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Newfoundland and Labrador Region

Canadian Science Advisory Secretariat
Science Advisory Report 2017/046

SCIENCE GUIDANCE ON DESIGN STRATEGIES FOR A NETWORK OF MARINE PROTECTED AREAS IN THE NEWFOUNDLAND AND LABRADOR SHELVES BIOREGION

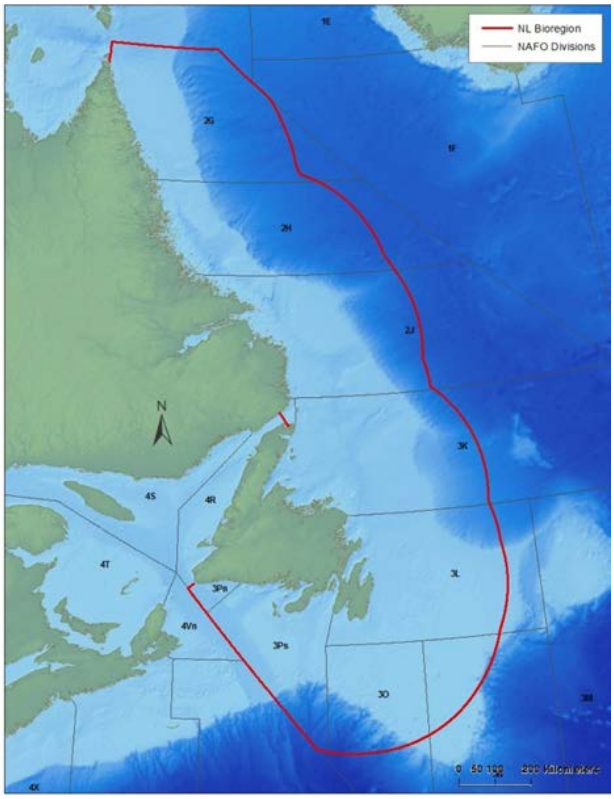

Figure 1: Planning Area for the Newfoundland and Labrador Shelves Bioregion.

Context

Canada has agreed to the Convention on Biological Diversity (CBD) Aichi Target 11 which includes the conservation of 10% of coastal and marine areas by 2020. Areas of high biodiversity and those that provide ecosystem services are of particular importance. The Newfoundland and Labrador (NL) Shelves have been identified as one of the five priority bioregions for Marine Protected Area (MPA) network development. The primary goal of Canada's MPA network is to provide long-term protection of marine biodiversity, ecosystem function, and special natural features.

Fisheries and Oceans Canada (DFO) Ecosystems Management (Oceans Program, NL Region), has identified Strategic Objectives, Conservation Priorities (CPs) and Operational Objectives (OOs) for the NL Shelves Bioregion based on stakeholder identified priorities and science. For each of the OOs, information on design strategies or targets is required to determine how much/many of each ecological component to aim to protect.

A Steering Committee has used the best available scientific information and advice regarding the design strategies for a MPA network in the NL Shelves Bioregion. A framework for setting design targets was developed and used to provide a range of targets which can be used as inputs into Marxan (software selected by the Oceans Program that delivers decision support for MPA network design; Ball et al. 2009).

Oceans Program, NL Region requested advice from DFO Science to develop design strategies and associated targets to aid in the development of a network of MPAs in the NL Shelves Bioregion. A Science advisory meeting was held to: (1) Review the proposed framework for setting targets for OOs identified for the NL Shelves Bioregion, and (2) Review proposed design strategies and associated targets for each OO identified for the NL Shelves Bioregion.

This Science Advisory Report is a result of the May 16-18, 2017 meeting Science Guidance on Design Strategies for a Network of Marine Protected Areas in the Newfoundland and Labrador Shelves Bioregion. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- A framework to set targets from an ecological perspective for operational objectives was presented. This framework developed targets for physical/habitat features, species functional groups and 'at risk' species in a similar methodology and, in general, worked well for relatively data rich areas of the bioregion.
- Minor modifications of the framework were suggested by this review, for example increasing targets for sessile/stationary features. Other modifications were suggested but no consensus was reached during the meeting on how to address them. It was agreed that these modifications could be completed in conjunction with a Science/Oceans MPA Network Committee and would not require additional review.
- The framework presented did not capture ecological attributes in the coastal zone at the same extent or scale as areas in the offshore. It is recommended that the targets set under this framework be used with caution in the coastal zone and another approach is necessary for these areas.
- Incorporation of Indigenous knowledge should be a consideration. Indigenous groups should be engaged in the collection and utilization of the knowledge they have. This is particularly important in data poor areas, including coastal areas in northern Labrador.
- The framework presented for fish/corals utilized the DFO research vessel (RV) survey as one of its major inputs; this survey does not cover coastal or deeper areas of the bioregion (>1,500 m) and recently has not covered the Northwest Atlantic Fisheries Organization (NAFO) Division 2G, northern Labrador.
- Some historical data for fish does exist for the NAFO 2GH region and it was agreed the area should be treated separately and targets set for features in this area be used with caution when making management decisions due to the age and sparseness of the data.
- It was recommended that when setting targets for representativity, Ecological Production Units (EPUs), Eco-units and underwater features be used.
- Spatial management may work for certain aspects of the environment (sessile species, biogenic habitats) better than others (highly mobile species). This fact should be kept in mind when considering the targets developed into final MPA network design.
- In light of ecosystem/climate change, these targets should be revisited and revised in at least five years but no more than 10 years. Adaptive management mechanisms should be included in the MPA network.
- Boreal/temperate gradient should be considered when using targets and a review of initial scenarios should take this gradient into account and ensure that targets are met in the north as well as the south. Conservation Priorities (CPs) should be captured across the distinct areas of the bioregion.
- Connectivity has not been addressed in this review; this should be studied further to understand how they may be incorporated into future network design processes and should be considered throughout the MPA network planning process.
- A range of conservation targets (low, medium, high) was discussed and agreed upon at the conclusion of this meeting. The low target should be considered as the minimum target that should be set for each feature for planning purposes.

- A sensitivity analysis of the targets themselves, as well as the inclusion or exclusion of each feature and groups of features proposed from this review, is recommended. This should be reviewed by a Science/Oceans MPA Network Committee.
- The targets presented in this review represent the ecological inputs for MPA design. It is understood this is only one attribute being considered for the overall design and it was recommended that, as the design is finalized, be reviewed by Science to ensure the network is still viable from an ecological perspective.

INTRODUCTION

To reach the goal of protecting 10% of Canada's coastal and marine areas by 2020, Fisheries and Oceans Canada (DFO), working with Parks Canada (PC), Environment and Climate Change Canada (ECCC), Provincial/Territorial/Indigenous governments, and various stakeholders and Indigenous groups, is leading a process for the creation of a national network of Marine Protected Areas (MPAs). An MPA network is a "collection of individual marine protected areas that operate cooperatively and synergistically, at various spatial scales, and with a range of protection levels, in order to fulfill ecological aims more effectively and comprehensively than individual sites could alone" (Government of Canada 2011). The Newfoundland and Labrador (NL) Shelves Bioregion is one of five priority bioregions within Canada that have been identified for MPA network development. This area covers 1,013,509 km^2 from the northern tip of Labrador to the southwest coast of Newfoundland and offshore to the Exclusive Economic Zone (EEZ) (Figure 1).

The primary national goal of the network will be to provide long-term protection of marine biodiversity, ecosystem function, and special natural features (Government of Canada 2011). Under this goal, and following the national guidance on setting objectives for MPA networks, Oceans Program, NL Region has drafted Strategic Objectives (SOs) for the NL Shelves Bioregion which outline what the MPA network aims to achieve (Table 1). Associated with each SO, ecological features (e.g., species, habitats) have been identified as Conservation Priorities (CPs) that the network will aim to protect. For each CP, more specific Operational Objectives (OOs) are identified which indicate the desired state for each conservation priority. The CPs were based on prior work on the Placentia Bay-Grand Banks Large Oceans Management Area (LOMA), consultation with stakeholders, and feedback from DFO Science.

DFO Science has been asked to provide advice on design strategies for these CPs. Design strategies must identify:

1. The type of area or specific ecological feature to be conserved; and
2. The related conservation target, which indicates how much of the area or feature should be captured in the MPA network.

Table 1: Strategic Objectives (SOs), Conservation Priorities (CPs) and Operational Objectives (OOs) under Goal 1: To provide long-term protection of marine biodiversity, ecosystem function and special natural features of the marine environment (primary goal).

Strategic Objectives	Conservation Priorities	Operational Objectives
SO-1: Protect areas of uniqueness, aggregation, and fitness consequences (EBSAs)	CP-1.1: EBSAs	OO-1.1.1: Protect areas identified as EBSAs.
SO-2: Protect representative examples of ecosystem and marine habitat in the bioregion.	CP-2.1: Representativity	OO-2.1.1: Protect representative areas within each identified eco-unit. OO-2.1.2: Protect representative areas within each identified Ecosystem Production Unit. OO-2.1.3: Protect areas with strong oceanographic/ bathymetric features, e.g., tidal mixing zones, upwelling zones, and persistent primary productivity areas.
SO-3: Contribute to the protection of key elements supporting ecosystem functionality.	CP-3.1: Ecological functions (areas of aggregation including those known for spawning or breeding, nursery or rearing, feeding, migration, seasonal refugia).	OO-3.1.1: Protect areas important for life history stages of fish functional groups, including Atlantic Cod and forage fish. OO-3.1.2: Protect areas identified as high suitability habitat for Marine Mammals functional groups, including cetaceans. OO-3.1.3: Protect areas identified as important for marine bird functional groups.
SO-3: Continued.	CP-3.2: Structural features (features that result in areas of potential high productivity/biodiversity).	OO-3.2.1: Protect areas that have physical characteristics that make them consistent with Vulnerable Marine Ecosystem elements (e.g., seamounts, canyons). OO-3.2.2: Protect marine areas with high biodiversity, including areas of high richness of corals and sponges.

Table 1: Continued.

Strategic Objectives	Conservation Priorities	Operational Objectives
SO-3: Continued.	CP-3.3: Marine habitats	OO-3.3.1: Protect areas identified as significant concentrations of Corals and Sponges. OO-3.3.2: Protect areas that have the presence of biological indicator species of Vulnerable Marine Ecosystems. OO-3.3.3: Protect productive marine habitats (e.g., eelgrass beds, kelp forests).
SO-4: Contribute to the protection and recovery of identified at-risk species.	CP-4.1: At-risk species.	OO-4.1.1: Protect areas important for life history stages for species listed as endangered or threatened on Schedule 1 of the *Species at Risk Act*. OO-4.1.2: Protect areas important for life history stages for species listed as endangered or threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). OO-4.1.3: Protect areas important for life history stages for species that have been considered depleted under DFO/NAFO.

To undertake this review, an MPA Network Steering Committee was organized, including members from DFO Science and Oceans, Memorial University of Newfoundland, and Environment and Climate Change Canada (ECCC). The committee reviewed best practices from MPA network design processes in other regions and provided their expert knowledge and advice to inform the development of a range of conservation targets (low, medium, high) for ecological features within the NL Shelves Bioregion. This range of targets will allow some flexibility in the MPA network planning process.

The range of targets provided will be used by DFO Oceans Program as inputs for Marxan, a decision support tool for MPA network design. The MPA network design process will be iterative with additional economic, social and cultural information provided by Indigenous groups, the Oceans Program, and other interested parties considered in a post-Marxan analysis of the potential scenarios. Federal/Provincial governments, Indigenous governments and groups, and other interested parties will also take part in the consultation process. The draft MPA network design will be a map of areas for future protection. Areas selected for protection prior to 2020 will facilitate the Government of Canada's contribution to the national targets within the NL Shelves Bioregion; the MPA network design will also aid future network planning beyond these targets.

ANALYSIS

The methods used to develop the framework and set the range of conservation targets are summarized below. The final conservation targets are also presented here by category.

Ecological Features

For each design strategy, an ecological feature to be conserved must be identified. This can be anything from a spatially defined area to a group of species. The types of features identified in the conservation priorities for the NL Shelves Bioregion include Ecologically and Biologically Significant Areas (EBSAs), representative features, structural features, marine habitats, ecosystem function, and at-risk species. As spatial protection would not be expected to benefit all EBSAs equally, targets were not set for these features. Instead, once a MPA network design has been developed, overlays will be used to assess how much of these areas are captured by the network.

Representative features

Different approaches have been developed for defining marine ecoregions within the NL Shelves Bioregion. These ecoregions represent marine ecosystems or habitats which should be included within the MPA network. Park and Mercier (2014) identified six eco-units within the NL shelves based on a review of other classification systems. Pepin et al. (2014) identified six Ecological Production Units (EPUs) based on ecosystem function. While these systems capture larger scale habitats, they do not capture smaller-scale features, especially in coastal areas (e.g., bays, fjords). EPUs do not capture areas with depths greater than 1,000 m, but they include a separate unit for northern Labrador which is not included in the eco-unit system. As both systems were developed for different reasons and with different methods, to ensure the most representativity within the MPA network, targets should be considered for both eco-units and EPUs (Table 2). In order to capture the smaller scale features in the bioregion, it is recommended that other physical features associated with high productivity/biodiversity, including strong oceanographic/bathymetric features (e.g., tidal mixing zones, upwelling zones, and persistent primary productivity areas), be included under this conservation priority. However, since sufficient data do not currently exist to represent some of these features, geomorphic underwater features such as banks and channels can be used as proxies.

Table 2: Operational Objectives and pertinent ecological features for SO-2/CP-2.1. SO-2: Protect representative examples of ecosystem and marine habitat in the bioregion CP-2.1: Representativity

Operational Objective	Ecological feature
OO-2.1.1: Protect representative areas within each identified **eco-unit.**	*Eco-unit:* NL Shelves
	Eco-unit: Labrador Sea
	Eco-unit: Northern Grand Banks
	Eco-unit: Southern Grand Banks
	Eco-unit: Laurentian Channel/South Coast
	Eco-unit: Laurentian Fan
OO-2.1.2: Protect representative areas within each identified Ecosystem Production Unit	*EPU* - Grand Banks
	EPU - Laurentian Fan
	EPU - Labrador Shelf
	EPU - Labrador Shelf - offshore
	EPU - Newfoundland Shelf
	EPU - Newfoundland Shelf - offshore
	EPU - Southern Newfoundland
OO-2.1.3: Protect areas with strong **oceanographic/ bathymetric features**, e.g., tidal mixing zones, upwelling zones, and persistent primary productivity areas.	*UW Feature* - Bank
	UW Feature - Basin
	UW Feature - Bay
	UW Feature - Channel
	UW Feature - Continental shelf
	UW Feature - Drift
	UW Feature - Fan
	UW Feature - Fjord
	UW Feature - Moraine
	UW Feature - Ridge
	UW Feature - Rise
	UW Feature - Saddle
	UW Feature - Shoal
	UW Feature - Slope
	UW Feature - Spur
	UW Feature - Trough

Ecological function

Areas where species aggregate during various life history phases (e.g., spawning or breeding, nursing or rearing, feeding, migration, or refuge) give support to ecosystem functionality. Although data may be available to assess where these species aggregate, the reason for the aggregation may not always be known. Three main taxonomic groups (fish and invertebrates, marine mammals, and marine birds) are the focus of the OOs under this CP and each was divided into functional groups to represent the role that each plays in the ecosystem (Table 3). In order to assign scores to functional groups, each species within the group was assigned an individual score and then a group score was calculated as an average of all individual scores. Capelin spawning areas were treated separately and scored based on their spatial uniqueness and vulnerability relative to other habitat types.

Blue Whales, North Atlantic Right Whales and Killer Whales were not included in functional groups for scoring as their feeding and social behaviours did not fit well with any of the groups. Killer Whales are included under this CP, however Blue Whales and North Atlantic Right Whales are considered below as at-risk species. Pinnipeds were not considered for target-setting purposes because it is not anticipated that this taxonomic group would benefit from spatial management strategies. However, information on pinniped spatial distributions should be included as overlays in a post-Marxan analysis to determine the extent of their distributions within the proposed network.

The biomass distribution for fish functional groups is often controlled by a few dominant species. It was therefore determined that only the species representing the top 90% of the biomass for a functional group would be assessed and assigned scores. For marine birds, functional groups were assessed based on species representing >90% of the records where applicable. For cetaceans, dominant species were determined based on expert opinion and scores for rare species were removed from the overall functional group score.

Shrimp (Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*P. montaguii)* were assessed as their own functional group as they play a similar role in the ecosystem, while Snow Crab was assessed on its own because of its smaller relative biomass compared to shrimp and the fact that it has a different ecological function. Other invertebrate species or functional groups were not included because, while data are available, there has been no quality control performed date that would enable the creation of reliable data layers.

Table 3: Operational Objectives and pertinent ecological features for SO-3/CP-3.1. SO-3: Contribute to the protection of key elements supporting ecosystem functionality. CP-3.1: Ecological Functions (areas of aggregation including those known for spawning or breeding, nursery or rearing, feeding, migration, seasonal refugia).

Operational Objective	Ecological feature
OO-3.1.1: Protect areas important for life history stages of fish functional groups, including **Atlantic Cod** and **forage fish**.	*Fish Functional Group* – Small benthivores
	Fish Functional Group – Medium benthivores
	Fish Functional Group – Large benthivores
	Fish Functional Group – Planktivores
	Fish Functional Group – Plankpiscivores
	Fish Functional Group – Piscivores
	Fish Functional Group – Shrimp
	Fish Functional Group - Forage fish
	Fish Species – Snow Crab
	Capelin spawning areas
OO-3.1.2: Protect areas identified as high suitability habitat for **Marine Mammals** functional groups, including cetaceans.	*Marine Mammals Functional Group* - Mysticetes
	Marine Mammals Functional Group - Small cetaceans
	Marine Mammals Functional Group - Squid consumers
	Marine Mammals - Killer whales

Table 3: Continued.

Operational Objective	Ecological feature
OO-3.1.3: Protect areas identified as important for **marine bird** functional groups.	*Marine Bird Functional group* - Surface-seizing planktivores
	Marine Bird Functional group - Surface, shallow-diving piscivores/generalists
	Marine Bird Functional group - Surface, shallow-diving coastal piscivores
	Marine Bird Functional group - Pursuit-diving piscivores
	Marine Bird Functional group - Shallow pursuit generalist
	Marine Bird Functional group – Pursuit-diving planktivore
	Marine Bird Functional group - Plunge-diving piscivores
	Marine Bird Functional group – Coastal intertidal grazers
	Marine Bird Functional group – Coastal mulloscovores/piscivores

Structural features

This Conservation Priority deals with different features associated with high productivity/biodiversity. Specifically, it includes areas consistent with Vulnerable Marine Ecosystem (VME) elements (e.g., canyons and steep flanks), as well as areas of high biodiversity, including areas of high richness of corals and sponges. Areas of high fish diversity and areas with high coral richness were used as proxies for areas of overall high diversity. A data layer was developed to indicate areas of high invertebrate diversity but additional quality control is required of this dataset prior to accepting it as a reliable data layer. Areas of high chlorophyll *a* persistence were proposed as a proxy for high productivity, however it was recommended that these data layers not be incorporated into the Marxan analysis. chlorophyll *a* production cannot be protected or managed by an MPA, and therefore it would not be useful to include this feature. However, it is recommended that these data layers be used as overlays to identify whether data-poor, but potentially productive areas are included in the final MPA Network solutions. Table 4 outlines the ecological features for the two OOs identified under this CP.

Table 4: Operational Objectives and pertinent ecological features for SO-3/CP-3.2. SO-3: Contribute to the protection of key elements supporting ecosystem functionality. CP-3.2: Structural features (features that result in areas of potential high productivity/biodiversity).

Operational Objective	Ecological feature
OO-3.2.1: Protect areas that have physical characteristics that make them consistent with **Vulnerable Marine Ecosystems** (e.g., seamounts, canyons).	*VME Elements* - Canyons
	VME Elements - Steep flanks
OO-3.2.2: Protect marine areas with high **biodiversity,** including areas of high diversity of corals and sponges.	High fish diversity
	High species richness for corals

Marine habitats

The OOs for marine habitats include both offshore and coastal features which provide important ecosystem functions including providing habitat for refuge and feeding (Table 5). In the offshore, areas with significant concentrations of corals and sponges (Significant Benthic Areas, or SBAs) as well as areas that have biological indicators for VMEs are identified in the first and second

OOs while, in the nearshore, productive marine habitats such as eelgrass beds and kelp forests are represented in the third OO.

Although SBAs have only been identified for large and small gorgonians, sea pens, and sponges, a group for black corals was added because of their longevity, apparent rarity, and function within the ecosystem. However, these species are generally non-aggregating and there is a paucity of information relating to their spatial distribution; therefore, it was not possible to create a reliable data layer for this group.

For the VMEs, indicator species in the Crinoids, Bryozoans, and Ascidians groups were identified as ecological features. However, discussions on the reliability of the species distribution models for these groups warranted their removal from the current target setting process.

Table 5: Operational Objectives and pertinent ecological features for SO-3/CP-3.3. SO-3: Contribute to the protection of key elements supporting ecosystem functionality. CP-3.3: Marine Habitats.

Operational Objective	Ecological feature
OO-3.3.1: Protect areas identified as significant concentrations of **Corals and Sponges** (SBAs).	*Corals functional groups* - Large gorgonians
	Corals functional groups - Small gorgonians
	Corals functional groups - Sea pens
	Sponges functional groups - Sponges
OO-3.3.2: Protect areas that have the presence of biological indicator species of Vulnerable Marine Ecosystems.	N/A
OO-3.3.3: Protect productive **marine habitats** (e.g., eelgrass beds, kelp forests).	Eelgrass beds
	Kelp beds

At-risk Species

The OOs for at-risk species focus on protecting areas important for life history stages of four groups:

- Those designated as Endangered or Threatened under the *Species at Risk Act* (SARA);
- Those assessed as Endangered or Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC);
- Those that are in the Critical or Cautious zone (depleted) under the DFO Precautionary Approach Framework (PAF); and
- Those that are considered depleted under NAFO.

Not all species have enough data to be assessed, but those for which there are enough data to set targets can be seen in Table 6.

Table 6: Operational Objectives and pertinent ecological features for SO-4/CP-4.1. SO-4: Contribute to the protection and recovery of identified at-risk species. CP-4.1: At-risk species.

Operational Objective	Ecological feature
OO-4.1.1: Protect areas important for life history stages for species listed as endangered or threatened on Schedule 1 of the ***Species at Risk Act***.	Blue Whale
	Harbour Porpoise
	Ivory Gull
	North Atlantic Right Whale
	Northern Bottlenose Whale
	Northern Wolffish
	Spotted Wolffish
OO-4.1.2: Protect areas important for life history stages for species listed as endangered or threatened by **COSEWIC**.	Acadian Redfish
	American Plaice
	Atlantic Cod
	Beluga Whale
	Deepwater Redfish
	Leatherback Turtle
	Roundnose Grenadier
	Smooth Skate
	White Hake
	Winter Skate
OO-4.1.3: Protect areas important for life history stages for species that have been considered depleted under **DFO/NAFO.**	Northern Shrimp
	Witch Flounder

Target Score Development

As part of the process of developing this target setting framework, a Science/Oceans MPA Network Committee considered the systems developed in the Estuary and Gulf of St. Lawrence and Scotian Shelf Bioregions and adapted them as necessary for this region. Ecological features were given target scores based on a set of primary factors including: size/distribution, uniqueness, vulnerability, responsibility and current status. The relevant primary factors were selected based on the conservation priority being considered. Table 7 summarizes which factors were used to score each CP.

For size/distribution, proportional scores were used, whereas uniqueness and vulnerability scores ranged from 1-5 based on spatial extent, literature searches and/or expert knowledge. Responsibility scores were only assigned to marine birds based on the importance of the bioregion for particular species.

A final target score was generated by calculating the square root of the sum of squares of the scores for uniqueness and vulnerability, plus responsibility for marine birds. At-risk species were assessed for uniqueness, vulnerability, and responsibility (where applicable), and final scores were then increased based on their current status score. For functional groups, final target scores were calculated for each individual species and then the square root of the sum of squares was taken to find the group score.

Table 7: Relevant primary factors used in the assessment of each conservation priority.

Primary Factor	Representative Features	Ecological Function	Structural Features	Marine Habitats	At-risk Species
Size/ Distribution	X	-	X	-	-
Uniqueness	-	X	-	X	X
Vulnerability	-	X	-	X	X
Responsibility	-	X*	-	-	X*
Current Status	-	-	-	-	X

*Responsibility applies to marine birds only

Size/Distribution

For representative features (eco-units, EPUs and underwater features), the size/distribution factor was used to assign scores. In order to balance the target scores between large, common features and small, rare features, a scaling system was used where a target was assigned to the largest feature in the group, and the other features were assigned scores in proportion to it, with the aim that scores should fall within a range approximately equal to the square root of their respective total areas (Ardron et al. 2010). For example, in the eco-units group, a score was set for the NL Shelves as the largest feature in that group. A minimum low target of 2.5% was set for the largest feature (e.g. NL Shelves eco-unit); a medium target was set at a minimum of 5% and a high target was set at a minimum of 7.5%. Following the Marxan Good Practices Handbook (Ardron et al. 2010), the following formula was used to calculate targets:

$$(x_P/y_P) = (x_T/y_T)^{0.5}$$

where, "$_P$" is the protected area and "$_T$" is the total area. This was done for groups of features that are similar in scale.

Uniqueness

For marine habitats, ecological functions, and at-risk species, a uniqueness factor was calculated based on spatial information available for each ecological feature. This included data from the DFO RV trawl surveys (e.g., fish, corals, sponges), sightings databases (e.g., cetaceans and turtles), the Community-based Coastal Resource Inventory (CCRIs) (e.g. coastal biogenic habitats), and expert knowledge (e.g. marine birds). For features such as marine birds with distributions beyond the NL Shelves Bioregion, online databases (e.g., Status of Birds in Canada, Birds of North America, IUCN, FishBase), peer-reviewed research, and experts were consulted to consider national and/or global distributions.

Table 8 outlines the scores which were assigned based on a species' overall distribution, the number of eco-units they were observed in, as well as number of sightings. For example, a feature which is ubiquitous to the entire Northwest Atlantic including 4 or more eco-units in the NL Shelves Bioregion would be given a score of 1, while a feature found in few eco-units with few sightings would be given a score of 5.

Table 8: Scales for assigning spatial uniqueness scores to feature layers for fish, cetaceans, turtles and offshore biogenic habitats (corals, sponges and VME indicator species).

Score	Description
1	Found within and outside the Northwest Atlantic, as well as ≥4 eco-units in the NL Shelves Bioregion
2	Found in 3 eco-units in the NL Shelves Bioregion *or* endemic to the Northwest Atlantic
3	Found in 1-2 eco-units in the NL Shelves Bioregion
4	Found in ≥3 eco-units in the NL Shelves Bioregion, but ≤10 sightings (Mobile features) or ≤10 areas of significant concentrations (Sessile features)
5	Found in 1-2 eco-units in the NL Shelves Bioregion, but ≤10 sightings (Mobile features) or is non-aggregating and rare (Sessile features)

Marine birds were scored separately for uniqueness since they tend to aggregate in colonies for at least some part of the year. This scoring system is outlined in Table 9. Again, those species which are more widespread would have a lower score than those which are more spatially restricted within the bioregion.

Table 9: Scales for assigning spatial uniqueness scores to feature layers for marine birds.

Score	Description
1	Not aggregated and pervasive throughout the bioregion
2	Mildly aggregated and/or not evenly distributed throughout the bioregion
3	Aggregated and/or limited in distribution throughout the bioregion
4	Highly aggregated and/or restricted in range in the bioregion
5	Highly aggregated and severely restricted in range in the bioregion

Scores for each feature were combined into a composite score at the functional group level using the square root of the sum of squares for all species within that group.

Vulnerability

In order to assess vulnerability, information on Life History Characteristics (LHC) and Tolerance to Perturbation (TP) were assessed for each feature and combined to give a score.

Four sub-factors were considered in the LHC scores including: growth rate, age of sexual maturity, lifespan/adult annual survival, and fecundity. Tables 10-12 outline the scales used for assigning these scores for fish, cetaceans, and marine bird species. Where a taxonomic group contained more than five species, natural breaks in the data were used to divide the range into five classes. Where the values for a feature spanned more than one class, the average was used to assign a score. If a group had insufficient data or species (e.g., coastal and offshore biogenic habitats), a ranking of sub-factors was done and assessed by experts. For marine birds, growth rate was not used, and lifespan was replaced by adult annual survival. Sub-factor rankings and assessments for marine birds were completed with heavy input from ECCC.

Sub-factor scores were averaged and rounded to the nearest whole number to give a final LHC score. If information was not available for one or more sub-factors, the available sub-factors were averaged and used to assign the final score.

Table 10: Scales for assigning life history characteristic scores to fish species. The growth rate, k, refers to the von Bertalanffy growth parameter.

Score	Growth Rate (k)	Sexual Maturity (years)	Lifespan (years)	Fecundity (eggs/year)
1	0.71 – 0.85	0.30 – 2.30	2.10 – 11.0	>1,000,000
2	0.46 – 0.70	2.31 – 4.00	11.1 – 20.0	100,001 – 1,000,000
3	0.27 – 0.45	4.01 – 8.00	20.1 – 40.0	10,001 – 100,000
4	0.13 – 0.26	8.01 – 12.5	40.1 – 60.0	1,000 – 10,000
5	0.04 – 0.12	12.6 – 16.1	>60.0	<1,000

Table 11: Scales for assigning life history characteristic scores to cetacean species.

Score	Growth Rate (months to weaning)	Sexual Maturity (years)	Lifespan (years)	Fecundity (offspring/year)
1	5.0 – 8.0	3.5 – 5.5	9.0 – 23.0	0.68 – 1.00
2	8.1 – 15.0	5.6 – 7.0	23.1 – 37.0	0.51 – 0.67
3	15.1 – 19.0	7.1 – 10.5	37.1 – 52.5	0.38 – 0.50
4	19.1 – 24.0	10.6 – 12.5	52.6 – 60.0	0.28 – 0.37
5	24.1 – 31.0	12.6 – 13.5	>60.0	0.20 – 0.27

Table 12: Scales for assigning life history characteristics to marine birds feature layers.

Score	Sexual Maturity (years)	Adult Annual Survival	Clutch Size (eggs/brood)
1	1.0 – 2.0	0.75 – 0.80	4.6 – 8.0
2	2.1 – 3.0	0.81 – 0.85	3.1 – 4.5
3	3.1 – 5.0	0.86 – 0.90	2.1 – 3.0
4	5.1 – 7.0	0.91 – 0.95	1.1 – 2.0
5	7.1 – 10.0	>0.95	0.0 – 1.0

Species with low and/or declining populations are considered to be more vulnerable to disturbance; therefore, frequency of occurrence and population trends were used to assess their Tolerance to Perturbation.

Observation data for fish, cetaceans and turtles, and offshore biogenic habitats (corals, sponges and VME indicator species) within the NL Shelves Bioregion were used to assess frequency of occurrence. This data would include trawl survey data for fish, corals and sponges. The frequency of occurrence was calculated based on the proportion of observations. For cetaceans and turtles, the proportion of sightings was used. Natural breaks in the data were again used to assign classes from 1-5 (Table 13).

Table 13: Scales for assigning frequency of occurrence scores to fish, cetaceans, and offshore biogenic habitats.

Score	Frequency of Occurrence (%): Fish	Frequency of Occurrence (%): Cetaceans	Frequency of Occurrence (%): Offshore biogenic habitats
1	>48.0	>7.91	>25.09
2	35.1 – 48.0	4.76 – 7.91	10.51 – 25.09
3	18.1 – 35.0	2.21 – 4.75	7.31 – 10.50
4	10.1 – 18.0	0.75 – 2.20	1.05 – 7.30
5	2.0 – 10.0	<0.75	<1.05

Population estimates were available for most marine birds species, so it was used in place of frequency of occurrence (Table 14).

Table 14: Scores assigned to marine bird populations based on population size.

Score	Population size
1	1,000,000s
2	100,000s
3	10,000s
4	1,000s
5	<1,000

To identify population trends, DFO stock assessments, COSEWIC status reports, online databases (e.g., IUCN, Status of Birds in Canada, Birds of North America), and expert knowledge were used. If no information was available, the population trend was set as stable.

The overall score for Tolerance to Perturbation was computed by taking the frequency of occurrence score and adjusting it based on whether the population trend was increasing, stable or decreasing (Table 15). A lower score would indicate a higher tolerance to perturbation.

Table 15: Scale of Tolerance to Perturbation scores assigned based on Frequency of Occurrence and Population Trend.

Frequency of Occurrence	Population Trend Increasing (subtract 0.5 from Frequency of Occurrence score)	Population Trend Stable (no change in Frequency of Occurrence score)	Population Trend Decreasing (add 0.5 to Frequency of Occurrence score)
1	0.5	1.0	1.5
2	1.5	2.0	2.5
3	2.5	3.0	3.5
4	3.5	4.0	4.5
5	4.5	5.0	5.5

Responsibility

This factor was only considered for marine birds and takes into account the importance of the bioregion for each particular species. As appropriate for the distribution of the species, either the global or Atlantic basin population size was considered. The ECCC Status of Birds in Canada

website was used as the basis of the score classes (Table 16). Two scores could be assigned based on colonies versus at-sea populations of species as birds use different habitats during different parts of the year and some species move in and out of the bioregion. As the at-sea population scores were always the higher of the two, these were used as the final responsibility score. In addition to the dominant species within functional groups, Ivory Gull, the only at-risk bird species assessed, was also given a responsibility score.

Table 16: Scale of responsibility scores for marine birds based on proportion of the overall population hosted by the bioregion.

Score	Description
1	Bioregion hosts <1% of the population
2	Bioregion hosts 1-20% of the population
3	Bioregion hosts 20-50% of the population
4	Bioregion hosts 50-80% of the population
5	Bioregion hosts >80% of the population

Current Status

For at-risk species, current status was assessed and used to adjust the final target scores (Table 17). These species include species which are listed as endangered or threatened on Schedule 1 of the *Species at Risk Act,* species listed as endangered or threatened by COSEWIC, and species that have been considered depleted under DFO/NAFO.

Table 17: Target score adjustment based on current status.

Current Status	Target Score Adjustment
Endangered (SARA or COSEWIC)	+1.5
Threatened (SARA or COSEWIC)	+1.0
Depleted (DFO or NAFO)	+0.5

If a species has more than one status (e.g., endangered and depleted), the larger target adjustment was used for scoring. As this adjustment is somewhat arbitrary, expert opinion was used to finalize the scores, especially in cases where new, unpublished information exists for some species.

Proposed Conservation Targets

Target scores for individual species were calculated as the square root of the sum of squares of their uniqueness, vulnerability and responsibility (marine birds only) scores. Then, if a species was assessed for current status, the appropriate adjustment was added to this score. For functional groups, target scores were calculated for each species within a group, and then the square root of the sum of squares was taken to find the group score. Again, for some functional groups of fish, cetaceans, and marine birds, only the dominant species were assessed.

It was requested that Science provide a range of conservation targets (low, medium, high) for each ecological feature. The conservation targets to be used in Marxan for functional groups or at-risk species are calculated by multiplying the target score by 10. For sessile species and stationary features (e.g., corals and sponges, eelgrass and kelp habitat, capelin spawning beaches), the target score is multiplied by 20 to account for their increased vulnerability. To convert these to a range of scores, 10% was subtracted from each target for a low score, and

10% was added for a high score. It was recommended that a minimum conservation target of 10% be used for all features; therefore, low targets would be set at 10% if the calculated value was below this. There were two exceptions: first, in NAFO Divisions 2GH data are sparse and species distribution information is less reliable; therefore features in these zones were assigned a minimum target of 5%. Secondly, proportional targets were set on representative features with a minimum target of 2.5%.

The adjusted and final proposed target scores for all species are shown in Table 18.

*Table 18a: List of scores for OOs under **SO-2**: Protect representative examples of ecosystem and marine habitat in the bioregion and **CP-2.1**: Representativity.*

*In Current Status column indicates that a functional group contained one or more at-risk species.

Operational Objective	**Ecological feature**	**Primary Factor: Size (km^2)**	**Primary Factor: Uniqueness**	**Primary Factor: Vulnerability**	**Primary Factor: Responsibility**	**Primary Factor: Current Status**	**Final Target Score**	**Conservation Targets (%): Low**	**Conservation Targets (%): Medium**	**Conservation Targets (%): High**
OO-2.1.1: Protect representative areas within each identified **eco-unit.**	*Eco-unit:* NL Shelves	401,501	-	-	-	-	-	2.5	5.0	7.5
	Eco-unit: Labrador Sea	263,156	-	-	-	-	-	3.1	6.2	9.3
	Eco-unit: Northern Grand Banks	87,833	-	-	-	-	-	5.3	10.7	16.0
	Eco-unit: Southern Grand Banks	183,461	-	-	-	-	-	3.7	7.4	11.1
	Eco-unit: Laurentian Channel/South Coast	31,172	-	-	-	-	-	9.0	17.9	26.9
	Eco-unit: Laurentian Fan	42,866	-	-	-	-	-	7.7	15.3	23.0
OO-2.1.2: Protect representative areas within each identified Ecosystem Production Unit.	*EPU* - Grand Banks	252,610	-	-	-	-	-	2.5	5.0	7.5
	EPU - Laurentian Fan	31,584	-	-	-	-	-	7.1	14.1	21.2
	EPU - Labrador Shelf	126,177	-	-	-	-	-	3.5	7.1	10.6
	EPU - Labrador Shelf - offshore	168,736	-	-	-	-	-	3.1	6.1	9.2
	EPU - Newfoundland Shelf	251,893	-	-	-	-	-	2.5	5.0	7.5
	EPU - Newfoundland Shelf - offshore	91,911	-	-	-	-	-	4.1	8.3	12.4
	EPU - Southern Newfoundland	87,039	-	-	-	-	-	4.3	8.5	12.8

Table 18a: Continued.

Operational Objective	Ecological feature	Primary Factor: Size (km^2)	Primary Factor: Uniqueness	Primary Factor: Vulnerability	Primary Factor: Responsibility	Primary Factor: Current Status	Final Target Score	Conservation Targets (%): Low	Conservation Targets (%): Medium	Conservation Targets (%): High
OO-2.1.3: Protect areas with strong **oceanographic/ bathymetric features,** e.g., tidal mixing zones, upwelling zones, and persistent primary productivity areas.	*UW Feature* - Bank	244,284	-	-	-	-	-	2.5	5.0	7.5
	UW Feature - Basin	10,122	-	-	-	-	-	12.3	24.6	36.8
	UW Feature - Bay	3,084	-	-	-	-	-	22.2	44.5	66.7
	UW Feature - Channel	94,158	-	-	-	-	-	4.0	8.1	12.1
	UW Feature - Continental shelf	192,851	-	-	-	-	-	2.8	5.6	8.4
	UW Feature - Drift	47,192	-	-	-	-	-	5.7	11.4	17.1
	UW Feature - Fan	49,710	-	-	-	-	-	5.5	11.1	16.6
	UW Feature - Fjord	5,288	-	-	-	-	-	17.0	34.0	51.0
	UW Feature - Moraine	1,455	-	-	-	-	-	32.4	64.8	97.2
	UW Feature - Ridge	1,311	-	-	-	-	-	34.1	68.3	102.4
	UW Feature - Rise	1,439	-	-	-	-	-	32.6	65.1	97.7
	UW Feature - Saddle	26,375	-	-	-	-	-	7.6	15.2	22.8
	UW Feature - Shoal	2,539	-	-	-	-	-	24.5	49.0	73.6
	UW Feature - Slope	102,438	-	-	-	-	-	3.9	7.7	11.6
	UW Feature - Spur	11,501	-	-	-	-	-	11.5	23.0	34.6
	UW Feature - Trough	59,418	-	-	-	-	-	5.1	10.1	15.2

*Table 18b: List of scores for OOs under **SO-3**: Contribute to the protection of key elements supporting ecosystem functionality and **CP-3.1**: Ecological Functions (areas known as spawning or breeding, nursery or rearing, feeding, migration, seasonal refugia).*

Operational Objective	Ecological feature	Primary Factor: Size (km^2)	Primary Factor: Uniqueness	Primary Factor: Vulnerability	Primary Factor: Responsibility	Primary Factor: Current Status	Final Target Score	Conservation Targets (%): Low	Conservation Targets (%): Medium	Conservation Targets (%): High
OO-3.1.1: Protect areas important for life history stages of fish functional groups, including **Atlantic cod** and **forage fish**.	*Fish Functional Group* – Small benthivores	-	1.13	3.00	-	-	2.27	12.7	22.7	32.7
	Fish Functional Group – Medium benthivores	-	1.20	3.70	-	*	3.12	21.2	31.2	41.2
	Fish Functional Group – Large benthivores	-	1.26	3.24	-	*	2.66	16.6	26.6	36.6
	Fish Functional Group – Planktivores	-	1.58	2.13	-	-	1.88	10.0	18.8	28.8
	Fish Functional Group – Plank-piscivores	-	1.41	3.57	-	*	3.35	23.5	33.5	43.5
	Fish Functional Group – Piscivores	-	1.32	3.10	-	*	2.73	17.3	27.3	37.3
	Fish Functional Group – Shrimp	-	1.00	2.02	-	*	1.88	10.0	18.8	28.8
	Fish Functional Group - Forage fish	-	1.41	2.35	-	-	1.94	10.0	19.4	29.4
	Fish Species – Snow Crab	-	1.00	2.25	-	-	1.74	10.0	17.4	27.4
	Capelin spawning areas	-	4.00	1.00	-	-	2.92	48.3	58.3	68.3
OO-3.1.2: Protect areas identified as high suitability habitat for **Marine Mammals** functional groups, including cetaceans.	*Marine Mammals Functional Group* - Mysticetes	-	1.00	1.95	-	-	1.55	10.0	15.5	25.5
	Marine Mammals Functional Group - Small cetaceans	-	1.26	2.94	-	*	2.83	18.3	28.3	38.3
	Marine Mammals Functional Group - Squid consumers	-	1.00	3.13	-	-	2.32	13.2	23.2	33.2
	Marine Mammals Functional Group - Killer Whales	-	1.00	4.25	-	-	3.09	20.9	30.9	40.9
	Marine Mammals Functional Group – Pinnipeds	-	-	-	-	-	-	-	-	-

Table 18b: Continued.

Operational Objective	Ecological feature	Primary Factor: Size (km^2)	Primary Factor: Uniqueness	Primary Factor: Vulnerability	Primary Factor: Responsibility	Primary Factor: Current Status	Final Target Score	Conservation Targets (%): Low	Conservation Targets (%): Medium	Conservation Targets (%): High
OO-3.1.3: Protect areas identified as important for **marine bird** functional groups.	*Marine Bird Functional group* - Surface-seizing planktivores	-	1.80	2.19	3.81	-	2.74	17.4	27.4	37.4
	Marine Bird Functional group - Surface, shallow diving piscivores/generalists	-	2.00	2.86	2.24	-	2.39	13.9	23.9	33.9
	Marine Bird Functional group - Surface, shallow-diving coastal piscivores	-	2.53	2.02	1.26	-	2.01	10.1	20.1	30.1
	Marine Bird Functional group - Pursuit-diving piscivores	-	3.19	2.57	2.83	-	2.87	18.7	28.7	38.7
	Marine Bird Functional group - Shallow pursuit generalists	-	2.00	3.63	3.54	-	3.14	21.4	31.4	41.4
	Marine Bird Functional group - Pursuit diving planktivores	-	2.00	2.50	4.00	-	2.96	19.6	29.6	39.6
	Marine Bird Functional group - Plunge-diving piscivores	-	4.00	2.75	3.00	-	3.29	22.9	32.9	42.9
	Marine Bird Functional group - Ship-following generalists	-	-	-	-	-	-	-	-	-
	Marine Bird Functional group – Coastal intertidal grazers	-	4.00	1.38	1.00	-	2.51	15.1	25.1	35.1
	Marine Bird Functional group – Coastal mulloscovores/piscivores	-	4.35	1.98	1.89	-	2.96	19.6	29.6	39.6

*Table 18c: List of scores for OOs under **SO-3**: Contribute to the protection of key elements supporting ecosystem functionality and **CP-3.2:** Structural features (features that result in areas of potential high productivity/biodiversity).*

Operational Objective	Ecological feature	Primary Factor: Size (km^2)	Primary Factor: Uniqueness	Primary Factor: Vulnerability	Primary Factor: Responsibility	Primary Factor: Current Status	Final Target Score	Conservation Targets (%): Low	Conservation Targets (%): Medium	Conservation Targets (%): High
OO-3.2.1: Protect areas that have physical characteristics that make them consistent with Vulnerable Marine Ecosystems (e.g., seamounts, canyons).	*VME Elements* - Canyons	40,248	-	-	-	-	-	6.2	12.3	18.5
	VME Elements - Steep flanks	10,414	-	-	-	-	-	12.1	24.2	36.3
OO-3.2.2: Protect marine areas with high biodiversity, including areas of high richness of corals and sponges.	High fish diversity	-	-	-	-	-	-	10.0	20.0	30.0
	High species richness for corals	-	-	-	-	-	-	10.0	20.0	30.0

*Table 18d: List of scores for OOs under **SO-3**: Contribute to the protection of key elements supporting ecosystem functionality and **CP-3.3:** Marine Habitats.*

Operational Objective	Ecological feature	Primary Factor: Size (km^2)	Primary Factor: Uniqueness	Primary Factor: Vulnerability	Primary Factor: Responsibility	Primary Factor: Current Status	Final Target Score	Conservation Targets (%): Low	Conservation Targets (%): Medium	Conservation Targets (%): High
OO-3.3.1: Protect areas identified as significant concentrations of **Corals and Sponges.**	*Corals functional groups* - Large gorgonians	-	4.00	4.75	-	-	4.39	77.8	87.8	97.8
	Corals functional groups - Small gorgonians	-	4.00	4.25	-	-	4.13	72.5	82.5	92.5
	Corals functional groups - Sea pens	-	3.00	3.25	-	-	3.13	52.5	62.5	72.5
	Corals functional groups - Sponges	-	2.00	2.75	-	-	2.40	38.1	48.1	58.1

Table 18d: Continued.

Operational Objective	Ecological feature	Primary Factor: Size (km^2)	Primary Factor: Uniqueness	Primary Factor: Vulnerability	Primary Factor: Responsibility	Primary Factor: Current Status	Final Target Score	Conservation Targets (%): Low	Conservation Targets (%): Medium	Conservation Targets (%): High
OO-3.3.2: Protect areas that have the presence of biological indicator species of Vulnerable Marine Ecosystems.	N/A	-	-	-	-	-	-	-	-	-
OO-3.3.3: Protect productive **marine habitats** (e.g., eelgrass beds, kelp forests).	Eelgrass beds	-	5.00	2.00	-	-	3.81	66.2	76.2	86.2
	Kelp beds	-	4.00	1.50	-	-	3.02	50.4	60.4	70.4

*Table 18e: List of scores for OOs under **SO-4:** Contribute to the protection and recovery of identified at-risk species and **CP-4.1:** At-risk species.*

Operational Objective	Ecological feature	Primary Factor: Size (km^2)	Primary Factor: Uniqueness	Primary Factor: Vulnerability	Primary Factor: Responsibility	Primary Factor: Current Status	Final Target Score	Conservation Targets (%): Low	Conservation Targets (%): Medium	Conservation Targets (%): High
OO-4.1.1: Protect areas important for life history stages for species listed as endangered or threatened on Schedule 1 of the ***Species at Risk Act.***	Blue Whale	-	1.00	4.25	-	1.5	4.59	35.9	45.9	55.9
	Harbour Porpoise	-	1.00	1.50	-	1.0	2.27	12.7	22.7	32.7
	Ivory Gull	-	2.00	4.25	4.00	1.5	5.06	40.6	50.6	60.6
	North Atlantic Right Whale	-	4.00	4.25	-	1.5	5.63	46.3	56.3	66.3
	Northern Bottlenose Whale	-	2.00	3.50	-	1.5	4.35	33.5	43.5	53.5
	Northern Wolffish	-	1.00	4.00	-	1.0	3.92	29.2	39.2	49.2
	Spotted Wolffish	-	1.00	4.00	-	1.0	3.92	29.2	39.2	49.2

Table 18e: Continued.

Operational Objective	Ecological feature	Primary Factor: Size (km^2)	Primary Factor: Uniqueness	Primary Factor: Vulnerability	Primary Factor: Responsibility	Primary Factor: Current Status	Final Target Score	Conservation Targets (%): Low	Conservation Targets (%): Medium	Conservation Targets (%): High
OO-4.1.2: Protect areas important for life history stages for species listed as endangered or threatened by **COSEWIC.**	Acadian Redfish	-	2.00	3.00	-	1.0	3.55	25.5	35.5	45.5
	American Plaice	-	1.00	2.75	-	1.0	3.07	20.7	30.7	40.7
	Atlantic Cod	-	1.00	2.00	-	1.5	3.08	20.8	30.8	40.8
	Beluga Whale	-	3.00	4.00	-	1.5	5.04	40.4	50.4	60.4
	Deepwater Redfish	-	1.00	3.00	-	1.0	3.24	22.4	32.4	42.4
	Leatherback Turtle	-	1.00	2.75	-	1.5	3.57	25.7	35.7	45.7
	Roundnose Grenadier	-	1.00	4.75	-	1.5	4.93	39.3	49.3	59.3
	Smooth Skate	-	2.00	4.50	-	1.5	4.98	39.8	49.8	59.8
	White Hake	-	1.00	3.50	-	0	2.57	15.7	25.7	35.7
	Winter Skate	-	2.00	4.50	-	1.5	4.98	39.8	49.8	59.8
OO-4.1.3: Protect areas important for life history stages for species that have been considered depleted under **DFO/NAFO.**	Northern Shrimp	-	1.00	2.25	-	0.5	2.24	12.4	22.4	32.4
	Witch Flounder	-	1.00	2.75	-	0.5	2.57	15.7	25.7	35.7

Sources of Uncertainty

There are some areas where a lack of data may reduce the ability of Marxan to produce appropriately representative network scenarios. Coastal, northern (NAFO Divisions 2GH) and offshore deep-water (>1,500 m) areas all suffer from a lack of data or data resolution which makes it difficult to properly assign conservation targets. These areas may be underrepresented, or Marxan may select more arbitrary sites which are less suitable for protection.

Part of the reason for the lack of data in these areas is that a large portion of the data used in this analysis comes from the DFO RV survey. Although the survey has covered parts of NAFO Divisions 2GH in the past, it has not in recent years. The survey also does not extend into coastal or deeper areas. The sparseness of the data therefore means that targets set in these areas should be used with caution for management decisions.

In coastal areas, a post-Marxan overlay analysis should be used to compensate for some of this uncertainty. Coastal EBSAs may be useful for this assessment, although there are many data gaps in these areas and, furthermore, some of the datasets used to identify EBSAs in these areas are also incomplete. One recommendation could be to treat the coast as an additional eco-unit with a 10% minimum target. Additional research will need to be carried out to assess better methods and data sources for dealing with target setting in coastal areas to ensure a robust Marxan analysis. Results to date should be considered preliminary and will need expert review to ensure adequate representation.

The data inequality between northern and southern areas may tend to bias Marxan scenarios towards the southern areas. A possible solution may be to split the bioregion into north and south sub-regions. Other sources of data (e.g. Northern Shrimp survey) may be consulted to augment the information for the north, although these data are not always complete or comparable to data from surveys conducted by DFO. Again, additional research will be needed to find ways to deal with data deficiencies. In general, distribution between northern and southern areas within the network design scenarios should be considered during the review phase to ensure that targets are being met in both areas.

The Marxan software includes a species penalty factor (SPF) which allows a cost to be added when particular conservation targets are not reached for specific features. Therefore, in cases where there are large uncertainties in the data for certain features, the penalties could be decreased to account for this uncertainty. Also, for features of particular significance for protection (e.g., eelgrass, sponges), the penalties could be increased to ensure their inclusion. However, care should be taken when setting SPF values and additional work, including sensitivity analysis, needs to be done to ensure they are set appropriately.

In general, sensitivity analyses will be important to test aspects of the framework design and the final targets. The effect of adding or removing features, removing rare species from the assessment of functional groups, and the impact of using different methods to create data layers (e.g., rasters versus polygons) should all be examined and reviewed by a Science/Oceans MPA Network Committee.

Connectivity, replication of ecological features, and adequacy and viability of sites are three of the criteria listed by the Convention on Biological Diversity for effective networks of MPAs; however, they have not been assessed during this process. The effectiveness of spatial management for different ecological factors should also be considered. For sessile species such as corals and sponges, spatial management may work well, but for highly mobile species such as some species of sharks or cetaceans, it may be more difficult to find appropriate spatial

management tools to provide protection. These issues should be studied further to understand how they may be incorporated into network design and should be considered throughout the MPA network planning process.

CONCLUSIONS AND ADVICE

The target setting framework presented is based on the best practices and expert opinion presently available. Low, medium, and high conservation targets have been provided to allow some flexibility in the development of MPA network scenarios. It is recognized that these targets are only one of the inputs which will be used in the overall network design which will also involve the input of economic, social, and cultural information. It is therefore strongly recommended that during the development of the network design, Science should be consulted to ensure the ecological viability of the network is preserved.

Uncertainties still remain due to a number of factors. The data sets to be used in the analysis are not always complete or at the appropriate resolution which can lead to inequalities between areas. Coastal, northern and deep-water offshore areas should be given additional attention to ensure they are appropriately represented within the network. Targets for these areas should be viewed with caution. Sensitivity analyses will be required throughout to examine the impact that each aspect of the framework, including the targets, data layers, and SPFs, has on the final network design. In addition, if future changes are made to the conservation priorities, additional science advice should be sought. Other aspects that have not been considered at this point include connectivity and the impact of climate change. Additional research and expert opinion will continue to be important throughout the process.

OTHER CONSIDERATIONS

Although some Indigenous knowledge was included in some data layers (e.g. CCRI), active engagement with Indigenous groups to collect and incorporate their knowledge is encouraged. This may be particularly helpful in areas where data is limited such as coastal and northern areas.

Targets for VME indicator species, black corals, and invertebrate diversity were discussed at the meeting, however because of a lack of reliable data layers, targets for these features have not been set. These could be set in the future using the same framework design when reliable data is available.

While connectivity has not been addressed in this review, it is one of the CBD criteria for effective networks of MPAs and should be considered in future design processes. More research needs to be done on this topic.

Climate change should also be another important consideration for MPA network planning. The implications of these changes (e.g. shifts in species distribution) are not well understood. This will require further research which should be incorporated into the overall network design.

SOURCES OF INFORMATION

This Science Advisory Report is from the May 16-18, 2017 meeting Science Guidance on Design Strategies for a Network of Marine Protected Areas in the Newfoundland and Labrador Shelves Bioregion. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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E-Mail: DFONLCentreforScienceAdvice@dfo-mpo.gc.ca
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