flexible (i.e., generates multiple good network design scenarios for the same set of conservation targets) and efficient (i.e., identifies scenarios with the least possible area and/or potential socioeconomic cost) in generating possible protected area network scenarios. *Marxan* is also repeatable, which allows for adjustments to be made to targets or other parameters as part of an iterative process that works toward an acceptable scenario. This tool is being used to assist in the design of the offshore component of the Scotian Shelf bioregional MPA network. As previously noted, the coastal components of the proposed MPA network will be identified using a different approach. Using a systematic approach is considered a good practice because it promotes transparency, inclusiveness, and defensibility in the planning process (Ardron *et al.* 2010).

Planning units and cost:

Marxan requires that the overall planning area is divided into planning units. Decision about the type and size of the planning unit is a critical step to attaining adequate results in *Marxan*. Types of planning units can include grids, hexagons and even natural units such as watersheds. Planning unit resolution (size) should be small enough to ensure that spatial variation of individual features is reflected but not too fine, which can considerably slow the optimization process. Previous *Marxan* analysis for the Scotian Shelf have used two-by-two arc minutes as the size of the planning unit. Such grids of approximately $10km^2$ were selected as a matter of being consistent with a geospatial database compiled by the Oceans and Coastal Management Division of DFO Maritimes Region (Horsman *et al.* 2011). In order to maintain consistency with previous work, the same size and type of planning unit (grids) was used for the current process.

For the purpose of this exercise we used the area of the planning unit ($10km^2$) as the cost value in the *Marxan* objective function. Therefore, the problem is restricted to find solutions that are efficient in meeting conservation targets and while minimizing the total area and boundary length required. Future iterations of this process will consider socioeconomic values as a different type of cost.

Marxan Calibration

In order to get efficient portfolios, it is necessary to balance the *Marxan* objective function through a series of experimental runs. This process ensures that solutions generated by *Marxan* are close to the lowest cost or optimum efficiency. For this analysis, the *Marxan* calibration process encompassed the checking and setting of the number of runs and iterations as well as Species Penalty Factor (SPF)[37] and Boundary Length Modifier (BLM)[38]. Aspects such as efficiency and boundary length were compared and final parameters were decided when efficient solutions both in terms of overall cost of the objective function and spatial configuration (visual) were found to be appropriate. The calibration process led to the selection of the following settings for the exploratory analyses: 500 BLM and 20 SPF for all conservation priorities.

Marxan Outputs

Marxan produces two basic outputs: the best solution and the summed solution. The best solution includes only the planning units selected in the run with the lowest overall objective function cost. The summed solution shows the frequency each planning unit was selected across all runs in a particular scenario. For instance, if *Marxan* is set to run two hundred times in a particular scenario, then the summed solution shows how many times each planning unit is selected out of two hundred. This output can be useful to identify hotspots for conservation and can indicate the relative value of planning units. However, designing a network based only on this output (summed solution) does not ensure all conservation priorities are represented and hence that all targets are being met.

Exploratory Marxan Analyses

A baseline analysis was completed and compared to the outputs of two groups of exploratory scenarios (Table C1). The baseline analysis included all conservation priorities with targets set at the bottom of the preliminary range outlined in Figure C1. For example, if the target range for a conservation priority was identified as Low-Medium (20–40%), the target for that conservation priority in the baseline analysis was 20%.The first group of exploratory analyses included five scenarios intended to investigate the effects of separately increasing the targets for each of the major conservation priority categories (i.e., coarse-filter, fine-filter [areas of high species richness, biogenic habitats and depleted species]) while keeping the targets for all other conservation priorities at the bottom of their respective target ranges. The second group of exploratory analyses was generated to determine where targets for the different conservation priority categories could be met most efficiently and better-understand the influence each category might have on the overall MPA network configuration.

There are endless potential combinations of targets that could be examined in this type of exploratory process. A simple short list of scenarios was selected to illustrate the effects of adjusting targets for different groups of conservation priorities. It should be noted that many of the conservation priorities described in the previous section were not included in the exploratory *Marxan* scenarios due to the lack of sufficient data (e.g., loggerhead turtle, Sowerby’s beaked whale, porbeagle shark, stalked tunicate fields, roundnose grenadier).

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[37] The SPF is a weighting factor defined by the user that applies when a conservation feature target is not met. Depending on the value assigned, the SPF intends to put more emphasis on the last component (cost for not meeting the targets) of the *Marxan* objective function, which forces *Marxan* to find solutions that meet the targets (Game and Grantham 2008).

[38] The BLM controls the clustering of the solutions by increasing the cost of reserves with high boundary-area ratio. This way *Marxan* intends to select more compact solutions (Game and Grantham 2008).

Baseline Analysis

The baseline analysis included all conservation priorities with all targets set at the bottom of the original target range that was presented at the November 2016 meeting (Figure C1). This scenario was to be used as a basis for comparison with the other exploratory scenarios presented below. It was selected as the baseline because it includes all conservation priorities but at the low end of the target range so it could be viewed as a minimum requirement for the MPA network in this illustrative exercise.

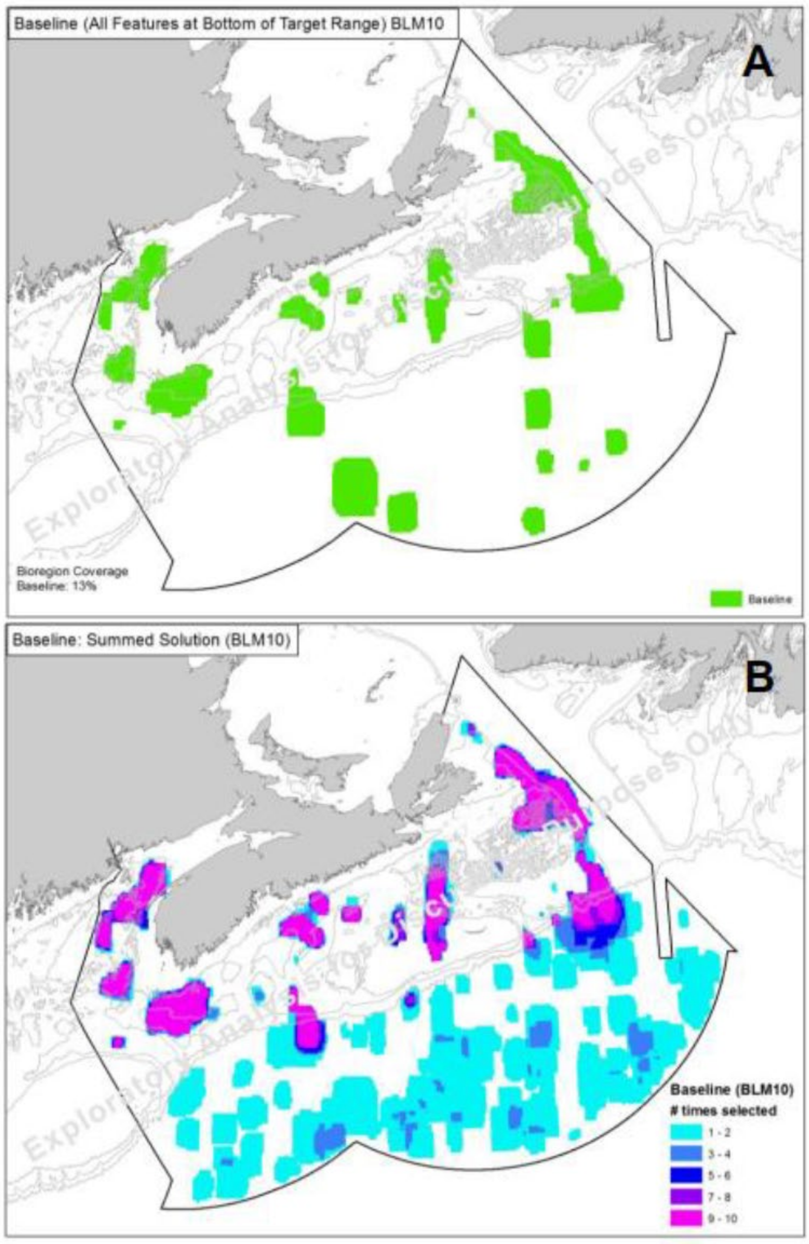

Figure C1. Exploratory baseline analysis (A) and summed solution (B). All targets for all conservation priorities set at the bottom end of the specified range with the boundary length modifier (BLM) set at 10. This output was used as the baseline scenario in this exploratory process.

Other potential baseline scenarios were explored using different target levels and BLM settings (Figure C2 and Figure C3).

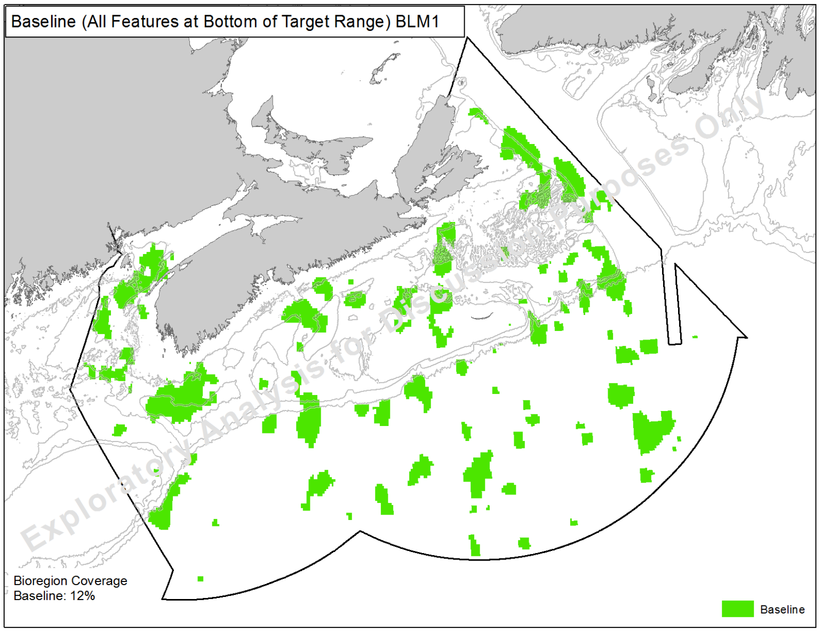

Figure C2. Exploratory baseline analysis. All targets for all conservation priorities set at the bottom end of the specified range with the boundary length modifier (BLM) set at 1. This output was not selected as the baseline scenario in this process because it was too fragmented.

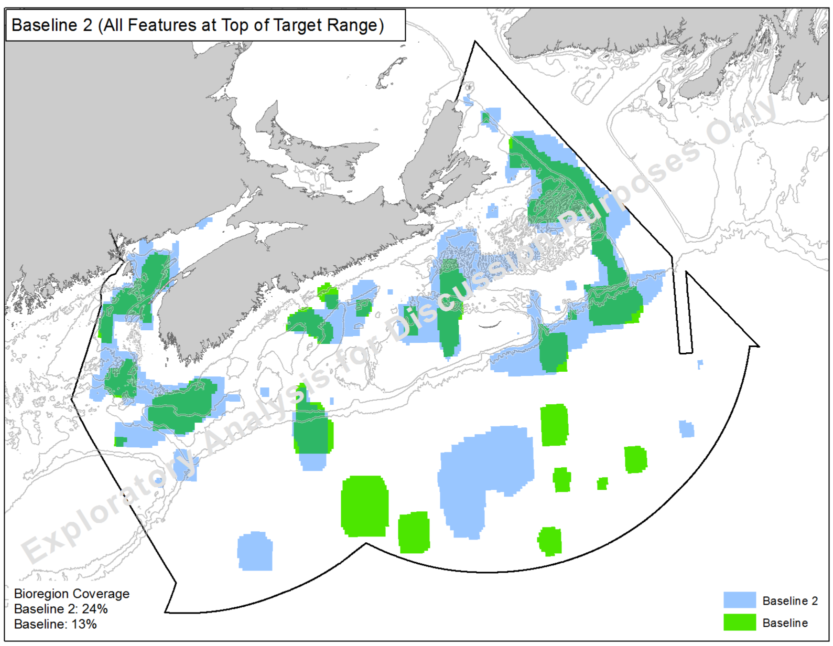

Figure C3. Exploratory baseline analysis. All targets for all conservation priorities set at the top end of the specified range with the boundary length modifier (BLM) set at 10. This output was not selected as the baseline scenario in this process because it was comprised of several large contiguous patches.

Exploratory Analyses: Group 1

The first group of exploratory analyses included five scenarios that were intended to test the effects of separately increasing the targets for each of the major categories of conservation priorities (coarse-filter, fine-filter [areas of high species richness, biogenic habitats, and depleted species]) to high (Figures C4–C8). In these scenarios, all other targets were kept at the low end of the recommended range. All outputs in this group overlapped significantly with the baseline and appeared to build or expand around the major patches. Where that expansion occurred depended on the conservation priority category for which the targets were increased. For example, many of the individual patches in the Baseline became connected when coarse-filter targets were increased in Scenario 1.1. This occurred as the patches on the shelf and in deeper water were expanded to meet the higher coarse-filter targets. A similar effect took place in Scenario 1.2 where fine-filter targets were increased but most of the expansion occurred on the shelf, where most of the fine-filter features are concentrated.

Examining the summed solutions for all of the exploratory outputs in this group shows that the scenarios are more constrained on the shelf than they are in the deep-water. This is due to the combination of the higher number of conservation priorities on the shelf and the higher targets for those conservation priorities when compared to the simple requirements (i.e., lower targets) of the coarse-filter features in deeper water.

The total area required for the different scenarios in this group is summarized in Figure C9. Increasing the targets for coarse-filter features resulted in the most significant increase in total area required, as 22% of the region would be required to meet these targets compared to 13% for the Baseline. Increasing the target for biogenic habitats had the least effect on the total area needed, which only increased by to 14%. Increasing the targets for depleted species and areas of high species richness increased the total area needs to 16% and 17% respectively.

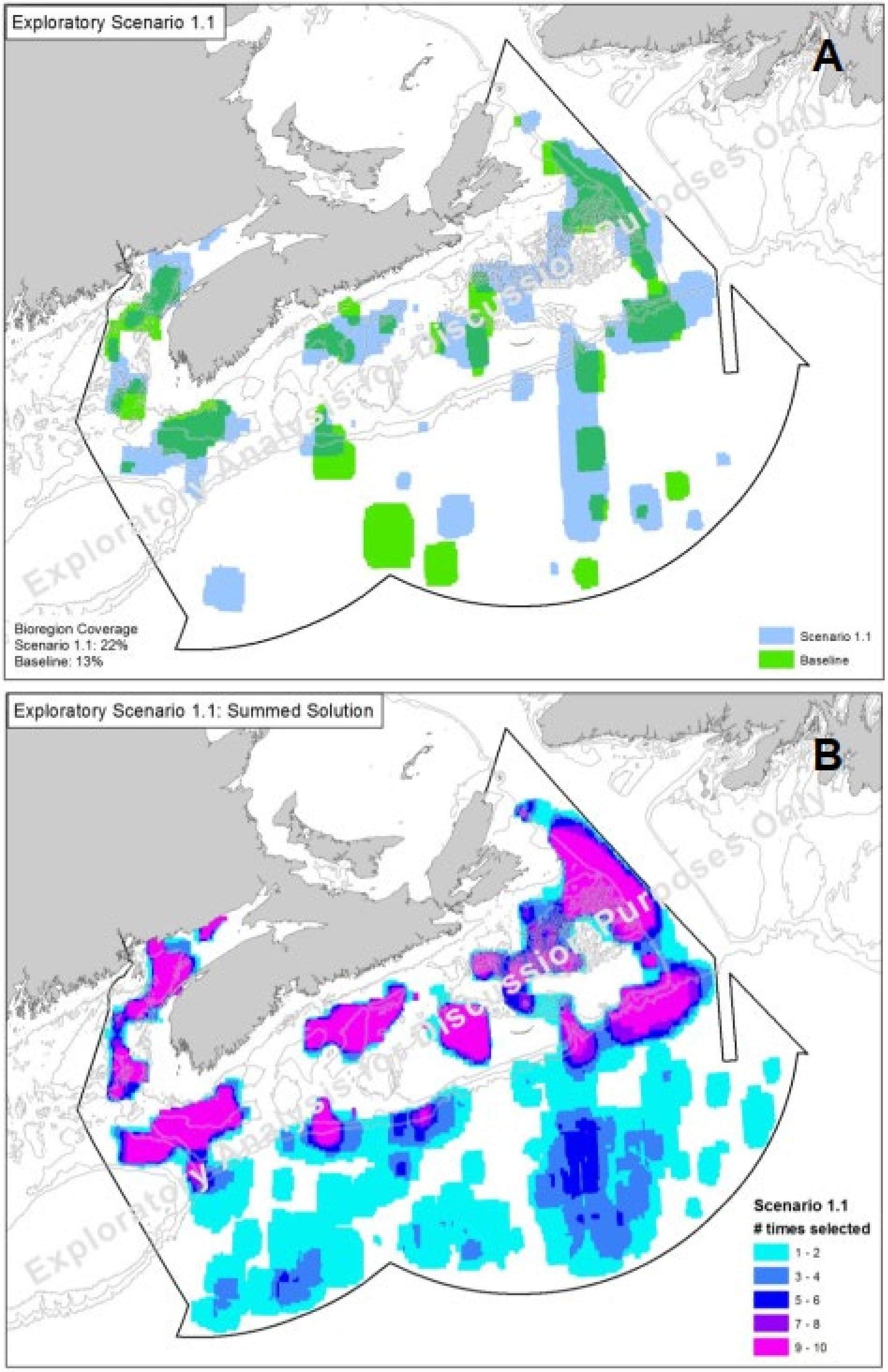

Figure C4. Exploratory analysis Group 1, Scenario 1. Best run (A) and summed solution (B). Coarse-filter targets set at highest level with all other targets set at the bottom end of the specified range with the boundary length modifier (BLM) set at 10.

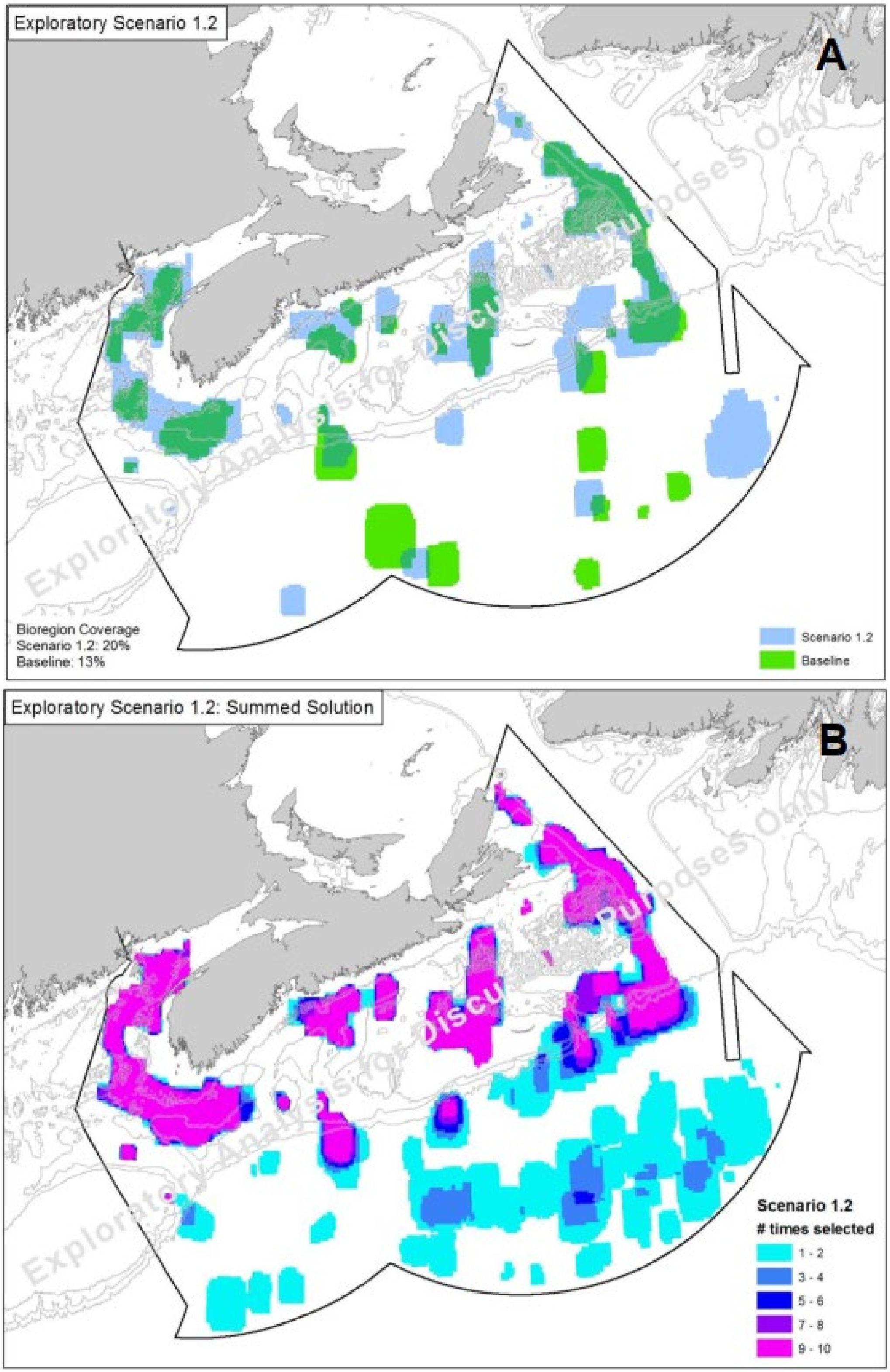

Figure C5. Exploratory analysis Group 1, Scenario 2. Best run (A) and summed solution (B). Fine-filter targets set at highest level with all other targets set at the bottom end of the specified range with the boundary length modifier (BLM) set at 10.

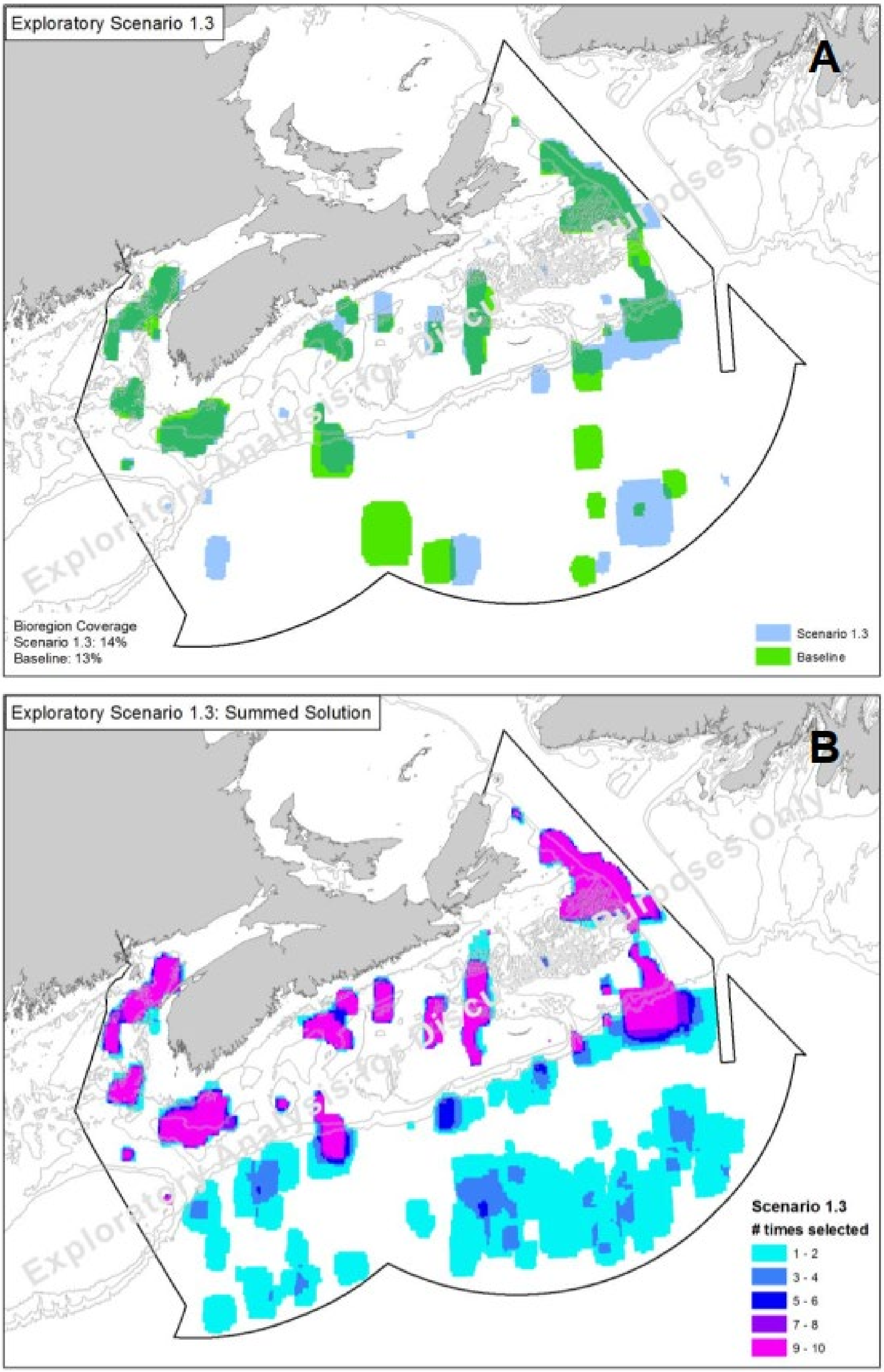

Figure C6. Exploratory analysis Group 1, Scenario 3. Best run (A) and summed solution (B). Biogenic habitat (fine-filter) targets set at highest level with all other targets set at the bottom end of the specified range with the boundary length modifier (BLM) set at 10.

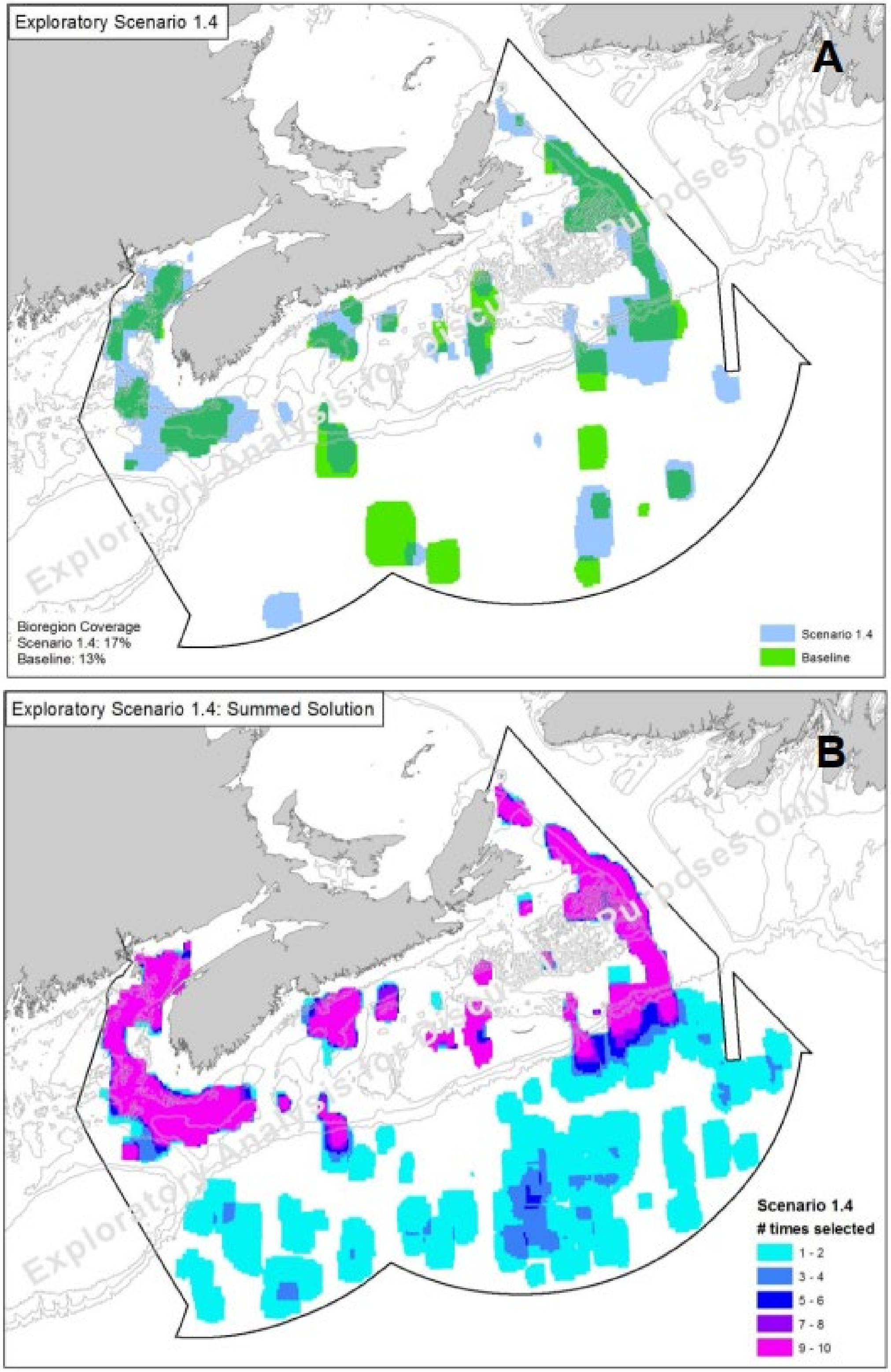

Figure C7. Exploratory analysis Group 1, Scenario 4. Best run (A) and summed solution (B). Depleted species (fine-filter) targets set at highest level with all other targets set at the bottom end of the specified range with the boundary length modifier (BLM) set at 10.

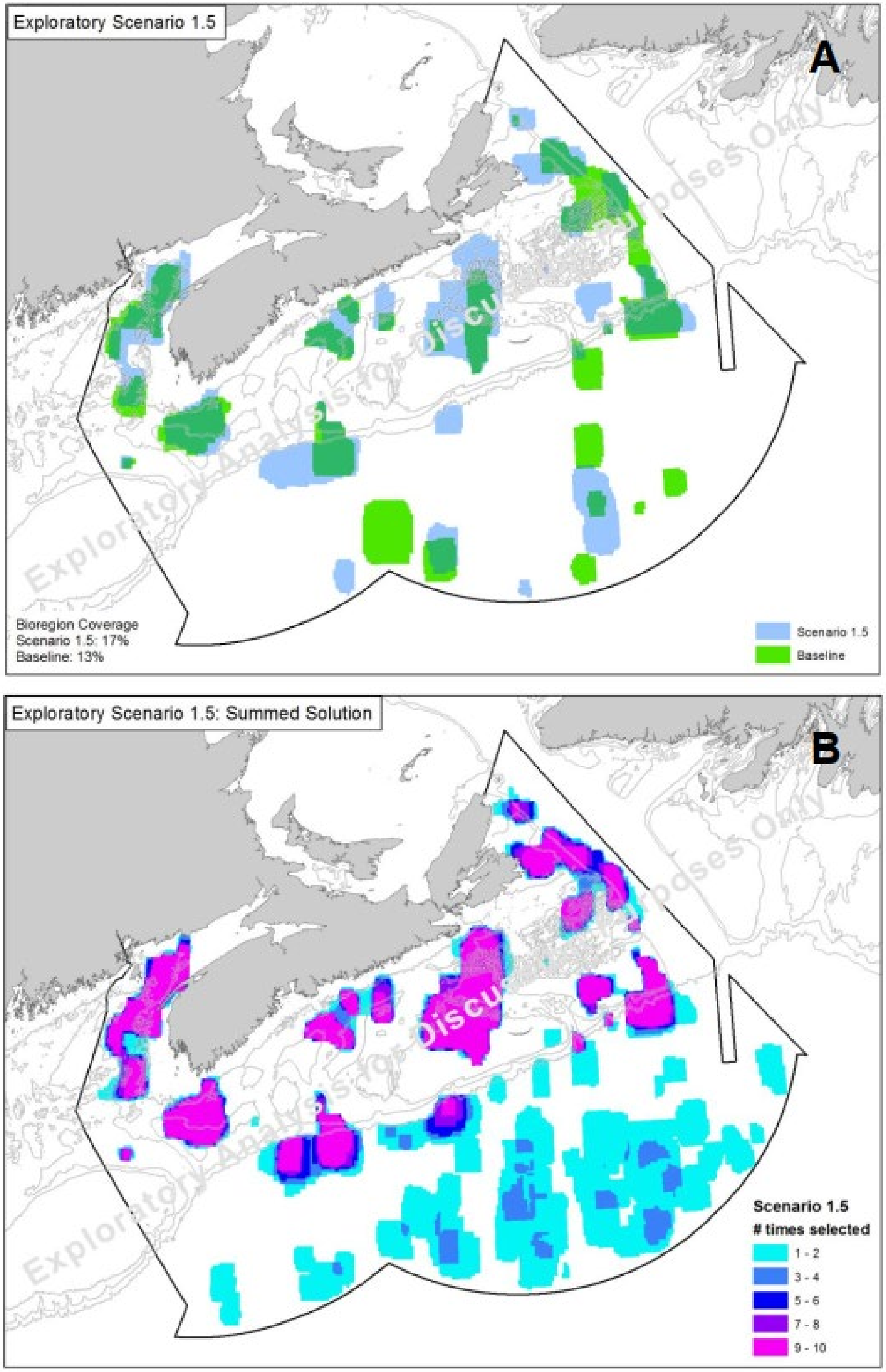

Figure C8. Exploratory analysis Group 1, Scenario 5. Best run (A) and summed solution (B). Areas of high species richness (fine-filter) targets set at highest level with all other targets set at the bottom end of the specified range with the boundary length modifier (BLM) set at 10.

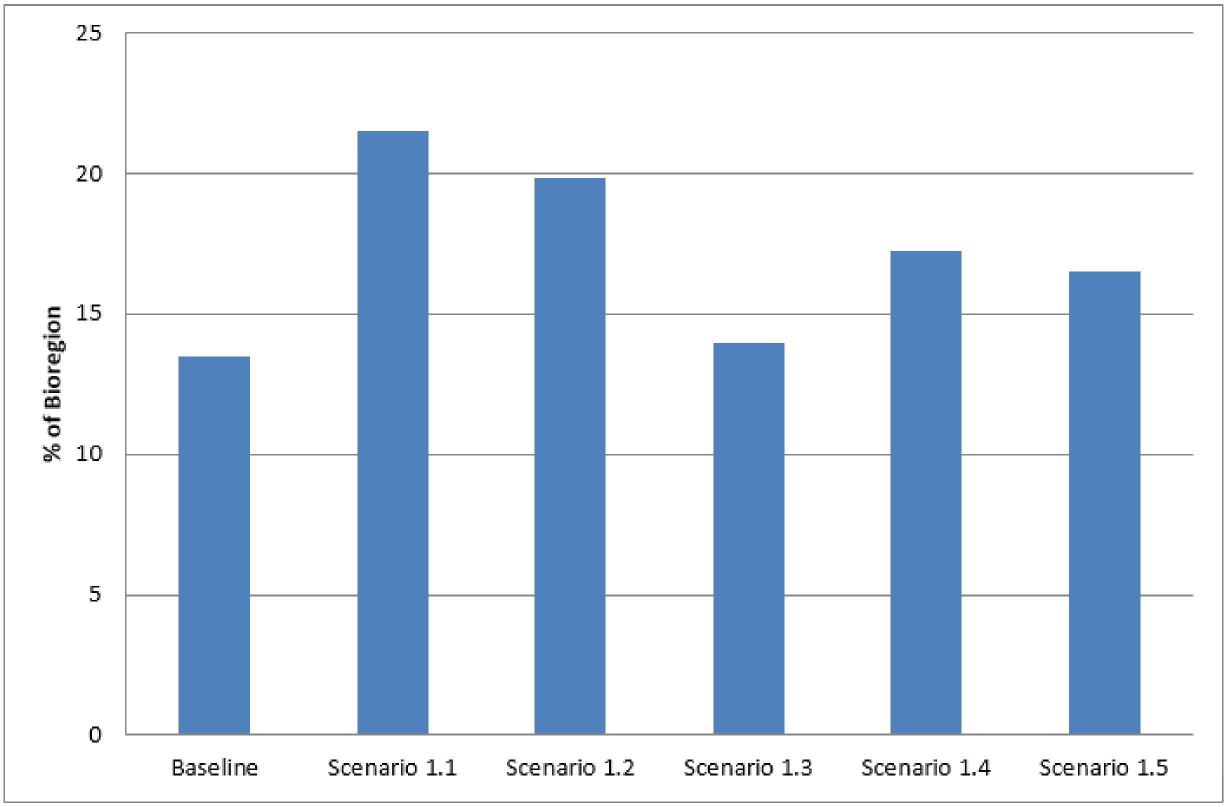

Figure C9. Percentages of the total area of the bioregion required to meet targets under the Group 1 exploratory scenarios.

Exploratory Analyses: Group 2

The second group of exploratory analyses consisted of five scenarios, including a scenario where targets were set at the high end of the range for each of the conservation priority categories (Figures C10–C14). The purpose of these scenarios was to determine where targets for different conservation priority categories could be met most efficiently and better-understand the influence each category might have on the overall network design. For this reason, the summed solution output was included along with the best run. The summed solution indicates how many times a planning unit was selected in the different number of runs that go into a *Marxan* analysis. Planning units that are selected more frequently are more important to achieving an efficient network solution. In these exploratory runs, the areas selected most frequently are assumed to be the most important areas or highest value areas for each category of conservation priorities.

The best run map for Scenario 2.1 (Figure C10) illustrates the flexibility that exists in scenarios focused only on representative features. There is relatively little overlap between this scenario and the baseline. The opposite is the case in most of the other scenarios where there is close alignment among the exploratory scenarios (2.2, 2.3, 2.4, 2.5) and the baseline.

Examining the summed solution maps for exploratory scenarios 2.2, 2.3, 2.4, 2.5 (Figures C11 to C14) highlights areas where fine-filter targets can be most efficiently met. The high selection frequency of certain planning units suggests that there will be less flexibility in meeting fine-filter targets, which is expected given the fact that these features are generally smaller and have higher targets than coarse-filter features. The summed solution for Scenario 2.1 (only coarse-filter features) reveals lower or less concentrated selection frequencies, particularly in the deep-water areas where conservation priorities are fewer and larger.

The total area required for the different exploratory scenarios in this group is summarized in Figure C15. The all coarse-filter high (2.1) and all fine-filter high (2.2) had the highest total area requirements at 21% and 16% respectively. The biogenic habitats scenario (2.3) had the lowest area requirements at 6%, which reflects the small size of these features.

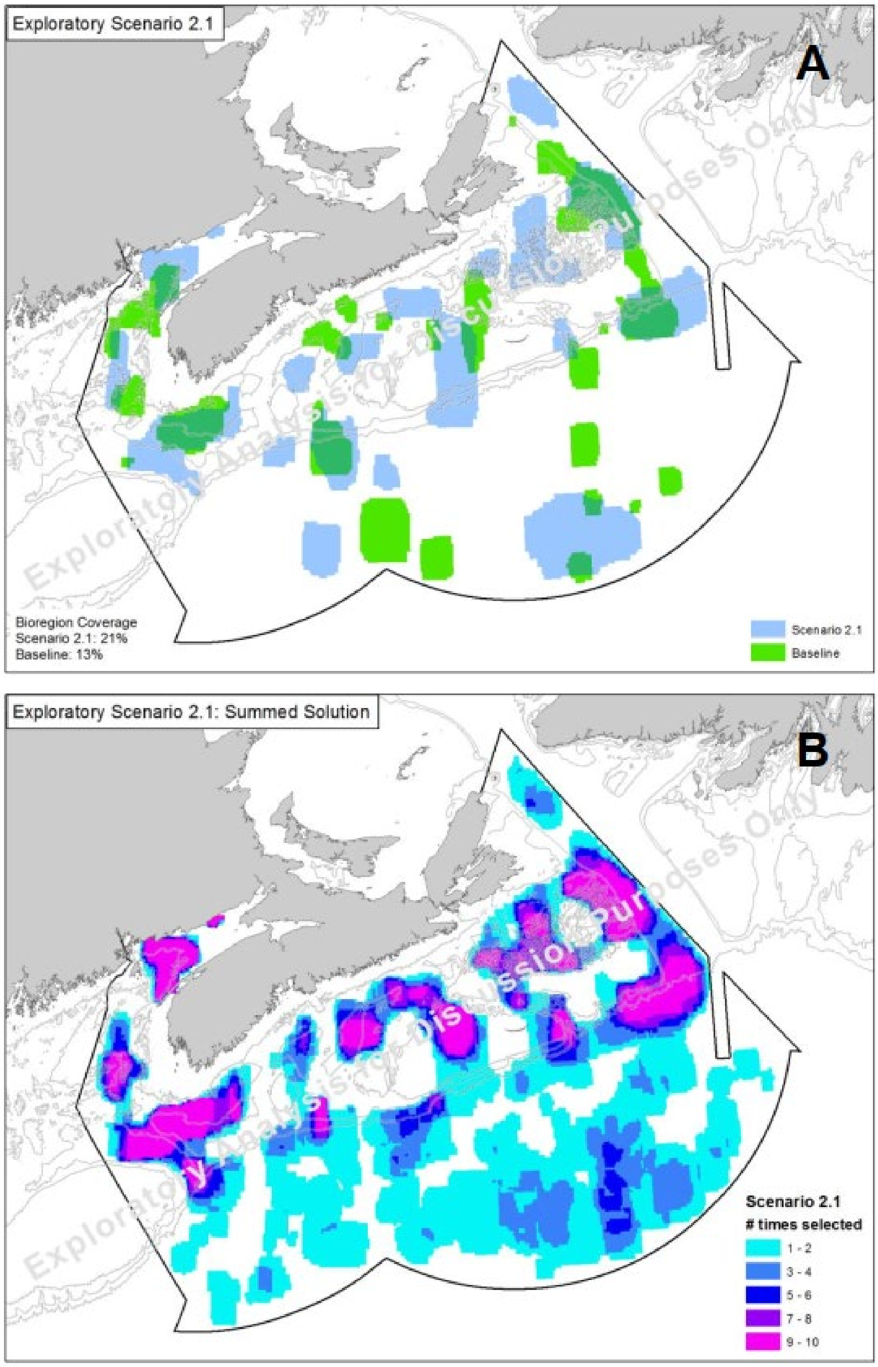

Figure C10. Exploratory analysis Group 2, Scenario 1. Best run (A) and summed solution (B). Coarse-filter features only with high targets and boundary length modifier (BLM) set at 10.

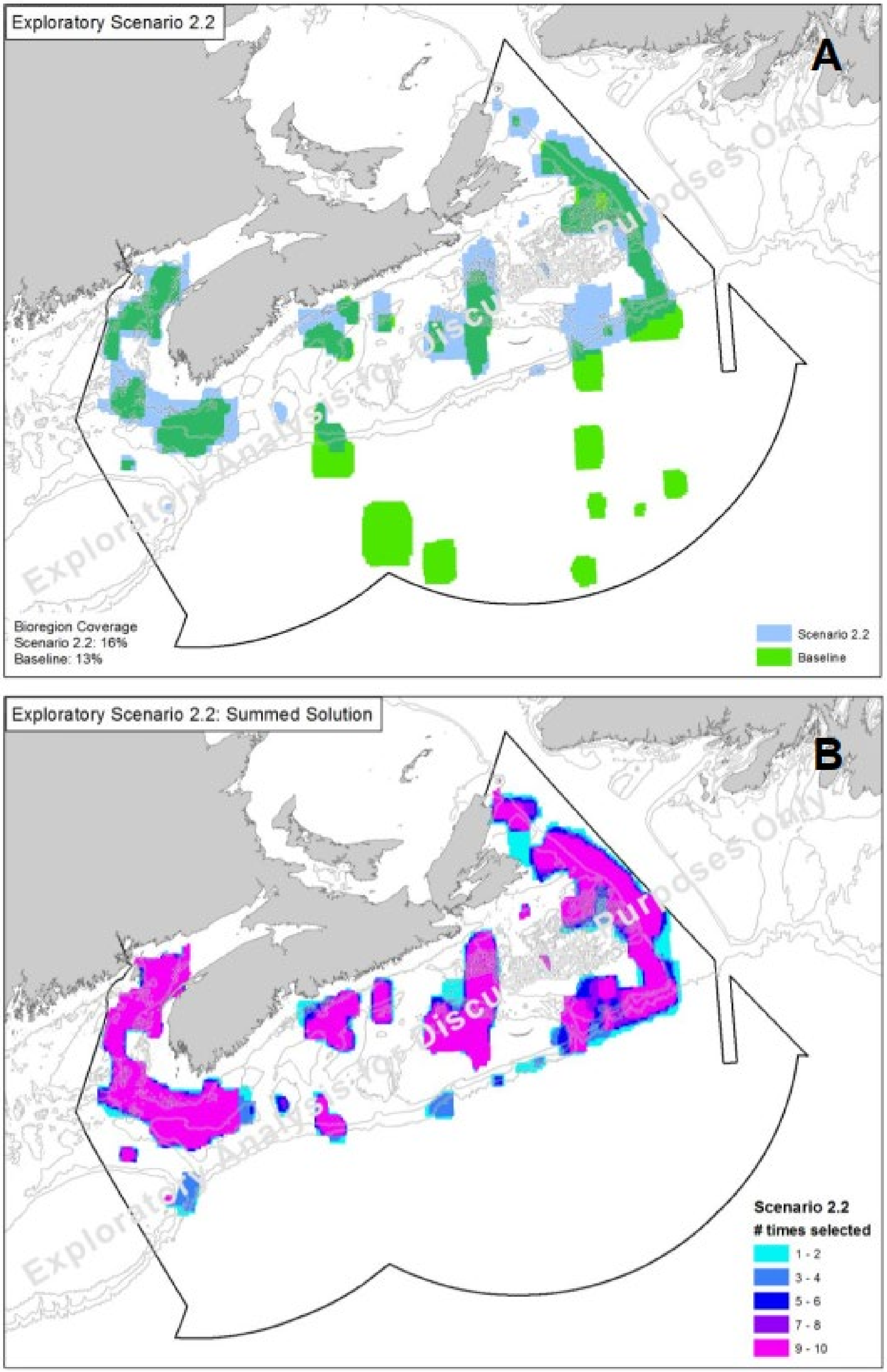

Figure C11. Exploratory analysis Group 2, Scenario 2. Best run (A) and summed solution (B). Fine-filter features only with high targets and boundary length modifier (BLM) set at 10.

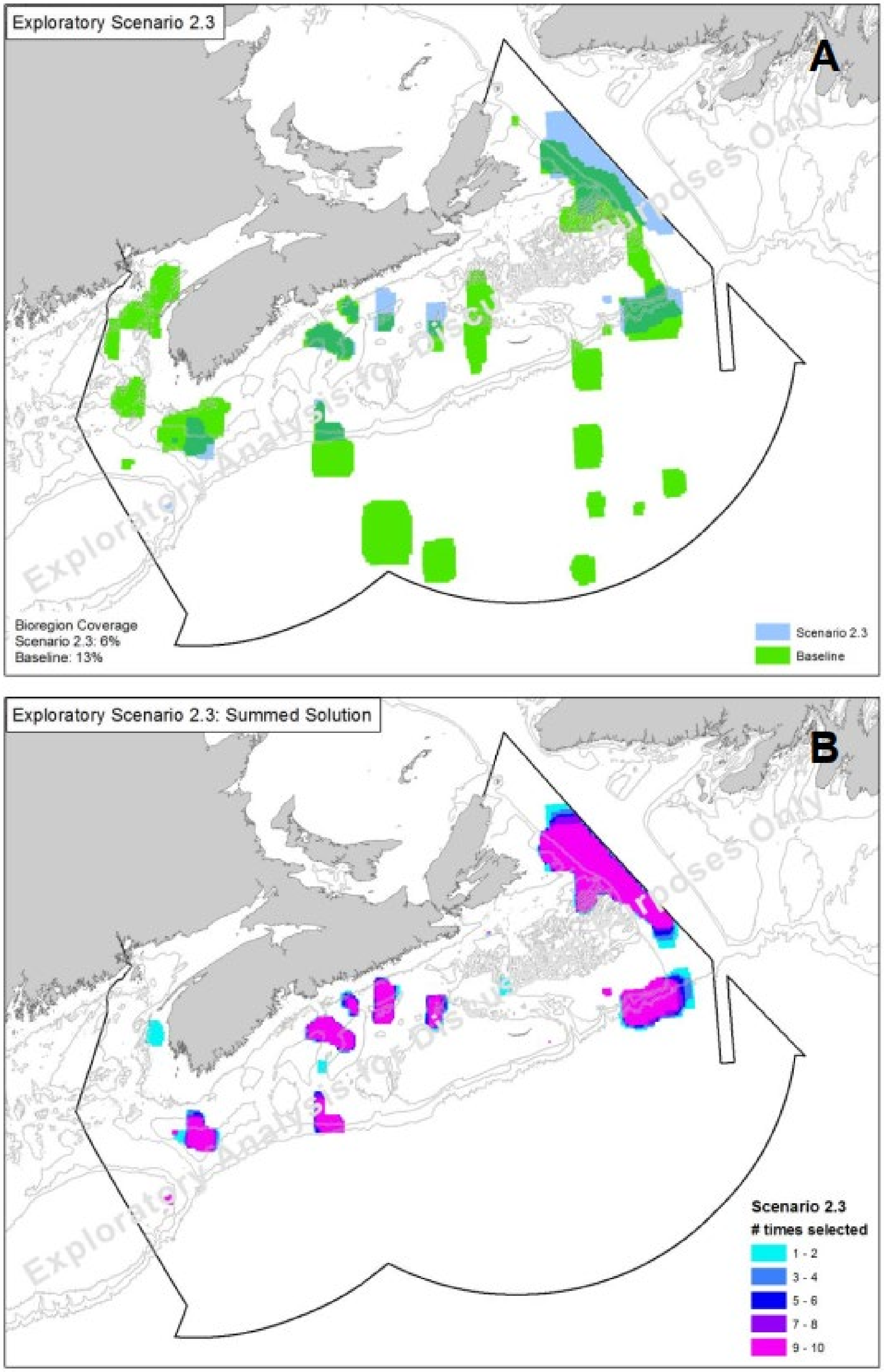

Figure C12. Exploratory analysis Group 2, Scenario 3. Best run (A) and summed solution (B). Biogenic habitats (fine-filter) features only with high targets and boundary length modifier (BLM) set at 10.

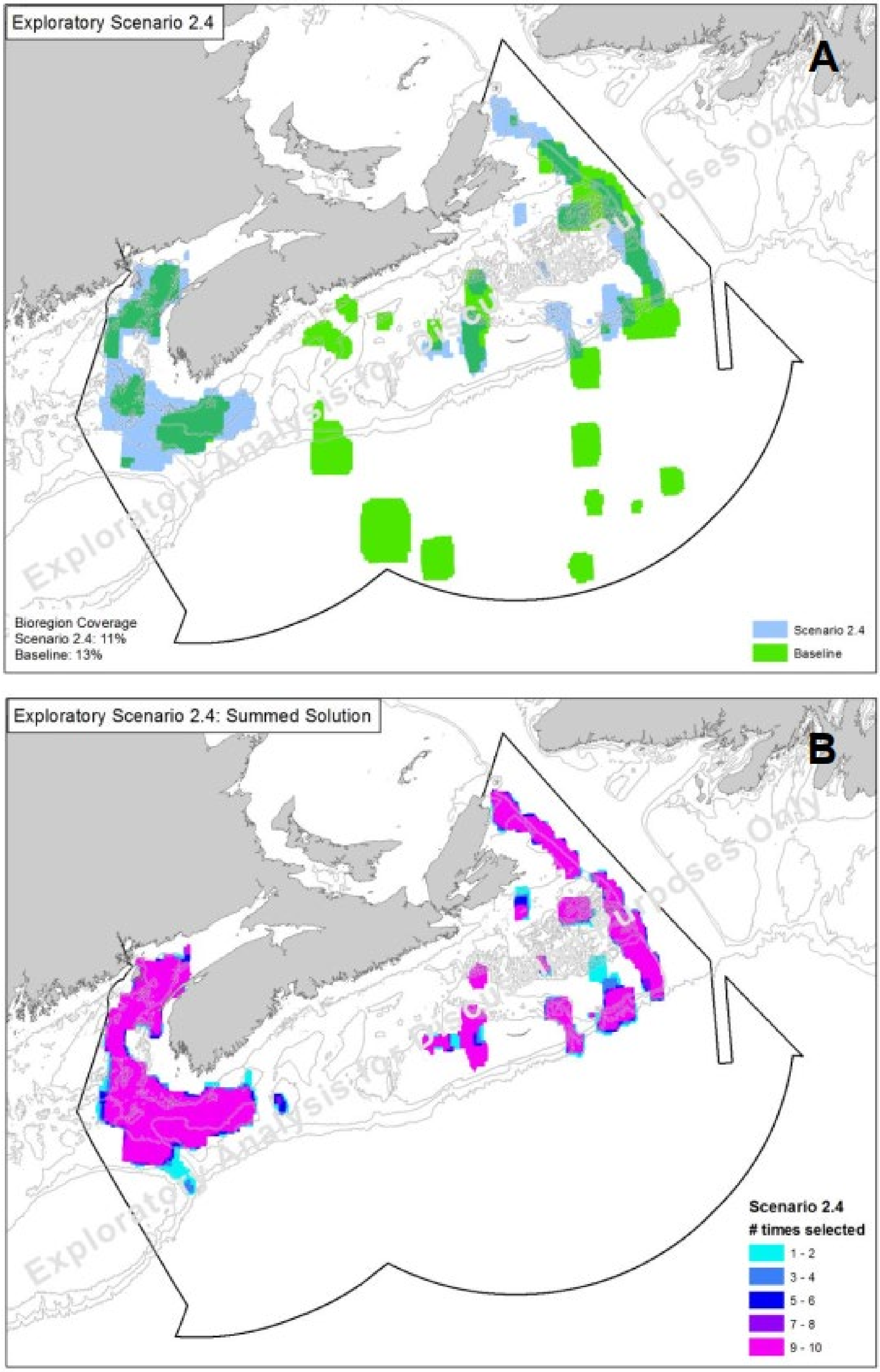

Figure C13. Exploratory analysis Group 2, Scenario 4. Best run (A) and summed solution (B). Depleted species (fine-filter) features only with high targets and boundary length modifier (BLM) set at 10.

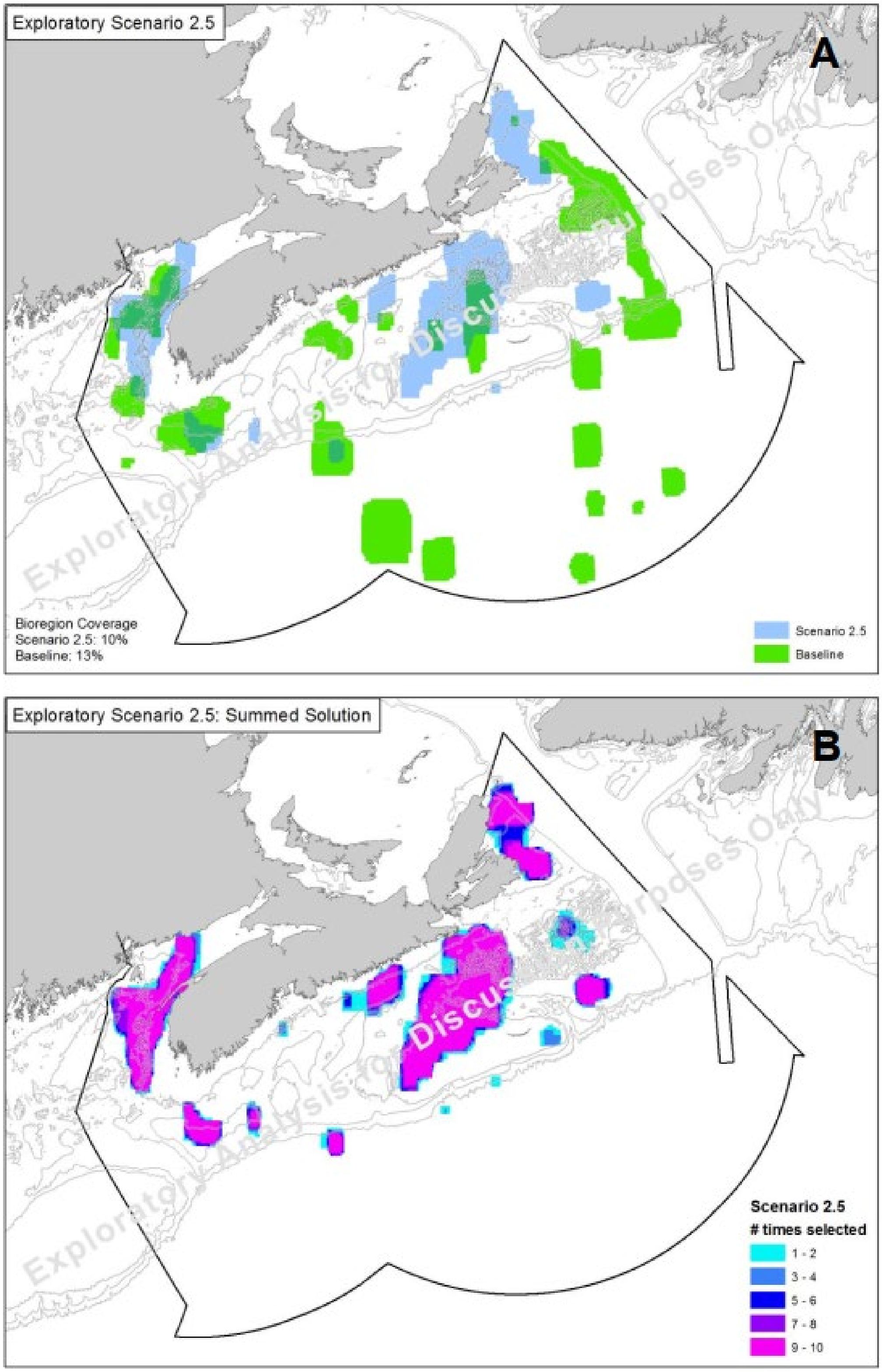

Figure C14. Exploratory analysis Group 2, Scenario 5. Best run (A) and summed solution (B). Areas of high species richness (fine-filter) features only with high targets and boundary length modifier (BLM) set at 10.

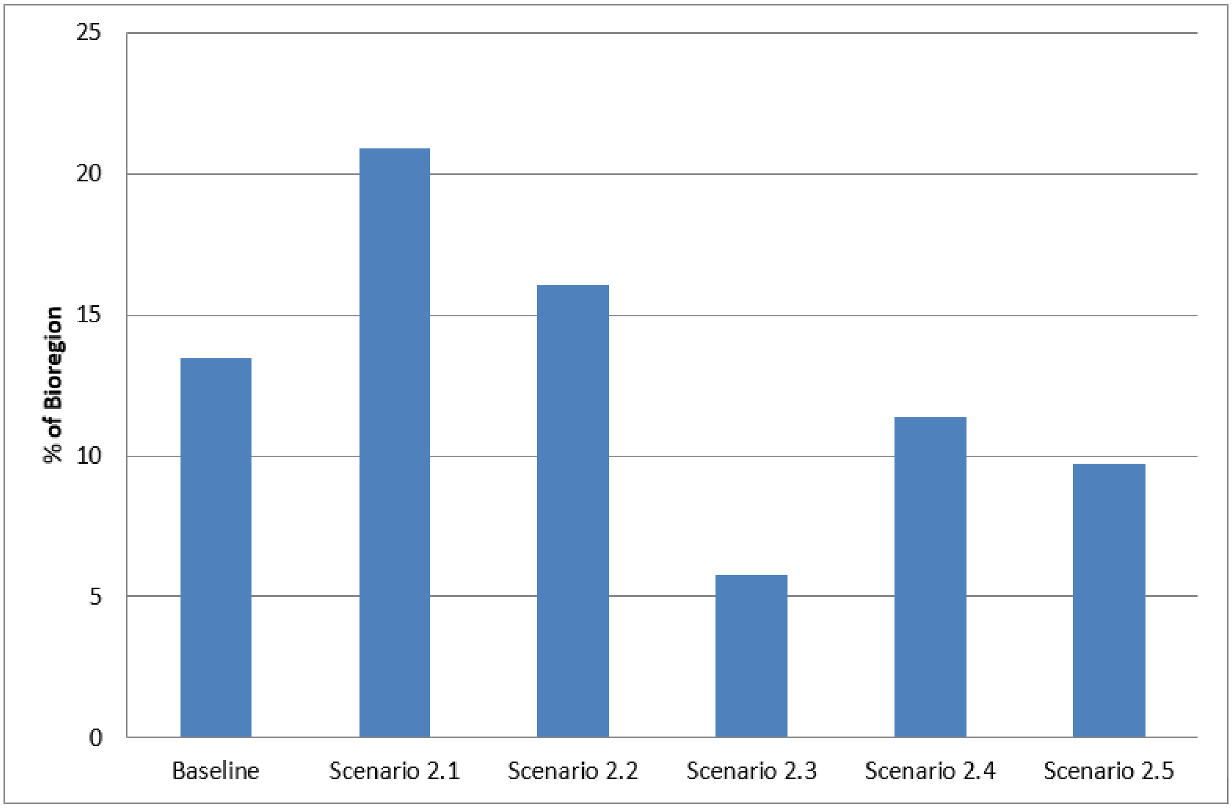

Figure C15. Percentages of the total area of the bioregion required to meet targets under the Group 2 exploratory scenarios.

Completing the exploratory *Marxan* analyses presented led to some general observations that should be noted. For instance, fine-filter features appear to have the strongest influence on the configuration of the MPA network scenarios. This is to be expected because they are generally smaller features with higher targets so *Marxan* must select them to achieve its targets. There is more flexibility in where coarse-filter features can be captured because they are typically larger features with lower targets. For example, there are many places where a representative example of Abyssal Plain habitat can be protected. It was also evident from the exploratory analyses that there is less flexibility in terms of where targets can be met on the shelf than there is in deeper water. This is due to the fact that nearly all of the fine-filter conservation priorities (i.e., smaller features with higher targets) are located on the shelf.

The baseline exploratory scenario could be viewed as a bare minimum for achieving some level of representation for all conservation priorities for the Scotian Shelf bioregional MPA network. However, it only captures 13% of the bioregion, which may not be sufficient to ensure biodiversity persistence over the long-term. Recent guidance suggests that a minimum of 30% of a particular region should be protected to effectively conserve biodiversity and ecosystem functioning (e.g., Jessen.*et al.* 2011). Increasing the targets of all conservation priorities to the high end of their respective ranges would increase the total area requirements, which may offer more comprehensive protection.

Combining coarse- and fine-filter features in a *Marxan* analysis can force the software to meet representative targets for coarse-filter features in areas that are important for depleted species, which may be the most impacted or least natural areas. However, this effect would be diminished with the inclusion of the fisheries cost layer, which will direct *Marxan* to select areas where there has been less fishing activity in recent years. So, including the fisheries cost layer is inadvertently incorporating some degree of naturalness. It should be acknowledged that the cost layer does not account for historical fishing as it only spans the past 10 years.

Appendix C References

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APPENDIX D: GLOSSARY OF TERMS

Benthic: Benthic refers to the lowest level of a body of water, such as the seabed, and includes the sediment surface and subsurface layers. Benthic species are organisms that live on, in, or near the seabed.

Biodiversity: The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (Convention on Biological Diversity definition).

Bioregion: A biogeographic division of Canada's marine waters out to the edge of the Exclusive Economic Zone, and including the Great Lakes, based on attributes such as bathymetry, influence of freshwater inflows, distribution of multi-year ice, and species distribution.

Coastal and marine areas: In a Canadian MPA network planning context, this includes Canada's oceans estate extending to and including the Great Lakes, from the high water mark in coastal or shoreline areas to the outer edge of the Exclusive Economic Zone.

Connectivity: Connectivity in the design of an MPA network allows for linkages whereby protected sites benefit from larval and/or species exchanges, and functional linkages from other network sites. In a connected network, individual sites benefit one another (CBD 2009).

Conservation: The *in situ* maintenance of ecosystems and natural and semi-natural habitats and of viable populations of species in their natural surroundings (International Union for Conservation of Nature definition).

Conservation priority: In a Canadian MPA network planning context, a conservation priority is a specific species, habitat or other ecological feature that a regional MPA network aims to protect.

Critical habitat: For species listed under the *Species at Risk Act*, critical habitat is the habitat that is necessary for a species' survival or recovery and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species. The *Species at Risk Act* (SARA) makes it illegal to destroy the critical habitat of a listed species.

Depleted species: Within the Scotian Shelf Bioregion MPA network planning context, depleted species are defined as any species that is listed as Endangered, Threatened or Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Some of these species have also been listed under *Species at Risk Act*. For fishes, the list of depleted species also includes species that are in the Critical or Cautious zone under the DFO Precautionary Approach Framework or at biomass levels that are less than forty percent of the long-term mean.

Design strategy: In a Canadian MPA network planning context, a design strategy is a detailed statement that, for each operational objective, specifies: (1) the types of areas or features to be conserved, and; (2) the relative targets for those area types.

Ecologically and Biologically Significant Area: Geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics (Convention on Biological Diversity definition).

Marine protected area: A clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (International Union for Conservation of Nature definition).

Operational objective: In a Canadian MPA network planning context, an operational objective is a specific and measurable statement that indicates the desired state for each conservation priority for a regional MPA network.

Protection: Any regulatory or other provision to reduce the risk of negative impact of human activities on an area.

Rare: Features, species, populations, or communities that only occur in a few locations. In practice, this term has an associated context of scale (i.e., globally rare, regionally rare, etc.).

Replication: An MPA network design principle meaning that all conservation priorities within a bioregion should be captured in at least two discrete MPAs within an MPA network, unless those features are unique (CBD 2009).

Representativity: An MPA network design principle that prescribes the inclusion of areas representing the different biogeographical subdivisions of the global oceans and regional seas that reasonably reflect the full range of ecosystems, including the biotic and habitat diversity of those marine ecosystems (CBD 2009).

Resilience: An ecosystem's ability to adapt to changing conditions in order to maintain its identity, structure, functions, and services (International Union for Conservation of Nature definition).

Sensitive: Species or habitats that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery (Convention on Biological Diversity definition).

Strategic objective: In a Canadian MPA network context, a strategic objective is a high-level statement that outlines what a regional MPA network aims to achieve.

Unique: Features, species, populations, or communities that are the only one of its kind. In practice, this term has an associated context of scale (i.e., globally unique, regionally unique, etc.).