Northwest Atlantic Fisheries Organization

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SCIENTIFIC COUNCIL MEETING – JUNE 2008

Report of the NAFO Scientific Council Working Group on Ecosystem Approach to Fisheries Management (WGEAFM)

NAFO Headquarters, Dartmouth, Canada
26-30 May 2008

Preamble

In recognition of an amended NAFO Convention (currently awaiting ratification) which has principles of an Ecosystem Approach to Fisheries Management, Scientific Council established a Working Group on the Ecosystem Approach to Fisheries Management in September 2007. Terms of Reference (ToR[1]) for this WG relate to the identification of eco-regions within the NAFO Convention Area (NCA) and the development of ecosystem health indicators.

Because of the growing importance of the Ecosystem Approach and its relevance to Scientific Council, contact was initiated with ICES in 2007 regarding possible future cooperation. The work of the Advisory Committee on Ecosystems, the Working Group on Ecosystem Effects of Fishing Activities (WGECO), the Working Group for Regional Ecosystem Description (WGRED), the Working Group on Multispecies Assessment Methods (WGSAM), the ICES Working Group on Fisheries Ecology (WGFE), and the joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), are particularly relevant.

1. Opening - Plenary Sessions

The inaugural meeting of WGEAFM took place at the NAFO Headquarters during 26-30 May, 2008. The Chair (Antonio Vázquez, Spain) welcomed attendant experts and observers and gave a brief introduction to the organizational structure of NAFO, focusing on the Scientific Council and Fisheries Commission. It was pointed out that NAFO continues to be a fisheries organization after the Convention was reformed. The role of the working group, as it relates to the Scientific Council, was explained. It was noted that since the establishment of this group, there were two requests from the Fisheries Commission to the Scientific Council that were referred the WG as they are related to Vulnerable Marine Ecosystems (Appendix 1).

The provisional agenda including revised ToR was adopted, and Don Power (Canada) was appointed as rapporteur.

Several participants noted that the enhanced ToR from the Fisheries Commission are wide-ranging and therefore an ambitious undertaking to accomplish in one week. One part of the Fisheries Commission ToR dealt with identifying Vulnerable Marine Ecosystems (VMEs). The WG agreed to focus on this aspect using the general criteria for identifying VMEs that have received general consensus internationally (i.e. the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas, draft for the August 2008 meeting) (FAO 2008a).

The Scientific Council Coordinator introduced background to the work assigned to the WG. It was noted that UNGA Resolution 61/105 related primarily to fisheries and included the need to document and to protect VMEs by 2008, and that UNGA Resolution 61/222 related primarily to conservation and the need for a network of Marine Protected Areas (MPAs) by 2012. Resulting relation to of UNGA Res. 61/105, FAO is developing Guidelines for the Management of Deep-sea Fisheries that should be finalized in August 2008 and adopted in 2009. The NAFO Fisheries Commission met in Montreal during 7-9 May 2008 to adopt measures to ensure that the deadlines related

[1] A list of most common acronyms is included in the very last page.

to UNGA Res. 61/105 were achieved. Supplementary ToRs for Scientific Council to address by the 2008 Annual meeting included further requests to Scientific Council for the identification of VMEs (the current work of WGEAFM), including maps and the evaluation of the existing fishing areas to be addressed by Scientific Council before September 2008. Examples of existing work on VMEs, including the ICES/NAFO Deep-water Ecology Working group (WGDEC) (ICES 2008b) and the Global Open Oceans and Deep Seabed biogeographic classification (GOODS, 2007), and on existing fishing areas using the NAFO Secretariat's VMS data, were highlighted.

A subsequent presentation by the Executive Secretary Dr. Johanne Fischer outlined the process of the various workshops leading to the draft FAO guidelines.

Over the course of the meeting, the WG discussed a strategy to apply the FAO guidelines, produce the maps and formulated advice on VMEs in the NAFO Regulatory Area (NRA). There was little time remaining to consider other ToR. However, the group agreed that some participants would contribute to drafting some text on other ToR, to provide background information on what has been going on outside of this group that would be pertinent to each ToR.

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1. Review of the Terms of Reference

ToR 1: To identify regional ecosystems in the NAFO Convention Area (NCA).

It was agreed that any ecoregion mapping of the NCA must be consistent with similar mapping done by coastal states in their respective EEZs. It was noted that Canada has qualitatively developed such a mapping inside its EEZ based on geological, physical, oceanographic, and biological properties (Powles *et al.*, 2004). These regions do not exactly match with NAFO Areas and Divisions, but from the NAFO point of view should be considered as an initial approach. However, it was agreed that, given that the Canadian mapping was based on quite wide scientific criteria, similar criteria should be applied to extend that mapping to the NRA to the extent possible.

A quantitative approach to defining regional ecosystems within the NCA is to assemble spatially-explicit data sets of key physiographic, oceanographic and ecological variables and to apply multivariate statistical methods to identify areas with common characteristics. The application of this approach for U.S. northeast continental shelf (NAFO Areas 5 and 6) was described as an example (Fogarty, 2008). The following variables were examined: Depth, Sediments, Mean Sea Surface Temperature, Annual Temperature Span, Stratification, Primary Production, Ratio Subsurface to Surface Chlorophyll a, Zooplankton Biomass, Benthic Biomass, Nekton Biomass, and Nekton Species Richness. These variables were chosen based on their importance for defining structural features of the physical environment directly relevant to ecological structure, oceanographic determinants of distribution and ecology of marine organisms, and indicators of the abundance and production of major taxonomic groups.

Because these variables are measured on different spatial scales, they first were placed in a common spatial frame of reference by computing the mean of each variable within statistical rectangles of 10 minutes longitude by 10 minutes latitude. These data were then analyzed by a Principal Component Analysis (PCA) to account for covariance among the input variables. It was found that the first four principal components accounted for approximately 75% of the variance. Increasing consideration to the first six principal components accounts for 90% of the variance. The PCA was done on the correlation matrix to account for disparate data scales involved. Following the delineation of the spatial distribution of the scores for the first six principal components, a hierarchical agglomerative cluster analysis was done on the scores. This analysis resulted in the identification of five major ecoregions on the U.S. Northeast Shelf. These include the eastern Gulf of Maine-Scotian Shelf, the Western Gulf of Maine, Georges Bank, the Mid-Atlantic Bight, and the Continental Slope (Figure 1).

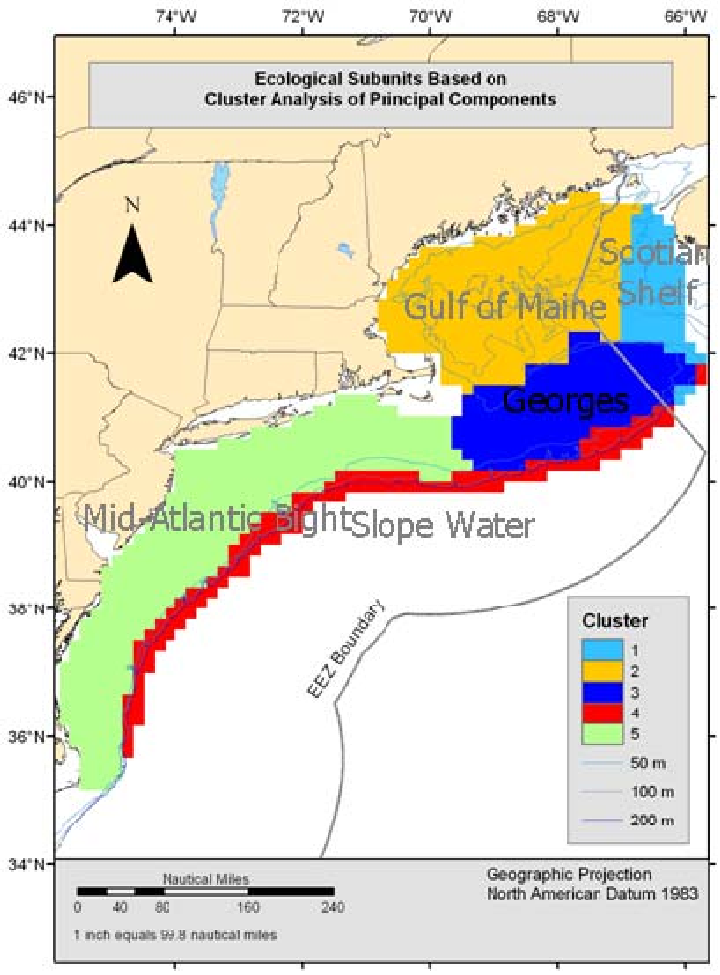

Figure 1. Designation of major ecoregions on the Northeast Continental Shelf of the United States in NAFO Subareas 5 and 6.

Next, overlays of selected ‘Focal Species’ (Cold-Water Corals, Cetaceans, and Sea Turtles) were constructed for the ecoregions to examine the relationships between species of particular concern and the individual regions (Figures 2-4). These overlays highlight the importance of the continental slope for cold water corals and cetaceans, the shallow Mid-Water slope for sea turtles in summer, and major subregions of the Gulf of Maine for cetaceans and corals.

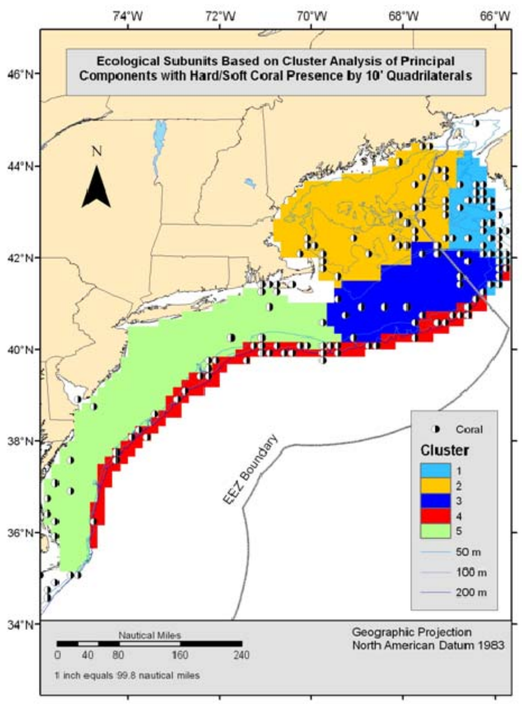

Figure 2. Overlay of cold-water coral distribution (presence-absence) on the designated ecoregions.

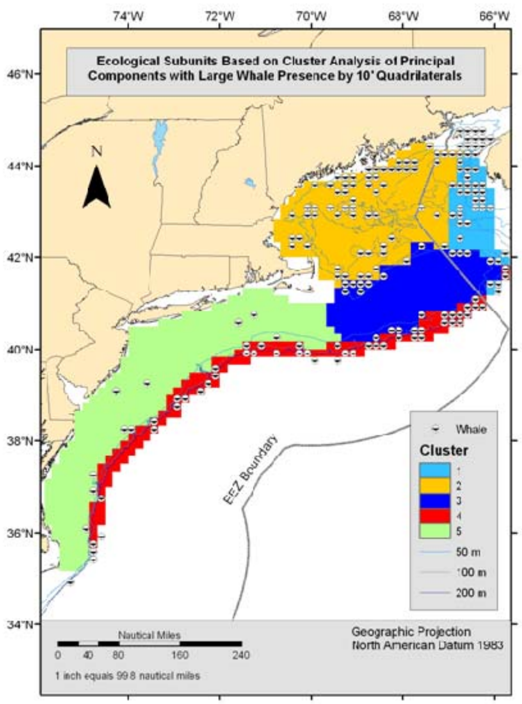

Figure 3. Overlay of cetacean distribution (presence-absence) on the designated ecoregions.

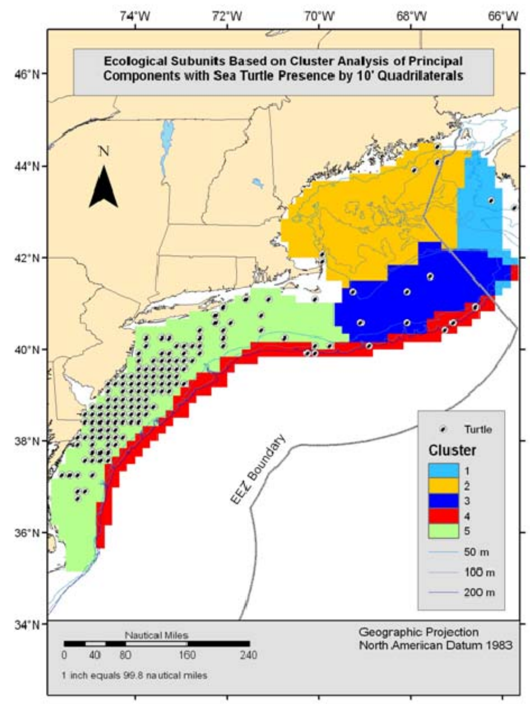

Figure 4. Overlay of sea turtle distribution (presence-absence) on the designated ecoregions.

ToR 2: To make an inventory of current knowledge on the components of each regional ecosystem (i.e. physical oceanography, primary production, zooplankton and secondary production, benthos and large invertebrates, fish and fish assemblages, seabirds, marine mammals, turtles, and fisheries).

2.a – Extant data sets

Given the time constraint, the working group did not attempt to summarize all available data sets for the NCA during this meeting. Nonetheless, the aim was to inform those WG participants not fully familiar with survey and monitoring activities in the NCA, a quick overview highlighted the basic data gathering activities currently in place.

Oceanographic surveys are the main source of information for physical oceanography and primary production. Satellite imaging is suitable for mapping primary production and satellite-based data products are becoming more common.

Bottom-trawl fishing surveys, scientific observers and NAFO observers are main sources of information on fish stocks, catches and by-catches. A list of current surveys in the area is provided by the SC Report every year.

The primary objective of RV surveys has traditionally been to provide fisheries-independent indices of abundance and biomass of main commercial species for their use in stock-assessment. Associated with this, ageing and maturity studies are also carried out. However, most surveys have evolved over the years trying to enhance their ability for sampling non-commercial species and to provide a wider picture of the marine community. Among the biological studies already implemented, or in the process of being implemented, in these RV surveys are an improved recording of benthic organisms, production of length-frequency distributions for all species, and stomach content analyses and growth and condition studies, typically for selected species. Some examples of these changes include the special attention towards identifying invertebrate by-catch in the NRA (Divs. 3LMNO) by the Spanish/EU groundfish bottom trawl since 2005, or the enhanced sampling (non-commercial species, bottom grab sampling, stomach contents) to be implemented in the 2J3KLNO Canadian multispecies fall survey as part of the DFO “Ecosystem Research Initiative” in the Newfoundland and Labrador region.

In addition to annual surveys, some dedicated research surveys aim to identify and characterize coral communities have also take place in recent years.

A detailed assessment and summary of extant data sets was postponed until next WG meeting.

2.b – Known data gaps

Since a detailed analysis of extant data sets was not conducted, only a very preliminary summary of knowledge gaps was attempted. Some of the identified gaps include:

Bottom topography. Current demands on mapping resources and delineating areas requires detailed knowledge of vast extensions of seascape at a very fine level of resolution. This type and quality of information is very limited in the NRA. This is a clear gap that will need to be address. This can be done using available multibeam technology, but it will require directed research efforts (dedicated multibeam mapping survey).

Deep-water benthic communites. Although the benthos has an important role in ecosystem functioning, little is know about its diversity, spatial distribution and associations, and even less in terms of dynamics. This type of information is also required. For example, there are no data for the benthos of Orphan Knoll or the Newfoundland seamounts and this knowledge will be required before re-assessing current seamount closures. Benthic surveys of the slope waters below 1000 m are equally important and should be given high priority. Since corals and other fragile benthic components are expected to be found, the use of non-destructive survey methods (e.g. Remote Operated Vehicles) are recommended.

Shelf benthic communities. These communities are better known than their deep-water water counterparts, but the geographical extent of the different associations, their structure (e.g. species composition, diversity) and their productivity and linkages with the pelagic production still remains largely unknown. This information is necessary to better understand the productivity of the whole system and how this impacts fish production.

Seamount fish communities. Very little is known on fish communities on seamounts in the NRA as these have not been heavily fished, or researched in any systematic way. This knowledge is fundamental if there is any expectation of providing science-based advice for any fishery (even pelagic ones) that may take place on them (see next item).

Mesopelagic fish. These fishes are also poorly studied both on the seamounts and slope waters and these communities are important ecosystem components as they transport nutrients from the surface waters to the deep (through diel vertical migrations of a kilometre or more) and are major prey items for larger pelagic fish.

Forage fish. Since forage fishes like capelin, sandlance and Arctic cod have a key role in shelf communities, they are better known than mesopelagic ones. Still, the knowledge on these components of the system is still far from adequate, prompting cases where even the status of the stocks is disputed (e.g. capelin in 2J3KL).

Trophic interactions. Fish diets are being studied to different extent among NAFO regions. For example the stomach content program run by the U.S. National Marine Fisheries Service out of the Northeast Fisheries Science Centre, or the one carried out by the EU in the Flemish Cap can generate time series of fish diets for a large number of species. However, there is no comparable coverage from Canadian surveys in 2J3KLNO, although there is ongoing work that is trying to expand the scope of current stomach content work. Diet studies are essential for developing trophic models, and can also be used to develop ecosystem indicators.

Marine mammals distribution. Marine mammals are often pinpointed as important top predators in marine system but for many of them we know very little (e.g. beaked whales). For example, little is known about their distribution in the NRA. A protocol for scientific observers may be useful.

A more detailed assessment of knowledge gaps will be performed in the next WG meeting.

2.c – Spatial and temporal coverage of data

Data available is largely confined to the fishing areas and seasons and to those taxa caught by groundfish gears. For coral and sponges, targeted benthic surveys are required to cover their depth range. This is important both for the determination of their distribution and abundance, which will allow for more effective conservation measures. Equally, as their distribution is spatially and temporally stable due to their attachment and longevity, fishing activity can be maximized by drawing boundaries which more closely approximate the coral locations.

2.d - Documentation

<u>Physical Oceanography</u>

The general features of the physical oceanography of the NCA are well known. The net residual transport involves the flow of cold, low salinity waters from the north by the Labrador Current toward the south (Figure A). The Labrador Current is formed with contributions from the Hudson Strait and the West Greenland shelf (Drinkwater and Mountain 1997). These two components respectively form inshore and offshore branches. The flow branches at the southern Labrador shelf, with some of the inshore component entering the Gulf of St. Lawrence through the Strait of Belle Isle. The remainder flows southward over the northeastern Newfoundland Shelf (Figure 5). The flow of the inshore branch continues over the western grand Bank and then toward the Gulf of St. Lawrence. The offshore component flows over the northeastern Grand Bank and divides with some of the flow rounding the northern edge of the Flemish Cap and with the remainder flowing to the south over the eastern Grand Bank toward the Laurential Channel. The waters within the Gulf of St. Lawrence are characterized by a cyclonic (counterclockwise) flow. The continued southward flow over the Scotian Shelf diverts into two components, the Nova Scotia Current and an offshore element over the shelf break. The Nova Scotia Current enters the Gulf of Maine with some water diverting into the Bay of Fundy and the remainder flowing counterclockwise through the Gulf. A portion of this water enters the Middle-Atlantic Bight though the Great South Channel with the remainder is entrained on Georges Bank where it forms an anticyclonic gyre (clockwise gyres also form over Browns Bank and Sable Island Bank). South of Georges Bank, the shelf water continues toward Cape Hatteras.

The Gulf Stream, a classical western boundary current system, comprises the dominant feature of the oceanography of the region (Figure A). Meanders of the Gulf Stream form rings and eddies that can entrain water off the shelf.

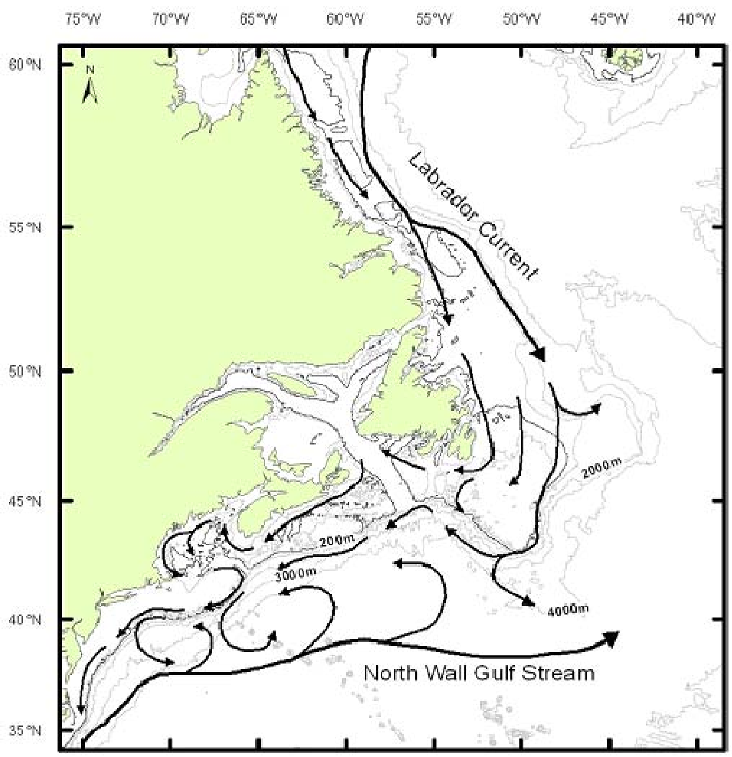

Figure 5. Major residual flow characteristics of the NCA.

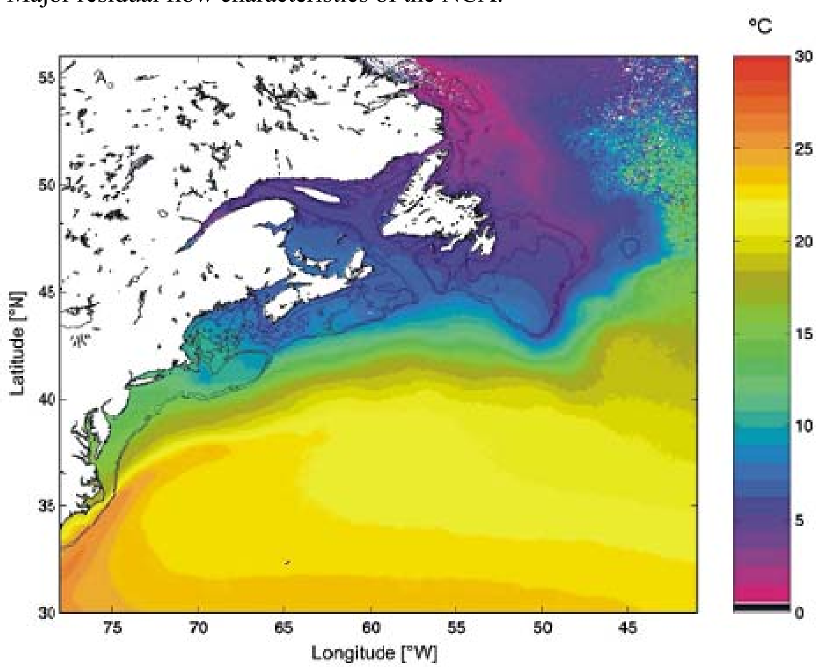

Figure 6. Satellite-derived mean annual sea surface temperature for the NCA.

Water temperatures within the convention area exhibit both strong latitudinal gradients (Figure 6) and strong seasonal amplitudes. Sea surface temperatures off Labrador and Newfoundland can be less than 0°C in winter to 10°C off Cape Hatteras (Drinkwater and Mountain 1997). In summer, sea surface temperatures can exceed 25°C in the southern most part of the convention area and as low as 2-4 °C in the north. These geographical and seasonal patterns are among the strongest in the North Atlantic.

Primary Production

The NCA has historically supported some of the most important capture fisheries in the world. The high fishery production is linked to generally high levels of primary production, although there are important regional differences in the latter throughout the convention area. Regions within the convention area characterized by high levels of primary production often have strong tidal mixing forces resulting in high level of nutrient availability, particularly in relatively shallow bank areas. Localized upwelling also plays an important role in supplying new nutrients in some areas. Although relatively few studies of primary production have been made in the northern part of the NAFO area, some data are available. Estimated levels of primary production on the Grand Banks are relatively low, averaging about 200 gC m^{-2} yr^{-1} throughout the year (summarized in Townsend et al. 2006). More information is available for the region from Nova Scotia south. Direct estimates of primary production for the Scotian Shelf using the ^{14}C method are relatively low (~100 gC m^{-2} yr^{-1}) but these are thought to be under-estimates (Townsend et al. 2006). Estimates for the offshore Gulf of Maine are on the order of 270 gC m^{-2} yr^{-1} based on ^{14}C measurements while estimates for Georges Bank exceed 400 gC m^{-2} yr^{-1}on the central crest of the bank with a bank-wide average of over 325 gC m^{-2} yr^{-1} . In the Middle Atlantic Bight, very high levels of primary production have been estimated in the immediate coastal region (over 500 gC m^{-2} yr^{-1}), reflecting high inputs of nutrients from terrestrial sources. Primary production on the Middle Atlantic shelf seaward of the coastal band is on the order of 300 gC m^{-2} yr^{-1}. The overall regional differences in primary production can be readily discerned in satellite-derived estimates of chlorophyll and primary production (Figure 7).

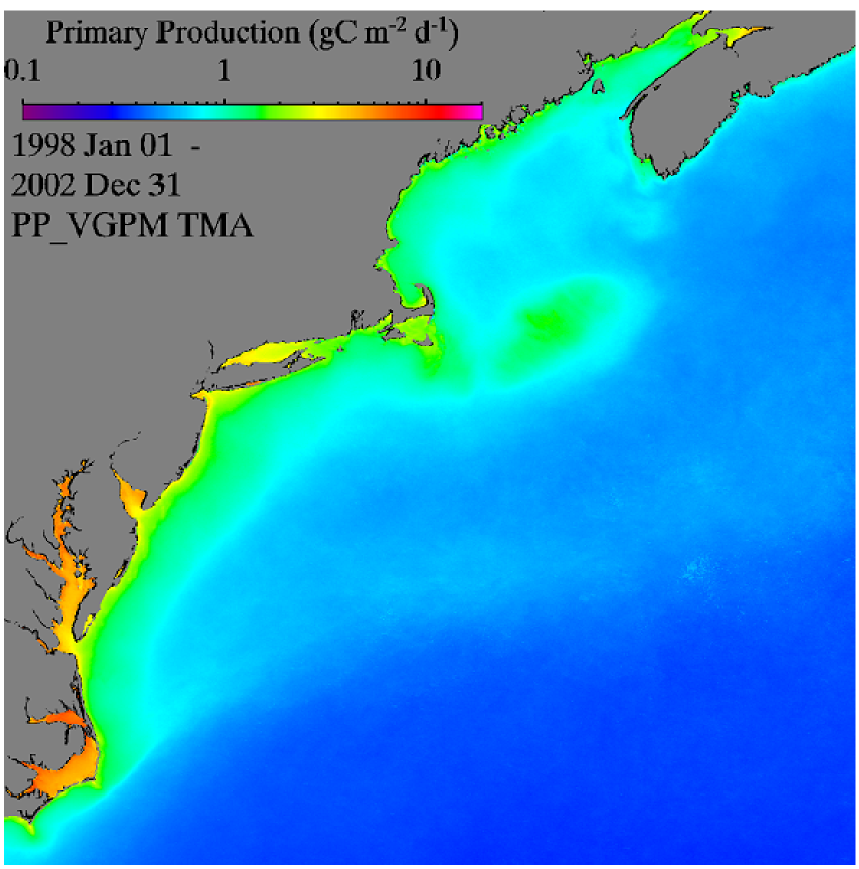

Figure 7. Estimates of primary production derived from satellite imagery in the southern part of the NCA.

Benthos and large invertebrates

The current knowledge of benthos and large invertebrates in the NCA is greater for the southern part, on the continental shelf of the northeastern United States and southeastern Canada (e.g.,Wigley and Theroux, 1981; Rowe *et al.*, 1982; Theroux and Wigley, 1998), where a number of studies have been undertaken, mainly on Georges Bank (Thouzeau *et al.*, 1991; Volkmann, 1996); in New England waters (Haedrich *et al.*, 1975; Hecker, 1990), near Sable Island (Kostylev, 2002), Browns Bank (Wildish *et al.*, 1989; Wildish *et al.*, 1992), in the Bay of Fundy (Kenchington, 2000), and on the Scotian Shelf (e.g., Kostyley *et al.*, 2001; Hargrave *et al.*, 2004, Kenchington *et al.*, 2006).

The northern portion of the NCA (Divs. 0, 1 y 2) is less well-studied, though some expeditions were carried out in the early part of the last century (The Goodthab Expedition in 1928, and the Canadian Arctic Expedition between 1913-1918).

Biocoenoses and biomass of benthos of the Newfoundland and Labrador region, northward to 56º North and to a lesser extent the waters of Nova Scotia and Georges Bank was studied by Nesis (1965), from 50 to 1500 m depth. He provided a description of the species assemblages of the offshore zoobenthos based on single grab samples supplemented by trawl samples.

More recently, some important studies in shallow waters have been completed (Stewart *et al*., 1985; Atkinson and Wacasey, 1989, Kenchington *et al*., 2001). The Geological Survey of Canada presented an atlas of seabed photographs on superficial sediments and benthic organisms identified from the photographs for the area from the Fundian Channel to north of the Grand Banks of Newfoundland and Flemish Cap (Lawrence *et al*., 1985).

Others benthic studies in the proximity of the Newfoundland and Labador region have been undertaken (Hutcheson *et al*., 1981; Houston and Haedrich, 1984; Schneider, 1987; Gagnon and Haedrich, 1991; Ramey and Snelgrove, 2003; Hargrave and Stewart, 2004).

Invertebrate identification on board commercial and scientific surveys is difficult due to the time involved, the specialized taxonomic knowledge required and the need to dissect some specimens to identify samples to the species level. Recently, there is an increasing interest in knowledge of all ecosystem components and the fishing effects on benthos, so efforts have been made to identify invertebrate bycatch in Spanish/EU and Canadian surveys. This is provided large scale coverage of certain taxa collected on fishing grounds. This data is very useful in describing the distribution of many invertebrate taxa. Because trawls are not good collection devices for most benthic invertebrate species, these data are best used to describe general distributions. Other sampling methods are required to determine the abundance and biomass of these organisms.

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Corals

Description of most common corals in NCA is included as Annex II along with an evaluation of their status as VME foundation organisms. The following groups of corals are considered indicators and key components of VMEs (Fuller *et al*., 2008):

Antipatharians (Black Corals)
Gorgonians (Sea Fans)
Cerianthid anemone fields
Lophelia and other reef building corals
Sea pen fields.

Antipatharians and Scleractinian corals (which include *Lophelia pertusa*) are also listed under Appendix II of the Convention on International Trade in Endangered Species (CITES). *Lophelia* reefs and sea pen fields are recognized as threatened habitat by the OSPAR Commission for the protection of the marine environment (Initial List of Threatened and/or Declining Species and Habitats).

The report of WGDEC (ICES, 2008) adequately identifies the general location of coral VMEs in the NAFO region. Further information on their distribution and suggestion of additional information based on the Spanish and Russian contributions is presented as maps in other sections of this report.

Corals are important structural habitats that contribute to vertical relief and increase the availability of microhabitats (Tissot *et al.*, 2006). Increasing complexity provides feeding opportunities for aggregating species, a hiding place from predators, a nursery area for juveniles, fish spawning aggregation sites and attachment substrate for fish egg cases and sedentary invertebrates (Reed, 2002; Fosså *et al.*, 2002; Etnoyer and Morgan, 2003), all of which have been reported for deep water coral habitats. In general, coral habitats in deep-water represent biodiversity hotspots for invertebrates (Reed *et al.*, 1982; Jensen and Frederiksen, 1992; Reed, 2002; Freiwald *et al.*, 2004, Mortensen and Mortensen, 2005), and commonly support a large abundance of fish (Koening, 2001; Husebo *et al.*, 2002; Krieger and Wing, 2002; Costello *et al.*, 2005, Tissot *et al.*, 2006).

Benthic assemblages dominated by corals and sponges have high diversity. Reed (2002) found over 20,000 individual invertebrates from more than 300 species living among the branches of ivory tree coral (*Oculina varicosa*) off the coast of Florida. Over 1,300 species of invertebrates have been recorded in an ongoing census of numerous *Lophelia* reefs in the northeast Atlantic (Freiwald *et al.*, 2004). Gorgonian corals in the northwest Atlantic have been shown to host more than 100 species of invertebrates (Mortensen and Buhl-Mortensen, 2005).

Organism size is an important aspect of structural habitat because it contributes to vertical relief and increases the availability of microhabitats (Tissot *et al.*, 2006). Increased complexity provides feeding opportunities for aggregating species, a hiding place from predators, a nursery area for juveniles, fish spawning aggregation sites, and attachment substrate for sedentary invertebrates (Fosså *et al.*, 2002; Reed, 2002), all of which have been reported for deep water coral habitats. Fish egg cases have been observed attached to both gorgonians (Etnoyer and Morgan, 2003) and vase sponges (Tissot *et al.*, 2006).

Fish are strongly associated with structure-forming invertebrates (Tissot *et al.*, 2006). Yelloweye (*Sebastes ruberrimus*) rockfish may use the large gorgonian coral *Primnoa* as vantage point to prey upon small fishes (Krieger and Wing, 2002). Commercially valuable species of rockfish, shrimp, and crabs are known to use coral branches for suspension feeding or protection from predators in Alaskan waters (Krieger and Wing, 2002). Husebø *et al.* (2002) documented a higher abundance and larger size of commercially valuable redfish, ling, and tusk in Norwegian waters in coral habitats compared to non-coral habitats. Costello *et al.* (2005), working at several sites in the Northeast Atlantic, report that 92% of fish species, and 80% of individual fish were associated with *Lophelia* reef habitats rather than on the surrounding seabed. Koenig (2001) found a relationship between the abundance of economically valuable fish (e.g., grouper, snapper, sea bass, and amberjack) and the condition (dead, sparse and intact) of *Oculina* colonies. *Oculina* reefs off Florida have been identified as essential fish habitat for federally-managed species, as have gorgonian-dominated deep coral communities off Alaska and the West Coast of the United States. However, Syms and Jones (2001) demonstrated that removal of high densities of soft corals caused no significant changes in the associated fish communities and that the heterogeneity of habitat generated by soft corals was indistinguishable from equivalent habitat formed by rock alone.

Aggregations of sea pens and sea urchins may provide important structure in low-relief sand and mud habitats where there is little physical habitat complexity. Also, these organisms may provide refuge for small planktonic and benthic invertebrates, which in turn may be preyed upon by fishes. They also may alter water current flow, thereby retaining nutrients and entraining plankton near the sediment (Tissot *et al.*, 2006).

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Sponges

Preliminary data on sponge catch in Maritimes Observer Records and Newfoundland research trawl surveys in the NAFO Convention Area

In the Northwest Atlantic, there are more than 300 species of sponges, ranging in form from thin and encrusting, to branching to mound forming. Species belonging to all three sponge classes Calcarea, Demospongae and Hexactinalledae are found in the NCA. With specific reference to vulnerable sponge species or species complexes, there are a few key sponge species and species complexes, some of which are circumboreal in distribution. The WGDEC report (ICES, 2008) states that there is little reported information on sponges in the Northwest Atlantic. The data and information included in this report add significantly to known sponge distributions.

Sponges as Ecosystems

Sponges, particularly those of large size, are known to be habitat forming structures, often with numerous other species living within and around their body structures. The extent to which an individual sponge can act as a host for other species is dependent on sponge surface characteristics, size of ostia, and the size of the sponge itself. Klittgaard (1995) found over 200 species within 11 sponges in the North Atlantic. As is found in many other habitats, species richness increases with habitat area for a broad variety of species (see review in Rosenzweig, 1995).

In sponges, volume can be considered a proxy for both habitat size and age. An increase in associated species richness with host volume has been found in sponges (Frith, 1976; Ubelaker, 1977; Westinga and Hoetjes, 1981; Villimizar and Laughlin, 1991; Duarte and Nalesso, 1996; Cinar and Ergen, 1998; Cinar *et al.*, 2002).

There is a distinct lack of data on associated communities of host animals between 100m and 300m and below 800m. The one abyssal point at 4100m, found 134 species associated with the deep sea sponge, *Hyalonema bianchoratum* (Beaulieu, 2001).

Sponges in the NAFO Convention Area

Sponges are widespread throughout all depths and bottom types in the Northwest Atlantic, however there are particular species and species groups that are vulnerable to fishing impacts. Similar to those areas described by WGDEC (ICES, 2008), sponges in the Northwest Atlantic can be categorized by three main types:

- Hexactinellid patches (*Vazella pourtalesi* (Schmidt 1870)), found to date on the Scotian Shelf in soft sediment areas as well as scattered specimens in areas where deep-sea corals are also found (Fuller, in prep). (Similar to the *Pheronema* patches in the Northeast Atlantic) (Figure 8).
- *Geodia* spp. found along the shelf edge, in gravel or hard bottom areas and have been found in areas in the Northeast Atlantic as well (Klittgaard and Tendal 2004, Bruntse and Tendal 2001) (Figure 9).
- *Thenea* sp. generally found in soft bottom, and growing on spicule mats.

Given the lack of in situ documentation of sponges in the NCA, with the exception of one video transect in the Emerald Basin in 2001 (Fuller, in prep.), it is difficult to know the extent of these patches.

Figure 8. *Vazella pourtalesi* population in the Emerald Basin on the Scotian Shelf, within Canada's EEZ.

Figure 9. Sponge bycatch in the NAFO Convention Area, representative of concentrations of *Geodia* spp.

Data Sources: Spatial and Temporal Coverage

Existing and readily available data sets on sponges in the NAFO Area include:

- Maritimes Observer Data (1977-2007)
- Newfoundland Trawl Survey (1995-2004)
- Spanish / EU Bottom Trawl Groundfish Surveys (3LMNO) (2005-2007)
- Russian observer data (2000-2007) (in Vinnichenko and Skylar, 2008)

Large sponge by-catches are recorded in a relatively low number of trips (< 5%) in both surveys and observer data (Fuller, unpublished; Murillo *et al*., 2008). However, large catches of sponges, up to 6000 kg have been recorded on the Scotian Shelf and in deeper waters along the Grand Banks, Flemish Cap and Labrador Shelf. With the progression of fisheries into deeper waters since the 1992 groundfish moratorium, large sponge catches have been recorded between 800 and 1400 meters throughout the Northwest Atlantic (Figure 10).

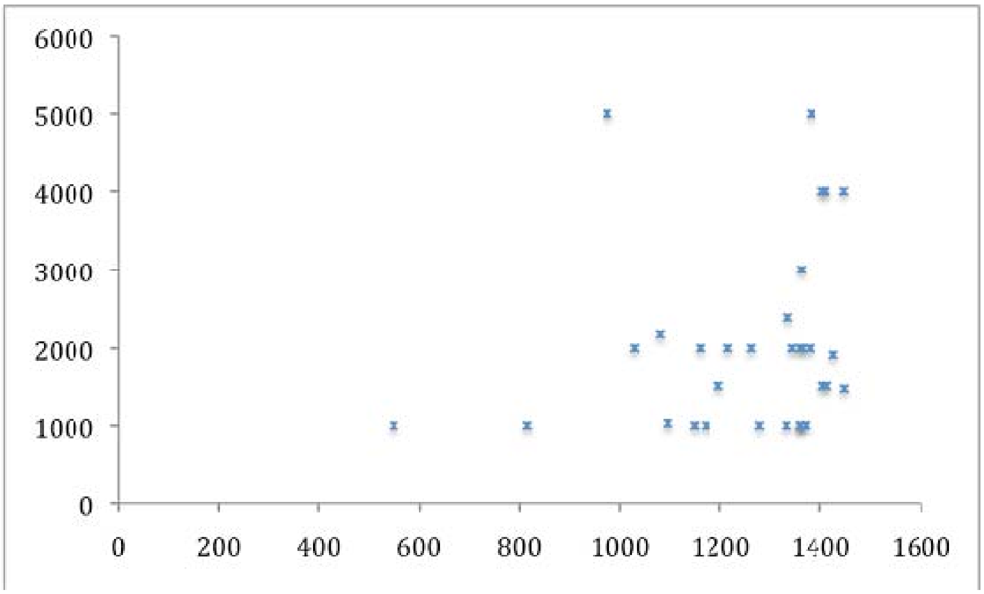

Figure 10. Depth of sponge bycatch > 1000kg as reported in Canadian trawl survey data (1995-2007).

Information Gaps

Sponges are not systematically recorded by fisheries observers in the NRA or in the whole NCA, however records do exist, particularly when an observer has witnessed a large catch of sponges. Trawl surveys in the Newfoundland Region have been collecting records on sponge catches as have surveys done by the Spanish/EU. There is a need for increased and systematic data collection, as well as mapping of habitats through multibeam as well as *in situ* investigations. Efforts should be made to develop an identification guide to sponges in the NRA to facilitate further data collection.

Management Context

There is currently no protection afforded to sponge concentrations in the NCA, however some sponge species may be protected in areas where there are coral closures in the NCA. Given the structural complexity that is known to exist in concentrations of sponges on the seafloor, and the long-lived nature of deep sea sponges, the three categories of sponges identified in this report are indicative of vulnerable marine ecosystems and should be included in any mitigation measures adopted to protect such systems from fishing impact, as directed by the UNGA Resolution 61/115.

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Other Benthic Taxa

A number of other benthic taxa meet the FAO criteria for vulnerable species and underpin benthic ecosystems. These include but are not limited to stalked crinoids and tunicates, xenophyophores, file shells, deep water urchins, sea stars, sea cucumbers and other echinoderms.

Megafaunal invertebrates form structure if they aggregate in high numbers, especially in areas of low relief (Tissot *et al.*, 2006). For example, high density “forests” of crinoids provide refuge and substrata for a wide variety of small fishes and invertebrates (Lissner and Benech, 1993, and Puniwai, 2002, both in Tissot *et al.*, 2006). Similarly, high-density aggregations of brittle stars and brachiopods in boulder-cobble areas and fields of sea urchins in sand and mud habitat also provide space and structure for other organisms (e.g., Brodeur, 2001). Another aspect to consider is that large epibenthic deposit-feeding holothurians may promote deep-sea benthic diversity by suppressing competitive exclusion among the smaller benthos in the surface sediment (Dayton and Hessler, 1972).

In addition, some organisms such as bryozoans, hydroids, ascidians, barnacles, etc., can provide habitat complexity in diverse environments. This biogenic turf can be used by fish as a refuge from predation, especially for juvenile life stages (Malecha *et al*., 2005).

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Fish, commercial invertebrates and fish assemblages

Bottom-trawl fishing surveys, scientific observers and NAFO observers are main sources of information on fish stocks, catches and by-catches. A list of current surveys in the area is provided by the SC Report every year.

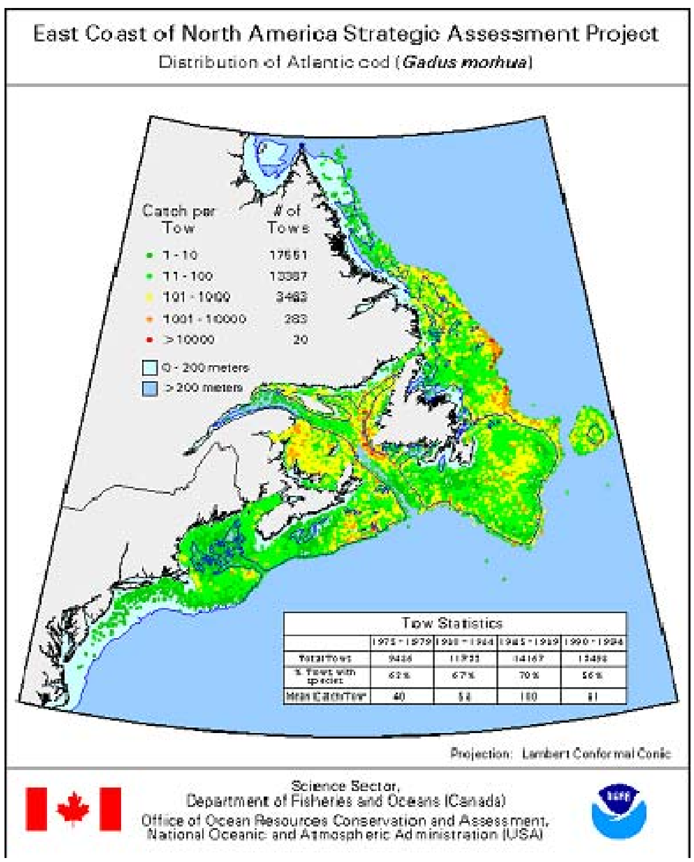

Figure 11. Broad-scale distribution of Atlantic cod in the NCA based on compilation of research survey information.

The primary objective of RV surveys has traditionally been to provide fisheries-independent indices of abundance and biomass of main commercial species for their use in stock-assessment. Associated with this, ageing and maturity studies are also carried out. However, most surveys have evolved over the years trying to enhance their ability for sampling non-commercial species and to provide a wider picture of the marine community. Among the biological studies already implemented, or in the process of being implemented, in these RV surveys are an improved recording of benthic organisms, production of length-frequency distributions for all species, and stomach content analyses and growth and condition studies, typically for selected species. Some examples of these changes include the special attention towards identifying invertebrate by-catch in the NRA (Divs. 3LMNO) by the Spanish/EU groundfish bottom trawl since 2005, or the enhanced sampling (non-commercial species, bottom grab sampling, stomach contents) to be implemented in the 2J3KLNO Canadian multispecies fall survey as part of the DFO "Ecosystem Research Initiative" in the Newfoundland and Labrador region.

Attempts have been made to assemble information derived from research vessel surveys and construct views of the large-scale distribution of species in the convention area. The first such attempt was the East Coast of North America Strategic Assessment (ECNASAP) Project. Although the project did not attempt to fully standardize results from the individual research vessel surveys throughout the convention area, this compilation does permit an evaluation of distribution patterns at least in terms of presence-absence of different species. An example of the distribution of Atlantic cod (expressed in terms of unstandardized catch-per-tow) is provided in Figure 11)

Scientific Council provides advice on these 18 stocks in the NRA:

- cod 3NO, 3M;
- American plaice 3LNO, 3M;
- witch flounder 2J3KL, 3NO;
- redfish 3LN, 3O, 3M;
- roughhead grenadier 2+3;
- Greenland halibut 2+3KLMNO;
- yellowtail 3LNO;
- skate 3LNO;
- white hake 3NO;
- squid 3+4;
- shrimp 3LNO, 3M;
- capelin 3NO

Much of available documentation on these stocks in the NRA is contained in the NAFO Scientific Council publications (SCR Documents, Journal of Northwest Atlantic Fisheries Science, NAFO Scientific Council Reports, etc.). Much of the information is available on the NAFO website, including SCR Documents from 2002 onward, electronic versions of all Journal volumes, Scientific Council Reports from 2000 onward, etc. SC Symposia in 2004 (Flemish Cap) and 2006 (Environmental and Ecosystem Histories) both contain relevant papers, including some information on groundfish assemblages in the NRA. Scientific Council also, from time to time, considers papers on other species for which it does not provide annual scientific advice, such as various elasmobranchs.

Other sources of information include the ICNAF literature (which is where many of the above stocks were assessed prior to the formation of NAFO in the late 1970's), various sources of primary publications, and papers in the Canadian Stock Assessment series (CSAS documents, and its fore-runner CAFSAC), in which information on some stocks which occur in the NRA (such as Div. 2J3KL cod, Div. 3L capelin) can be found.

Tunas, sharks, and other large pelagic fish are not managed or assessed by NAFO, but do occur in the NRA. Sources of documentation include ICCAT papers and reports, COSEWIC reports, CSAS documents, and primary literature.

Marine Mammals

There is relatively little published information on the distribution of marine mammals in the NRA (see selected references below). A number of studies have been carried out in recent years but analyses are still underway. However, general patterns of distribution can be described based upon preliminary analyses.

Two species of pinnipeds regularly inhabit the NRA, harp seals (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*). Both are wide, ranging, migratory species that summer in Arctic waters and winter primarily in the waters off Newfoundland and in the Gulf of St. Lawrence. However, both species are found primarily in offshore areas where they are rarely observed, making distributions difficult to quantify. Harp seals are primarily found along the continental shelf where they dive to depths of 500m or more (Stenson and Sjare, 1997; Stenson unpublished data). Seasonal movements vary annually and among individuals although no sex-related differences have been observed. Harp seals ranged from the northern Scotian Shelf and Grand Banks of Newfoundland in the spring and winter, north to Baffin Bay, southeastern Greenland and Hudson Strait in the summer. The northern Grand Banks, including the nose, appeared to be an important feeding area both during the winter and in the spring following pupping. The occurrence of seals on the southern Grand Banks, Flemish Cap and Scotian Shelf may indicate a southern shift in distribution in recent years.

Hooded seals are the second most abundant pinniped in the northwest Atlantic. Like harp seals, Northwest Atlantic hooded seals winter in the Gulf of St. Lawrence and off the east coast of Newfoundland and/or southern Labrador. However unlike harps, after pupping and breeding in March hooded seals spend the next 2 months feeding before eventually migrating to southeast Greenland where they moult in late June – July. Following moulting, hooded seals migrate around the west coast of Greenland to Davis Strait and into Baffin Bay where they feed prior to migrating southward in the late fall. Hooded seals inhabit shelf edges and deep waters areas of the Labrador Sea and Baffin Bay. In southern areas, they are often found along the edge of the Grand Banks and Flemish Cap where they dive to depths of over 1500m (Stenson *et al.* unpublished data).

The distribution of cetaceans in the NRA is poorly understood. Sighting reports, bycatch data and limited survey surveys indicate that the Southeast Shoal and nose and tail of the Grand Banks are important feeding areas for many species (Lawson unpublished data). Cetaceans such as humpback and northern bottlenose whales aggregate and feed along the Southwest Slope and eastern edge of the Grand Banks, particularly among the canyon areas. Less is known about the distribution of cetaceans in the deep Atlantic waters although many species including sperm, fin, humpback, pilot and minke whales, dolphins (white-sided and white-beaked), harbour porpoise and various beaked whales have been observed. A large scale sighting survey was carried out during the summer of 2007 to estimate abundance of cetaceans across the North Atlantic. Although efforts in the northwest Atlantic were concentrated on the continental shelf, the results of these surveys will provide the first comprehensive estimate of abundance and distribution of cetaceans in the area.

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Turtles

Several species of sea turtles occur in the NRA, most records there are bycatch associated with the pelagic longline fisheries for tuna and swordfish that occur south and west of the Flemish Cap off the shelf bordering the Gulf Stream (Bleakney, 1965; Lewison *et al.,* 2004; Garrison, 2003). These large pelagic fisheries are not managed by NAFO and are well separated from shelf waters. The two most common species encountered are the leatherback turtle (*Dermochelys coriacea*) and the loggerhead turtle (*Caretta caretta*). The near surface waters appear to be foraging habitats for a considerable number of these two species. The status of leatherback and loggerhead turtle populations in the western North Atlantic appears to be stable, but their numbers are thought to be much reduced from historic levels (DFO, 2006). In Canada, leatherback turtles are listed under the Species at Risk Act (SARA) as "Endangered" and loggerhead is currently being assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Other species rarely encountered in the NRA are Kemps Ridley (*Lepidochelys kempii)* and Green turtle (*Chelonia mydas)*.

The working group had no marine turtle experts present during its meeting but recognized their importance as important ecosystem components. Information on the loggerhead and leatherback turtles was extracted from the NOAA website (see links below) and supplemented with available information from Canada:

Loggerhead Turtle *(Caretta caretta)*

Loggerheads are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. Loggerheads are the most abundant species of sea turtle found in U.S. coastal waters. In the Atlantic, the loggerhead turtle's range extends from Newfoundland to as far south as Argentina. Within the North Atlantic, juvenile loggerheads have been primarily studied in the waters around the Azores and Madeira (Bolten, 2003). Other populations exist (e.g., in the region of the Grand Banks off Newfoundland), but data on these populations are limited. The juvenile turtles around the Azores and Madeira spend the majority of their time in the top 5 m of the water column. The greatest cause of decline and the continuing primary threat to loggerhead turtle populations worldwide is incidental capture in fishing gear, primarily in longlines and gillnets, but also in trawls, traps and pots, and dredges. Loggerhead turtles are protected by various international treaties and agreements as well as national laws. They are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), which means that international trade of this species is prohibited. Loggerheads are listed in Appendices I and II of the Convention on Migratory Species (CMS) and are protected under the following auspices of CMS: the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA) and the Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa. Loggerheads are also protected under Annex II of the Specially Protected Areas and Wildlife (SPAW) Protocol of the Cartagena Convention. Additionally, the U.S. is a party to the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), which is the only binding international treaty dedicated exclusively to marine turtles. The loggerhead turtle was listed under the US Endangered Species Act (ESA) as threatened throughout its range on July 28, 1978.

(Source: http://www.nmfs.noaa.gov/pr/species/turtles/loggerhead.htm)

Leatherback Turtle *(Dermochelys coriacea)*

The leatherback is the largest turtle and the largest living reptile in the world. Mature males and females can be as long as six and a half feet (2 m) and weigh almost 2000 lbs. (900 kg). The leatherback is the only sea turtle that lacks a hard, bony shell. Leatherbacks are commonly known as pelagic animals, but also forage in coastal waters. In fact, leatherbacks are the most migratory and wide ranging of sea turtle species. Thermoregulatory adaptations such as a counter-current heat exchange system, high oil content, and large body size allow them to maintain a core body temperature higher than that of the surrounding water, thereby allowing them to tolerate colder water temperatures. Nesting female leatherbacks tagged in French Guiana have been found along the east coast of North America as far north as Newfoundland with occasional records off Baffin Island. Atlantic Canada supports one of the largest seasonal foraging populations of leatherbacks in the Atlantic. The greatest causes of decline and the continuing primary threats to leatherbacks worldwide are long-term harvest and incidental capture in fishing gear. Harvest of eggs and adults occurs on nesting beaches while juveniles and adults are harvested on feeding grounds. Incidental capture primarily occurs in gillnets, but also in trawls, traps and pots, longlines, and dredges. Together these threats are serious ongoing sources of mortality that adversely affect the species' recovery. Leatherback turtles are protected by various international treaties and agreements as well as national laws. They are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), which means that international trade of this species is prohibited. Leatherbacks are listed in Appendices I and II of the Convention on Migratory Species (CMS) and are protected under the following auspices of CMS: the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA) and the Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa. Leatherbacks are protected under Annex II of the Specially Protected Areas and Wildlife (SPAW) Protocol of the Cartagena Convention. The U.S. is a party of the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), which is the only international treaty dedicated exclusively to marine turtles. The leatherback turtle was listed under the US Endangered Species Act as endangered in 1970. (Sources: http://www.nmfs.noaa.gov/pr/species/turtles/leatherback.htm; http://www.seaturtle.ca/). The leatherback turtle is classified as critically endangered by the International Union for the Conservation of Nature (IUCN) and in Canada is considered as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). It is further protected in Canada by the Species at Risk Act.

In 2000, NOAA closed a fishing area on the Grand Banks to provide additional protection for loggerhead and leatherback sea turtles caught as bycatch by U.S. fishermen during Atlantic pelagic longline fishing operations. This area remained closed through to 2004 when new technology was developed to reduce the mortality of sea turtles caught in pelagic longlines.

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Fisheries

Spatial fishing effort within the NRA was determined using commercial fishing vessel positions containing in the VMS database housed in the NAFO Secretariat. A vessel was taken to be trawling if the calculated speed was between 2-4 knots. Owing to the precise nature of the VMS data, it is difficult to disaggregate the information by fleet, target species, etc., but it is generally possible to decide this afterwards based on an examination of the area and depth of the fishing effort. Figure 12 shows the combined fishing effort in the NRA for 2003-2007. For example, the red area corresponds to more than 100 hours of fishing over the five years per one minute latitude-one minute longitude square (minute square) or 20 hours per year per minute square. Significant fishing effort restricted to depths less than around 1 500 m around the slopes of the Flemish Cap and the nose and tail of the Grand Banks. There is evidence of limited bottom fishing on two individual seamounts in the Corner Seamount system, but little to none elsewhere. There are five areas currently closed to bottom-contact fishing gears. There are four “seamount” closures protecting demersal fish and benthic habitats on the Orphan Knoll, the Newfoundland, New England and Corner Seamount systems that were closed from 1 January 2007 to 31 December 2010. A coral area was also closed from 1 January 2008 to 31 December 2012. These closures will be reviewed in September 2010 and September 2012, respectively.

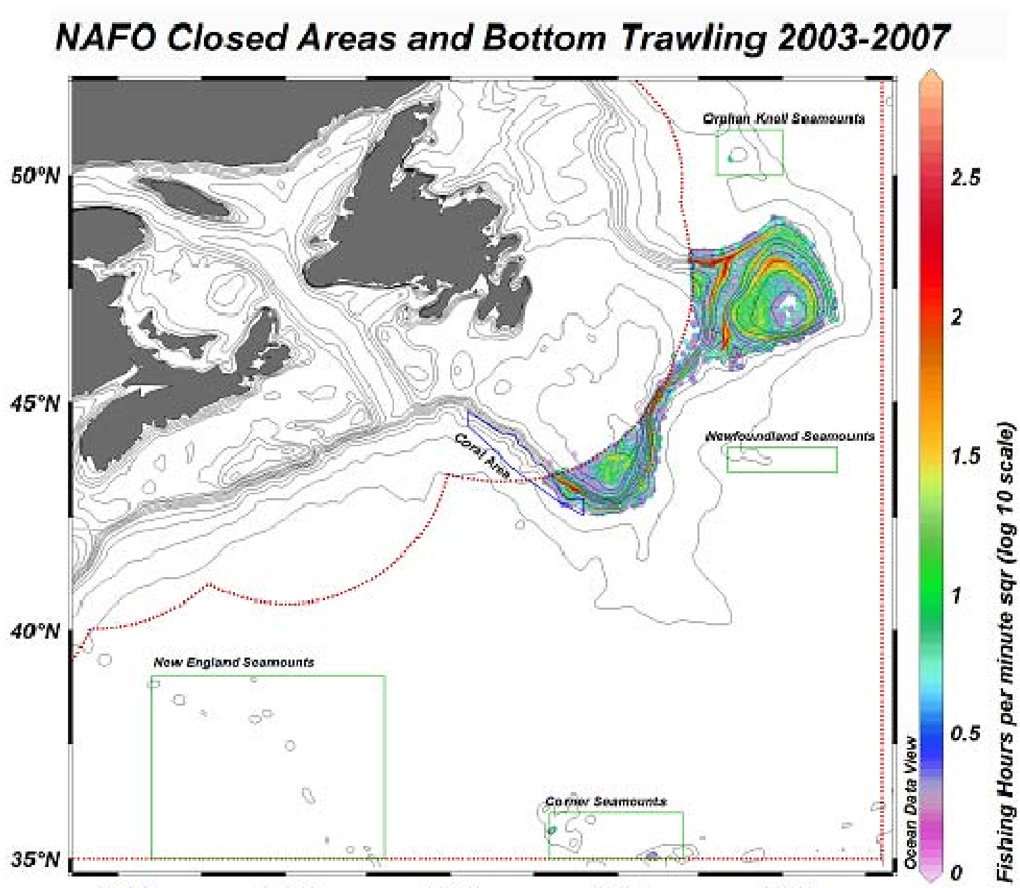

Figure 12. Map of total fishing effort in 2003-2007 and current closures to bottom fishing in the NRA. Density indicates logarithm base 10 of the hours fished in one minute latitude-one minute longitude square.

2.e – The management context (national, regional and international) in terms of systems and governance

Management context for the various ecosystem components was notconsidered at the meeting, however important national and international protection measures are cited where applicable in 2.d above.

2.f – A list of all targeted species, management plans thereof and associated issues (e.g. bycatch, gear disturbance, etc.)

This issue was not considered in the meeting.

ToR 3: To explore the feasibility of different tools (e.g. ecosystem indicators, modelling, etc.) that could be used in management advice in the NAFO area.

The WG did not have time to explore the feasibility of different tools that could be used in management advice in the NAFO area due to the additional and high priority work tasks assigned. However, a presentation was made by Dr. Ellen Kenchington on the ICES Working Group of the Ecosystem Effects of Fishing Activites (WGECO) approach. WGECO began a review of sensitive and vulnerable species in the OSPAR area in the early 2000s in response to a request from OSPAR. The definitions adopted were:

- Sensitive Species: A species easily adversely affected by a human activity, and/or if affected is expected to only recover over a very long period, or not at all (OSPAR, Texel/Faial Criteria).

- Fragile Species: Sessile and slow moving species, often characterized by rigid bodies or tubes that are particularly sensitive to physical damage, usually with a body size > 2 cm and living as epifauna or sub-surface infauna. This term is often used in the literature, including the ICES literature, to describe species that are vulnerable to human-induced or environmental change due to their life-histories. Species such as elasmobranchs would fall into this later definition.

The WGECO with assistance from the Benthic Ecology Working Group (BEWG) then reviewed the literature with respect to identifying all benthic species which met these criteria. The species list was generated from the 1986 Benthic Survey of the North Sea.

This work evolved to examining the impact of fishing gear types on habitat components and identifying mitigation measures to reduce the impact where possible. Ultimately this was expanded to include a list of 8 high level ecosystem components (e.g., seabirds, fish). This matrix has been used and expanded by OPSAR and presently includes approx. 2700 combinations, including threats other than those imposed by fishing gears. This matrix is currently being populated by indicators which would allow managers to monitor the various ecosystem components. This work is ongoing and its development can be traced through the various WG reports since 1999. In the context of this matrix WGECO has defined two measures which parallel the language used in the FAO draft guidelines:

- Sensitivity is the degree to which a component responds to a pressure, and is a function of its resistance to a pressure (i.e. how much of the pressure it can withstand) and its inherent resilience (i.e. its recovery potential).
- Vulnerability is the probability or likelihood that a component will be exposed to a pressure to which it is sensitive. When undertaking the assessment, the extent of spatial overlap between pressure and component would be assessed so that where there was no spatial overlap, there was no need to take the assessment any further.

The recent development of high level agreements by FAO, EU Maritime Strategy and IUCN have highlighted the need for a clear understanding of some broad ecosystem management concepts such as 'significant adverse impacts', 'vulnerable marine ecosystems', and 'good environmental status'. Without a clear understanding of how these can be practically interpreted and applied consistently across national boundaries, progress with the achievement of these important international commitments will be slow. WGECO have a history of working to integrate across many ecosystem components and from different national perspectives, and would propose to apply their knowledge to this important issue through a Terms of Reference to ICES for consideration at the 2008 Annual Science Conference and Business Meetings:

a) Define and demonstrate with selected case studies / examples the practical interpretation of the high level terminology used in the international agreements on managing marine ecosystems. Specifically these should include the broad ecosystem management concepts ‘significant adverse impacts’, ‘vulnerable marine ecosystems’, and ‘good environmental status’. This should include explicit consideration of reference conditions, thresholds and recovery rates, in relation to both ecosystem structure and function;

This work, if sanctioned, should be of use to NAFO in clarifying these terminologies. Equally, the WGEAFM report and supporting documents will well inform the WGECO process.

3.a – Criteria for the identification of VME (Vulnerable Marine Ecosystems).

A general discussion ensued on identification of VMEs and the scale and context in which the FAO criteria (FAO 2008b) would be applied. It was noted that although VMEs have a spatially explicit context (i.e. are to cover “areas”), the ecosystem attribute is not confined to just habitat as they also house sensitive species. The term “vulnerability” also needed context because the likelihood that, for example, a sensitive habitat would experience substantial alteration from short-term or chronic disturbance would be zero in areas beyond the technological ability of utilize bottom contact gear at the depth of the habitat does not yet exist. The WG agreed to the following approach in its task to identify VMEs (Figure 13).

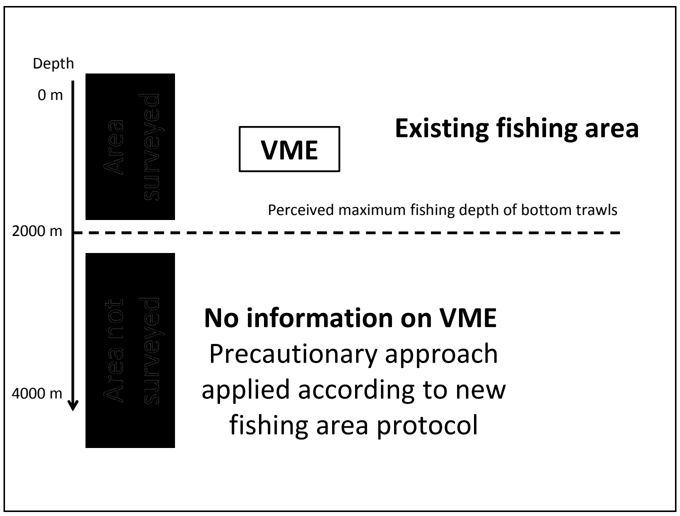

Figure 13. Conceptual framework for assigning VMEs.

The identification and delineation of VMEs, is dependent on an understanding of vulnerability and how this is applied to unfished areas. Most of the collected benthic data needed to identify VMEs comes from bottom trawls used on commercial and research vessels. For this reason, VMEs can really only be defined when data has been collected and when the bottom depth is less than the presumed current maximum trawl depth of around 2000 m. This is also consistent with the vulnerability criteria. Areas outside of the existing fishing area will in the future be subject to a new fishing area protocol and VMEs can be later identified as part of the submitted impact assessment. Areas will also be subject to an encounter protocol and this should generally help to halt the overall decline in biodiversity. The group felt that there was little risk to the unknown VMEs in currently unfished areas, and so no attempt was currently made to extrapolate or predict VMEs in these unfished areas. Identified and delineated VMEs in the existing fishing areas will presumably be subject to additional management measures aimed to protect the high species biodiversity within these special regions.

In an attempt to make the FAO criteria in identifying VME (FAO 2008b) operational, the WG agreed to use various sources of survey or observer data to produce distribution maps for corals and sponges, with the intent to delineate areas within the NRA based on the high density areas of coral and sponge. The species to include were determined by a literature review of their attributes (see Annex 2; Fuller *et al*., 2008). The next step was to overlay this VME with the maps produced for the fish species to strengthen the validity of the VME. In this way the WG considered that it would be offering the best possible advice on identifying VME while acknowledging that further work would be required to refine any designated VME based on additional habitat and community information. The results of this framework are presented under previous ToR 2.d.

A Case Study from Hatton Bank: a example of a scientific process to identify VME

A case study was presented of specifically designed for the identification of VME and habitats in relation with the high-seas deep-water fisheries, in order to advise on conservation measures, such as areas closed to bottom fishing (Durán Muñoz *et al.*, 2007, 2008).

In 2005 the ICES-Working Group on Deep Water Ecology (WGDEC) reported available information in the literature on the occurrence of cold-water corals on the Hatton Bank. In their report (ICES, 2005) the WG recognized:

"*Without a properly planned habitat mapping exercise based on wide-area acoustic survey (e.g. multibeam sonar) with adequate visual ground-truthing, it is impossible to provide a true picture of the distribution of cold-water corals on the Hatton Bank. Equally it is impossible to provide a true picture of where such habitat-forming species do not occur…..*"

Through an interactive process that involved conventional fisheries science, geomorphology, sedimentology and benthic ecology, the Spanish interdisciplinary project (ECOVUL/ARPA) developed a methodological framework to address these types of issues. The approach proved to be very useful to define practical criteria for the identification of VMEs, to improve the knowledge about their distribution and the adverse impacts of bottom trawl fisheries, and to produce high quality advice on habitat protection in the ICES and NEAFC context. Moreover, this methodology was referred by FAO (FAO, 2008a) as a suitable example of data collection to identify VMEs.

Applying the aforementioned interdisciplinary approach, the project identified the deep-water bottom trawl fishery footprint on the Hatton Bank Western slope (NEAFC Regulatory Area, North East Atlantic), mapped the main fishing grounds and related seabed habitats and studied the interactions between fishing and cold-water corals.

These results were then used to recommend, with high level of precision, the spatial limits of an area closed to bottom fishing (the Hatton Bank north western outcrops area closed), as an essential conservation measure to protect the cold-water corals in the framework of the Ecosystem Approach to Fisheries Management.

Durán Muñoz *et al.* (2008) summarize methods used (joint analysis of fishing effort and vulnerable benthic invertebrate by-catch distributions, VMS plots, multibeam surveys, sub-bottom profiler, standardized bottom trawls, dredges and box-corer), main results, and discuss the utility of this approach, the advantages of this high resolution method, and the opportunity and feasibility of applying it in the NRA.

Identification of Vulnerable Marine Ecosystems (VMEs) in the NAFO Regulatory Area (NRA)

Despite their name Vulnerable Marine Ecosystems (VMEs) are not whole ecosystems. For the most part VMEs are actually subcomponents of a larger ecosystem which can be associated with a precise geographical location. VMEs are typically expected to have some degree of internal homogeneity, constituting ecotopes and/or biotopes, but their actual geographical extent is variable and they can also encompass multiples ecotopes/biotopes (e.g. seamounts).

The FAO guidelines for the management of deep-sea fisheries in the high seas currently being developed (FAO 2008b) indicates five criteria that should be used to identify VMEs. These criteria are:

i. Uniqueness or rarity - an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by other similar areas. These include:
    - habitats that contain endemic species;
    - habitats of rare, threatened or endangered species that occur only in discrete areas; or

- nurseries or discrete feeding, breeding, or spawning areas.

ii. Functional significance of the habitat – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.

iii. Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities.

iv. Life-history traits of component species that make recovery difficult - ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics:
   - slow growth rates;
   - late age of maturity;
   - low or unpredictable recruitment; or
   - long-lived.

v. Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

These criteria are not restrictive; FAO guidelines clearly state that they can be expanded and/or adapted for their application in specific cases.

<u>Making the criteria operational for non-mobile organisms</u>

Sessile and very low mobility organisms (e.g. corals, sponges, bivalves) are expected to play a more central role in the process of identifying VMEs. The WG considered corals and sponges as core biological components to identify VMEs but did not constrain VMEs to them.

Corals

The FAO guidelines recognize that not all coral species are vulnerable or form ecosystems. In identifying coral VME components, the size, structural complexity, gregariousness, fragility, vulnerability to fishing gears, rarity, longevity, role in the ecosystem (associated species, biodiversity) and international recognition of status were considered. These are documented in the supporting publication (Fuller *et al*., 2008). The following groups of corals are considered indicators and key components of VMEs:

Antipatharians
Gorgonians
Cerianthid anemone fields
Lophelia and other reef building corals
Sea pen fields

Sponges

In the NAFO Convention Area, within the Canadian EEZ, three clear areas emerge as important regions for sponges (Figure 14):

1) On the Scotian Shelf, particularly in the Emerald Basin, the monospecific patch of *Vazella pourtalesi* represents a significant and unique population.
2) The region along the Labrador shelf is also significant as there are catches greater than 1000kg per tow.
3) Finally, there is a significant concentration of sponges in the Davis Strait that overlaps with the area identified by Edinger *et al.* (2007).

Canadian surveys do not adequately cover the Flemish Cap area, however information from Russian and Spanish/EU survey offers additional data providing an increased level of coverage for this area (see Figures 15 and 16).

For the purposes of identification of vulnerable marine ecosystems, the data available in the NRA clearly show defined areas where sponges are more abundant than in other areas. From Figure 14 and 17, the northwest edge of the Flemish Cap, the southern region of the Flemish Pass continuing south along the slope emerge as important sponge VMEs. Large catches have also been recorded southwest of the Flemish Cap.

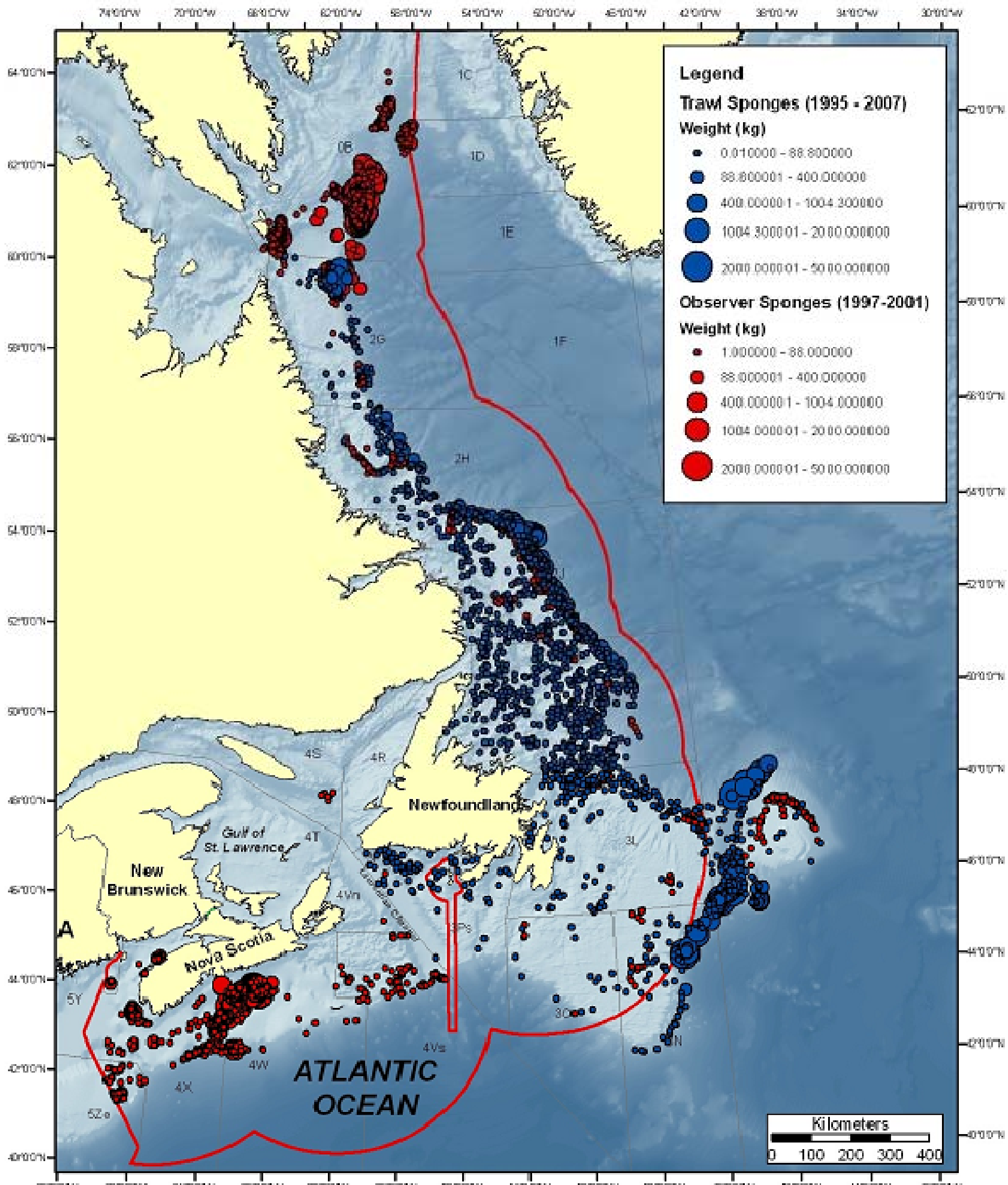

Figure 14. Sponge distribution in the NAFO Area, data is from Canadian Trawl Survey Data (1995-2007) and Maritimes Fisheries Observer data (1977-2001).

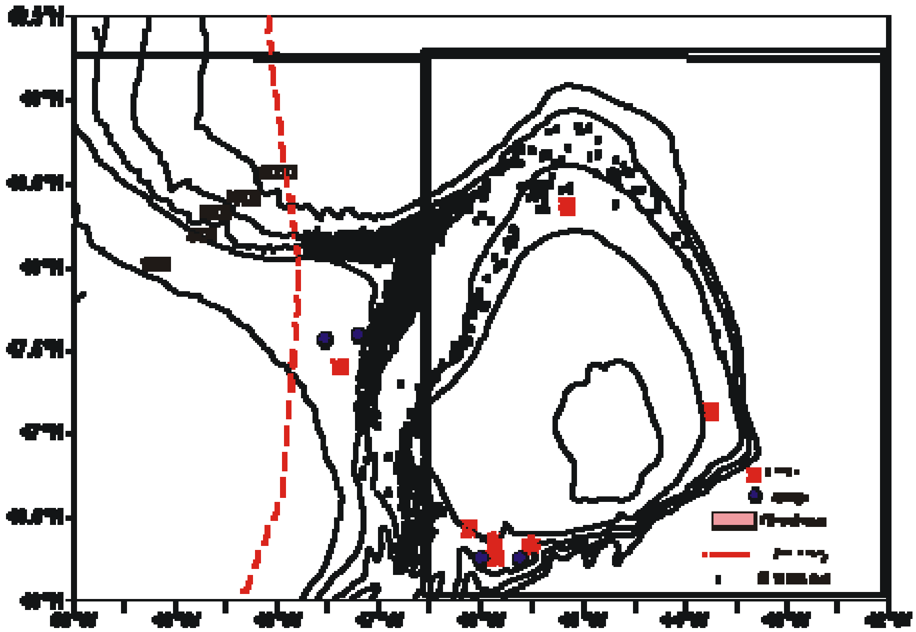

Figure 15. Russian fleet location on Greenland halibut fishery in the NAFO Div. 3LM by observers data (2000-2008) and corals/sponges occurrence by Russian fishery maps and description data (Vinnichenko and Skylar, 2008).

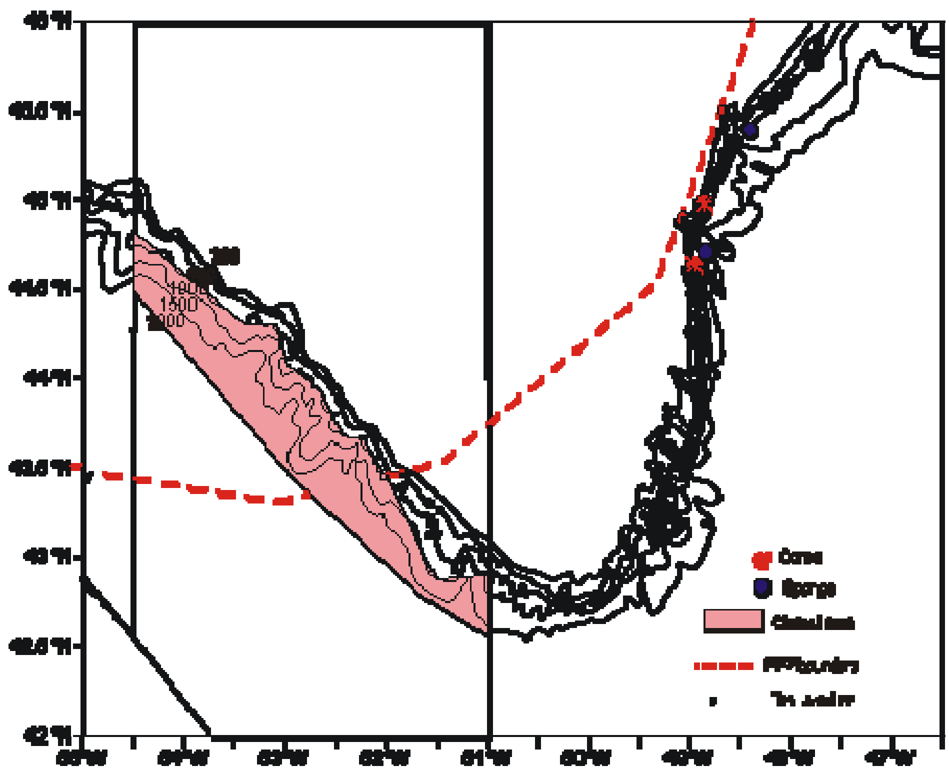

Figure 16. Russian fleet location on Greenland halibut fishery in the NAFO Div. 3NO by observers data (2000-2008) and corals/sponges occurrence by Russian fishery maps and description data (Vinnichenko and Skylar 2008).

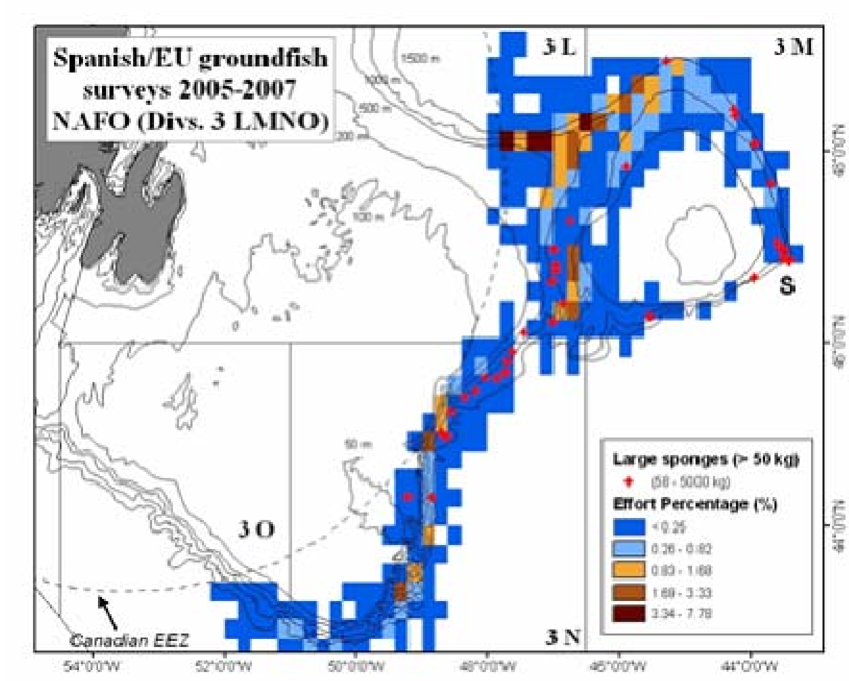

Figure 17. Records of large sponges by-catch (estimated weights in some cases) derived from Spanish/EU groundfish surveys data sources (2005-2007) in NAFO Divisions 3LMNO, superposing to the footprint of the Spanish Greenland halibut fishery for period 2001-2006, showing that these areas are not being subjected to intense bottom trawl fishing. In terms of biomass, bottom trawl by-catches obtained by haul ranged from a maximum of 5000 kg to a minimum of 58 kg (only records bigger than 50 kg/haul are represented). Effort percentage values per rectangle of 0.2 x 0.2 degrees. (from Murillo *et al.*, 2008a).

<u>Making the criteria operational for mobile organisms</u>

Although information from other taxa was also considered, the bulk of the available data on mobile species corresponded to fish. The incorporation of these data for identification and delineation of VMEs followed a step-wise process. The steps were:

Step 1: Select a subset of the criteria that can be applied to individual species, and develop concrete operational definitions about how they will be applied.

From the original five criteria, only three were considered suitable for examination at the individual species level (i, ii, and iv). These criteria were made operational as follow:

i. Uniqueness or rarity. A species or stock will be selected for further consideration if it is:

a) endemic of a specific location, or
b) is listed by one or more national and/or international organizations as being under a special conservation category, or
c) is under fishing moratorium, or
d) there is evidence that the stock in the Grand Bank and/or NRA has declined to low levels in recent years.

ii. Functional significance of the habitat. A species will be selected for further consideration if there are relatively discrete areas that are considered critical for the well-being and/or recovery of the species/stock (e.g. spawning, nursery or feeding areas) in the NRA.

iv. Life history traits. A species will be selected for further consideration if it possesses life history traits (slow growing, late maturation, unpredictable recruitment, high longevity) that may impact on recovery rates.

These operational criteria were used to identify species that may help to define concrete areas that could constitute good VME candidates.

Step 2: Based on available information (scientific survey data series, conservation status of the species given by different organizations, general biology of the species, preliminary knowledge on local spatial distribution and other spatially-explicit information), identify those species that should be examined in more detail. The selected species are expected to be the best candidates to help identify areas suitable for consideration as potential VMEs. These species can be deemed as Tier 1 species (Table 1).

Step 3: Develop distribution maps for Tier 1 species, their spawning, nursery and/or feeding grounds, depending on the available information. The analysis of these maps and a closer examination of the biology and ecology of these species should be used to further restrict the Tier 1 species list. The more detailed examination of Tier 1 species is intended to verify the consistency of the application of the criteria, revisit the original selection and the applicability of the criteria, and to further reduced the set of species to be considered, if deemed necessary. Species that pass this second examination are considered Tier 2 (Table 1).

Step 4: Develop composite maps using available information on Tier 2 species. These composite maps and any other relevant information on these Tier 2 species will be used, in conjunction with the gathered knowledge on sessile organisms and geological/topographical features, to identify areas for consideration as VMEs.

Applying the criteria for fish species in the Grand Bank, Flemish Cap and seamounts in the NRA

Two sources were considered to generate the initial list of fish species for consideration. The first one, associated to the Grand Bank area, was the list of species recorded in DFO research surveys (Annex 1). The second source was the list of fish species recorded in sea mounts (Vinnechenko, 1997).

After initial examination (Step 2 above) a total of 27 species were selected for the Tier 1 list. These species were further examined and the criteria were applied (Step 3 above). Distribution maps and other spatially-explicit information were examined to determine if each of these species was suitable for inclusion in the Tier 2 list (Table 1). Core references for this process included distribution maps (Kulka *et al.*, 2003; Kulka, 2006; DFO 2008), spawning areas (Ollerhead *et al.*, 2004), and trends in survey indices for the Grand Bank (DFO surveys) and Flemish Cap (EU bottom trawl surveys) areas. Life history characteristics were discussed; FAO sheets and FishBase were checked. From the initial 27 species included in Tier 1, only 21 were kept as part of the Tier 2 list (Table 1).

For the Grand Bank and Flemish Cap section of the NRA maps for Tier 2 species were produced. These maps were based on Canadian RV survey data for the period 1995-2004 and the EU survey for the period 1988-2007. More precisely, maps of average abundance density were produced following Kulka (1998). From these species-specific maps, the areas containing approximately 90% of the entire abundance were extracted. These multiple maps were then overlaid to produce a single map depicting the most relevant areas for the selected species (Figure 18).

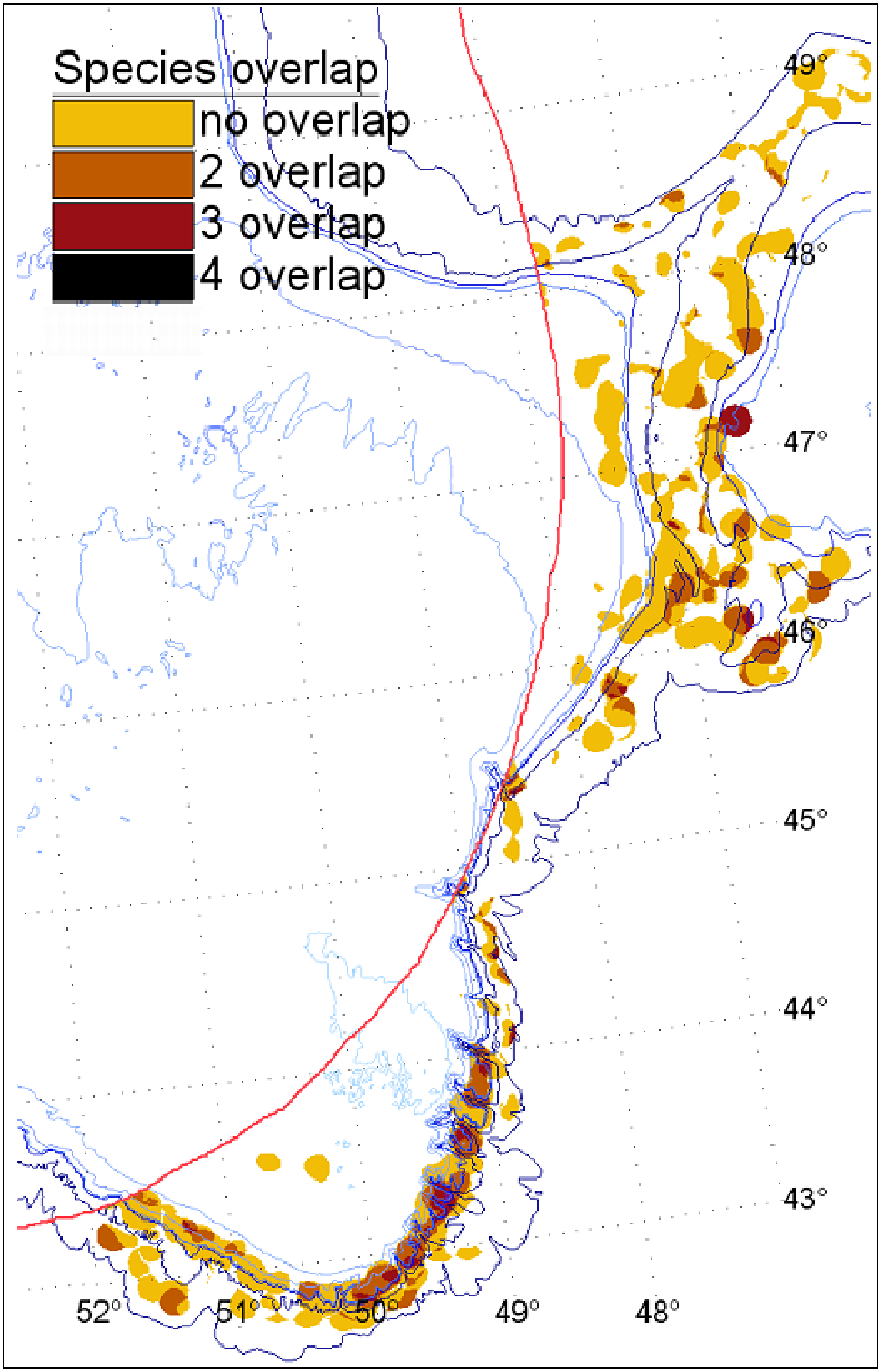

Figure 18. Areas of concentration of selected species (Tier 2 list, Table 1).

Table 1. Fish species selected for analysis towards identification of VMEs with details on the step-wise process applied to develop the Tier 2 list

		Tier 1	Fulfilment of Criteria			Tier 2 Fulfilment of Criteria	
Common name	Scientific name	Initial rationale for inclusion	i	ii	iv	Inclusion	Rationale
redfish, deep water	*Sebastes mentella*	NAFO moratorium	n	n	y	yes	Distribution restricted to slopes, core concentrations in the NRA
redfish,golden (*marinus*)	*Sebastes marinus*	NAFO moratorium	n	n	y	yes	Distribution restricted to slopes, core concentrations in the NRA
American Plaice	*Hippoglossoides platessoides*	NAFO moratorium	n	n	n	no	Ample distribution, no critical concentrations in NRA
cod, Atlantic	*Gadus morhua*	NAFO moratorium	n	n	n	no	Ample distribution, no critical concentrations in NRA
witch flounder	*Glyptocephalus cynoglossus*	NAFO moratorium	n	n	n	no	Ample distribution, no critical concentrations in NRA
Capelin	*Mallotus villosus*	NAFO moratorium	y	y	n	yes	Critical spawning grounds in the Southeast Shoal for 3NO stock
dogfish,black	*Centroscyllium fabricii*	life history	n	n	y	yes	Restricted areas of high concentration in the GB and NRA
grenadier, roundnose	*Coryphaenoides rupestris*	life history	n	n	y	yes	Restricted areas of high concentration in the GB and NRA
grenadier, roughhead	*Macrourus berglax*	Designated [special concern, COSEWIC], life history	n	n	y	yes	Restricted areas of high concentration in the GB and NRA
deep sea cat shark	*Apristuris profundorum*	life history	n	n	y	yes	Restricted areas of high concentration in the GB and NRA
hake, white (common)	*Urophycis tenuis*	low abundance	n	n	y	yes	Restricted areas of high concentration in the GB and NRA
wolffish, striped	*Anarhichas lupus*	Designated [special concern, COSEWIC & SARA]	y	n*	?	yes	Restricted areas of high concentration in the GB and NRA
wolffish,broadhead	*Anarhichas denticulatus*	Designated [threatened, COSEWIC & SARA]	y	n*	?	yes	Restricted areas of high concentration in the GB and NRA
skate,smooth	*Malacoraja senta*	Final assessment stage, COSEWIC	y	y	y	yes	Restricted areas of high concentration in the GB and NRA, potential for local population

		Tier 1	Fulfillment of Criteria			Tier 2	Fulfillment of Criteria
Common name	Scientific name	Initial rationale for inclusion	i	ii	iv	Inclusion	Rationale
wolffish, spotted	*Anarhichas minor*	Designated [threatened, COSEWIC & SARA]	y	n*	?	yes	Restricted areas of high concentration in the GB and NRA
halibut (Atlantic)	*Hippoglossus hippoglossus*	Designated [endangered, IUCN]	y	n	n	no	Ample distribution, no critical concentrations in NRA
mako, shortfin	*Isurus oxyrinchus*	Designated [threatened, COSEWIC]	y	n	y	no	Ample distribution, pelagic, no critical concentrations in NRA
porbeagle	*Lamna nasus*	Designated [endangered, COSEWIC]	y	n	y	yes	Spawning grounds in the NRA
skate, spinytail	*Bathyraja spinicauda*	life history	n	n	y	yes	Highest concentrations along the slope, Restricted areas of high concentration in the GB and NRA
shark,Portuguese	*Centroscymnus coelolepis*	life history, presence in seamounts	y	?	y	yes	rare species with high frequency of records in the NRA, also present in seamounts
shark,basking	*Cetorhinus maximus*	life history	n	n	y	no	Ample distribution
Alfonsino	*Beryx splendens*	presence in seamounts	y	y	n	yes	distribution and concentrations highly associated to seamounts
Beryx decadactylus	*Beryx decadactylus*	presence in seamounts	y	y	n	yes	distribution and concentrations highly associated to seamounts
Orange roughy	*Hoplostethus atlanticus*	presence in seamounts	y	y	y	yes	distribution and concentrations highly associated to seamounts
Hoplostethus mediterraneus	*Hoplostethus mediterraneus*	presence in seamounts	y	y	y?	yes	distribution and concentrations highly associated to seamounts
Wreckfish	*Polyprin americanus*	presence in seamounts	y	y	y?	yes	distribution and concentrations highly associated to seamounts
Cardinalfish	*Epigonus telescopus*	presence in seamounts	y	y	y?	yes	distribution and concentrations highly associated to seamounts

3.b – Adverse impacts of bottom fishing activities on VME

The most Vulnerable Marine Ecosystems (VMEs) are ones that are both easily disturbed and are very slow to recover, or those that may never recover. Vulnerable ecosystem features may be physically or functionally fragile. According to this definition (FAO, 2008a), cold-water coral ecosystems are considered VMEs.

Bottom trawling has deleterious impacts on complex habitats (Watling and Norse, 1998; Auster and Langton, 1999). The structural characteristics and long-lived nature of some deep water corals make them especially vulnerable to damage by the mechanical impacts of bottom fishing activities (Probert *et al.,* 1997; Phillipart, 1998; Freiwald *et al*., 2004).

In the last years, the studies of fishery impacts to the benthos and the ecosystem in NAFO area are increasing (Messieh *et al*., 1991; Collie *et al*., 1997; Prena *et al*., 1999; Kenchington *et al*., 2001; Hermsen *et al*., 2003; Gilkinson *et al*., 2005; Henry *et al*., 2006; Kenchington *et al*., 2006; Kenchington *et al*., 2007) and are very useful to understand the fishery effects on the ecosystem, though most of them are in small areas and shallow waters and the effects in deep waters could be very different.

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3.c – Methods for the longer term monitoring of the health of VME.

Once VMEs are identified, non-destructive monitoring programs can be put in place to ensure that the areas are not being fished illegally and to monitor recovery if applicable. Ecosystems are not static and natural change is to be expected. Key organisms can be assessed periodically for recruitment, abundance, spatial footprint, etc., dependent on the species. Should fishing activities be allowed in all or part of a VME, then extra effort should be made to ensure that removal of fish or shelfish has not had a detrimental impact on other ecosystem components.

3.d – Ecosystem indicators, how to translate model outputs and empirical indicators into management advice.

Indicators are needed to support the implementation of an ecosystem approach to fisheries management (EAF), by providing information on the state of the ecosystem, the extent and intensity of fishing effort (or mortality) and the progress of management in relation to the objectives (Jennings, 2005). In general, indicators need to be identified for all of the ecosystem components representing a range of trophic levels, including indicators of the economic and social consequences of the regulatory controls. The numbers and types of indicators used to support an EAF will vary among management regions, depending on resources available for monitoring and enforcement and actual and potential fishing impacts.

Although there are several indicator taxonomies or frameworks, there are some common approaches and properties to consider when selecting which ones to use (Link, 2006). Most ecological indicators in an EAF context typically include some metrics associated with the state of the system such as: size, production, diversity, “canary” species, energy flow – trophodynamics, habitat and physio-chemical regime. State indicators provide feedback on the state of ecosystem components (benthos, seabirds, mammals, plankton, etc.) and the extent to which management objectives, which usually relate to state, are met. Ecosystem state can only be managed if the relationships with fishing (pressure) and management (response) are known.

Predicting such relationships are fundamental in developing effective management frameworks that allow the assessment advice to be adopted in management plans. Implicit in making such predictions is an understanding of how the various ecosystem components interact. Therefore indicators which assess the extent of ecosystem component interaction (such as the flow of energy between trophic levels) are particularly important for advice and management purposes, but at present these type of indicators are not routinely used for assessment and management purposes (Boldt *et al.*, 2006). However, recent advances in the development and application of ecosystem models which describe the interactions and dynamics of ecosystem components (Bundy *et al.*, 2007) are at a stage where they offer real potential as indicators of function.

The above general framework for the identification of indicators has recently been considered by an ad hoc meeting of independent experts on “indicators and associated data requirements to measure impacts of fisheries on the marine ecosystem” (Gerjan *et al.*, 2007). This group identified a number of indicators based upon current data availability and research requirements for a range of state and pressure ecosystem components; namely:

i. conservation status of vulnerable fishes according to IUCN (International Union for Conservation of Nature) decline criteria,
ii. abundance of vulnerable marine mammals, reptiles or seabirds,
iii. mean weight and mean maximum length of fish species,
iv. proportion of sensitive habitats impacted,
v. abundance of sensitive benthos species,
vi. age and size at maturation of exploited fish species,
vii. spatial and temporal distribution of fishing effort,
viii. catch and discard rates.

For each of these indicators the ad hoc group provided essential additional information on their application, further research and data collection requirements. However, WGEAFM considers that the inclusion of additional indicators are required to fully support an EAF, notably those which relate to, and provide the links between, environmental (e.g., SST, DIN, DIP, salinity, depth etc.), plankton (ocean colour, Chlorophyll-*a*, zooplankton and phytoplankton) and economic/social (value of landings by species) ecosystem components.

As an example, the application of the above indicator iii to Flemish Cap was presented (Vázquez and Piñeiro, 2008). The proportion biomass of larger fish over the total from survey results was calculated using 30, 35 and 40 centimetres as reference length. Results indicate a continuous decline in the last 20 years (Figure 19), but their complete interpretation is still uncertain. The decline in the proportion of large fish could be due to recruitment (i.e., increase in the proportion of young fish), to species replacement and/or to a reduction in the age/size at maturity.

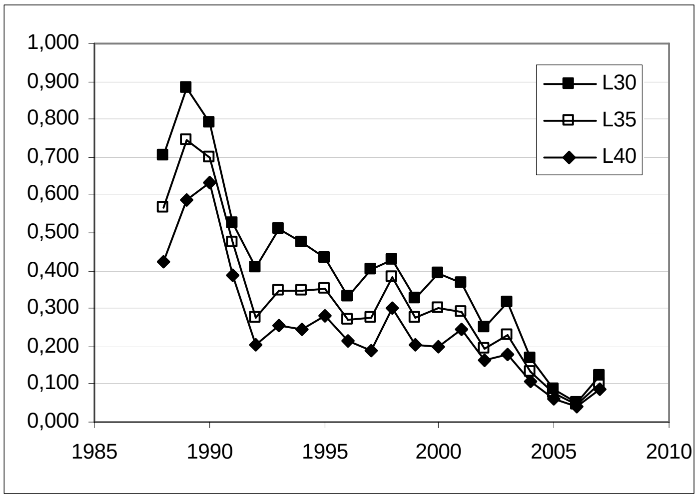

Figure 19 . Proportion of survey biomass for fish grater than 30, 35 and 40 cm: L30, L35 and L40 respectively.

Clearly not all assessment areas will support the same level of data availability, but where resources are limited, priority should be directed in obtaining information which represent the widest (fullest) range of ecosystem components (including fishing pressure, environmental, biological state changes, and the economic and social responses). WGEAFM also recognise that establishing indicators at an operational level in support of EAF will develop over time, with some indicators likely to increase in importance whilst others proving less useful, particularly as regional specific ecosystem dynamics (particularly the links between state and pressure changes) become better understood and predictable for the manageable pressures in the area.

Although the actual role and utility of indicators will evolve over time, it is important to understand that indicators (as well as marine protected areas, multispecies and ecosystem models, classical stock-assessment models, and many other elements) are expected to be just one component of an EAF strategy.

3.e – Identification of major questions that need to be addressed in each region and across NAFO at large.

No review was done on this issue. However, it is noted that data are needed on non-commercial species in the NAFO Area in order to better understand ecosystem functioning and the impact fisheries have. There are some major data gaps indicated above and member states should be encouraged to support efforts to fill these both within their EEZs and in the high seas.

3.f – Extant multispecies, MRM (extended SS), food web, aggregate, biophysical, and full ecosystem modelling efforts.

There is a significant amount of work currently on the go related to multispecies and ecosystem modelling worldwide. The WG did not have enough time to summarize these efforts or to explore their application to the NAFO area. A proper discussion of this ToR was postponed to the next WG meeting.

Nonetheless, it was noted that there are several recent publications that provide a good coverage of the state of the art on these issues. Plaganyi (2007) provides a recent and comprehensive review of models in support to EAF, and this synthesis has been used as starting point for discussing best practices in an ecosystem modelling context (FAO, in press). National management bodies of NAFO contracting parties (e.g. NMFS in US and DFO in Canada) have also recently held workshops to discuss multispecies and ecosystem models in a management context (DFO, 2008 and references within), and the ICES Working Group on Multispecies Assessment Methods also summarized some of the modelling work currently on the go in the NAFO region (ICES, 2007).

International efforts to obtain information on the meso and bathy-pelagic fish and invertebrates, including cephalopods, and associated benthic species have been undertaken by the Mid-Atlantic Ridge Ecosystems program (MAR-ECO), a Sloan Foundation-sponsored component of the Census of Marine Life (Sutton *et al*., 2008). A similar international project was initiated in 2007 in the Gully canyon on the Scotian Slope (Kenchington *et al*., 2007; Kenchington, 2007). These projects when completed will greatly increase our knowledge of pelagic/benthic linkages on seamounts and slopes and inform foodweb studies.

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ToR 4: Data needs and sampling recommendations.

Being oceanographic and bottom-trawl surveys the main providers of scientific information on the ecosystem in the area, data gaps as identified in response to ToR 2.b will be not cover without any additional or new research initiatives.

Concerns are expressed on the use of bottom-trawl surveys to get biological data from closed areas to bottom contacted fishing, e.g. on and around seamounts. The significant areas to protect are usually so small that a single bottom-trawl survey could be very detrimental. Some non-destructive techniques should be used. WGEAFM recommends that a project of any proposed survey or experimental fishing in closed areas be first revised by the NAFO SC.

ToR 5: To comment as necessary on the ICES/NAFO WG on Deep-water Ecology's report on its relation to the NAFO area.

NAFO became a co-sponsor of the ICES working group on Deep-water Ecology (WGDEC) in 2007 and provided Terms of Reference for WGDECs 2008 meeting in March. The report of the ICES-NAFO Joint Working Group on Deep-water Ecology (ICES 2008b) was presented by Dr. E. Kenchington, the NAFO representative on WGDEC. The Terms of Reference addressed by WGDEC were as follows:

The 2007 Statutory meeting of ICES gave the Working Group on Deep Water Ecology the following terms of reference:

a) provide a review of the effects of fishing in OSPAR Area V;

b) review the 'Guidelines for management of deep-sea fisheries on the high seas' that will be considered by FAO COFI in 2008 and consider for reflection by ICES and NAFO;

c) the types of advice that fisheries clients may request of ICES and NAFO, should the guidelines be implemented;

d) the types of information and terms of reference that WGDEC and any other relevant expert groups may need in order to respond to requests as identified in i);

e) if the information in ii) is not thought to be available currently, consider a plan of action to acquire and organise the necessary information;

f) continue to collate information on habitats (research and survey results) and fisheries use (VMS and fisher's information) on Hatton Bank in order to refine the advice for closed areas;

g) update compilations and maps of occurrence of structural habitats (hard and soft corals, large sponges) in the North Atlantic specifically identifying major coral concentrations in the Northwest Atlantic;

h) identify or confirm the existence of coral concentrations in a specific area of NAFO Div. 30, which roughly coincides with the zone between 400 and 2000 m deep (detailed map to be supplied by NAFO) and using the results of d), evaluate whether this zone is the most important for coral in the Northwest Atlantic;

i) examine patterns of fishing in deep-water areas other than Rockall and Hatton banks, such as the seamounts and continental slope, to determine where intensive fishing is occurring and evaluate the likelihood of sensitive habitats being present in those areas;

j) review codes of conduct for carrying out scientific research in sensitive deep-water habitats with a view to developing an ICES code of conduct;

k) Continue to develop and compile a database and map of areas where biological research/survey has occurred in the deep water area (>200m) of the North Atlantic and considering the report of the Planning Group on the North-east Atlantic continental slope survey (PGNEACS), make recommendations for future work in this area;

l) determine priority areas for multibeam or sidescan sonar survey on Rockall, Hatton Bank and adjacent seamounts;

m) consider suitable sized buffer zones around closed areas, taking into account ability to detect closed area infringements.

Many of these ToRs are of direct relevance to NAFO, even if they relate to advice outside of the NRA. For example, a request from the NEAFC to consider buffer zones around closed areas have broad applicability. In addressing ToR g, the WG compiled for the first time an Atlantic wide database of cold water corals that is contained in an ARGIS format so that additional layers can be used to address specific questions in specific areas. This database was used to address the issue of the placement of the coral closure in 3O and to highlight other areas where VMEs are likely to occur.

Some of the conclusions of the report relevant to the NAFO ToRs include:

- it would be precautionary to consider 20% of the seafloor above 2000 m in each of the seamount closures as available for exploratory activities rather than 20% of the entire area most of which is unfishable;

- for the largest area embraced by the 3O closure there is no information on the benthos and so there can be no verification that VMEs are being protected. In contrast the closure protects only a small percentage of known VMEs in the vicinity. The upper boundary should be moved 1) to be consistent with the depth contour covered across the area (800m) and 2) to include species living in shallower water (moving upper boundary to match shallower contour);
- four additional areas were identified along the NL continental margin which should be considered for protection. Two of these were previously identified in the Edinger *et al*. (2007) report and two other areas were proposed.

The known distribution of coral was used to support these conclusions and detailed maps are provided in the report. A further observation is the lack of benthic data from the Orphan Knoll and Newfoundland seamounts.

The full report is available online from:
http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGDEC

ToR 6: Review FC Working Paper 08/18 (Revision 2): Supplementary Request to Scientific Council

This response is focused in the NAFO Regulatory Area, as requested by the Fisheries Commission, but some areas inside adjacent EEZ are also cited because they are the natural extension of others outside already considered.

6.a – Identifying vulnerable species and habitat-forming species that are documented/considered sensitive and likely vulnerable to deep-sea fisheries.

This issue has been cover in the response to ToR 3.a: Criteria for identifying VME.

6.b – Identifying areas (mega-habitats) which are topographical, hydro-physical or geological features (including fragile geologic structures) known to support vulnerable species, communities, or habitats.

As outlined in the Draft FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO 2008b), certain geological and topographical features – such as seamounts and canyons – are known to support vulnerable species, communities or habitats and therefore qualify as VME. The distinct ecology of canyon and seamount ecosystems is documented through examples in Canada (Fenton *et al.*, 2002, Canessa *et al.*, 2003), the United States (e.g., Moore *et al.*, 2001), and elsewhere. Canada has established marine protected areas to conserve The Gully, a submarine canyon on the edge of the Scotian Shelf, and Bowie Seamount, off the west coast due to their distinct ecological values and sensitivity to human activities.

The most prominent mega-habitats in the NRA are the nose and tail of the Grand Bank and Flemish Cap and the continental slope associated with these features. In the context of VMEs, certain parts of the banks and slope will be more vulnerable than others. Many seamounts and several knolls occur beyond the continental shelf. This section focuses on describing some of the more discrete features identified within and beyond the shelf and slope areas that are known or likely to contain or support VMEs (Figure 20).

Canyons

Submarine canyons are defined as "steep-sided valleys cut into continental slopes" (http://www.britannica.com/eb/article-9070103/submarine-canyon). Canyon ecosystems can support diverse biological communities (Hecker *et al.*, 1980), including sensitive structure forming coldwater corals and deep-sea fishes (Gordon and Fenton, 2002; Rutherford and Breeze, 2002).

Fifteen canyons occur along the continental shelf edge in the NRA, with the highest density along the eastern edge of the southern Grand Bank (Figure 21). These include: Desbarres Canyon (inside Canadian EEZ), Treworgie Canyon (inside Canadian EEZ), Jukes Canyon, Whitbourne Canyon, Denys Canyon, unnamed canyon one, Cameron Canyon, Jackman Canyon, unnamed canyon two, Guy Canyon, Hoyles Canyon, unnamed canyon three, Kettle Canyon, unnamed canyon four, Clifford Smith Canyon, Lilly Canyon, and Carson Canyon (listed from west to east). For the purposes of this exercise, the 200 m isobath was used to delineate the upper limit of the canyons found in the NRA while the lower limit varied but generally was determined by the 2000 m isobath. Carson and Lilly Canyons extend into the Canadian EEZ.

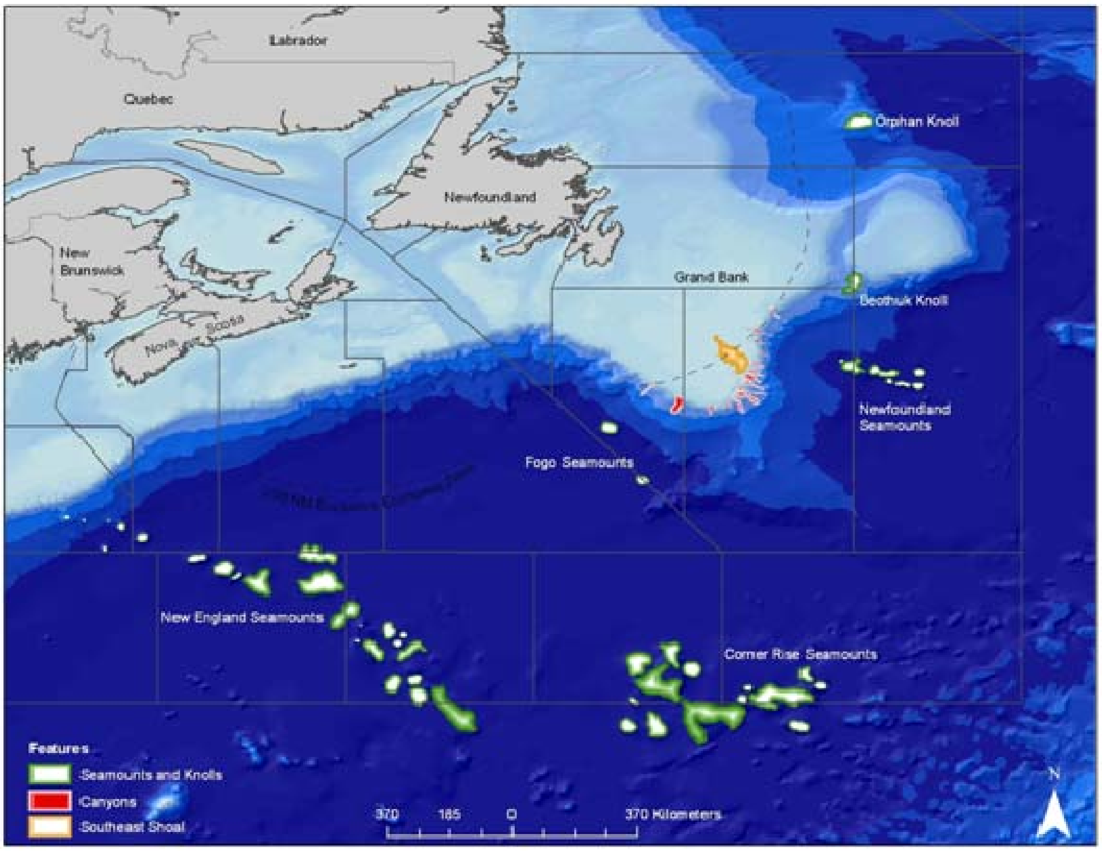

Figure 20: Map of topographical features in the NRA that are known or likely to support or contain VMEs.

The ecology of the canyons in the NRA is not well documented; however, extensive research on other canyons in the region (e.g., The Gully [Gordon and Fenton, 2002]) suggests that these features support vulnerable species and communities. It is therefore proposed that that the canyons of the NRA represent VMEs.

Seamounts and Knolls

A seamount is an elevation of the sea floor, 1000 m or higher, that is either flat-topped or peaked and occurs as discrete peaks or in a linear or random groupings (Neuendorf *et al.*, 2005). Seamount ecosystems are sensitive to anthropogenic disturbance because the fishes and invertebrates they are comprised of are mostly slow growing, long-lived, late to mature, and experience low natural mortality (Morato *et al.*, 2004; Stocks, 2004). Deep-sea fishes aggregate on seamounts and filter-feeding invertebrates – including corals and sponges – are often found attached to the hard substrates associated with these features (Clark *et al.*, 2006). Seamount species also display a relatively high degree of endemism. These characteristics indicate that seamounts are vulnerable to fishing pressure (Stocks, 2004).

Several distinct seamount chains can be found in the NRA along with a few isolated knolls, which are smaller, more rounded seamounts. The majority of these features are located in deep water well beyond the continental slope, with the prominent groupings including the New England Seamounts, the Corner Rise Seamounts, and the Newfoundland Seamounts. Other seamounts and knolls in the NRA include: the Fogo Seamounts, Orphan Knoll and Beothuk Knoll. Of the 43 seamounts identified in the NRA, only four were are at depths less than 1800m (Kulka *et al.*, 2007a).

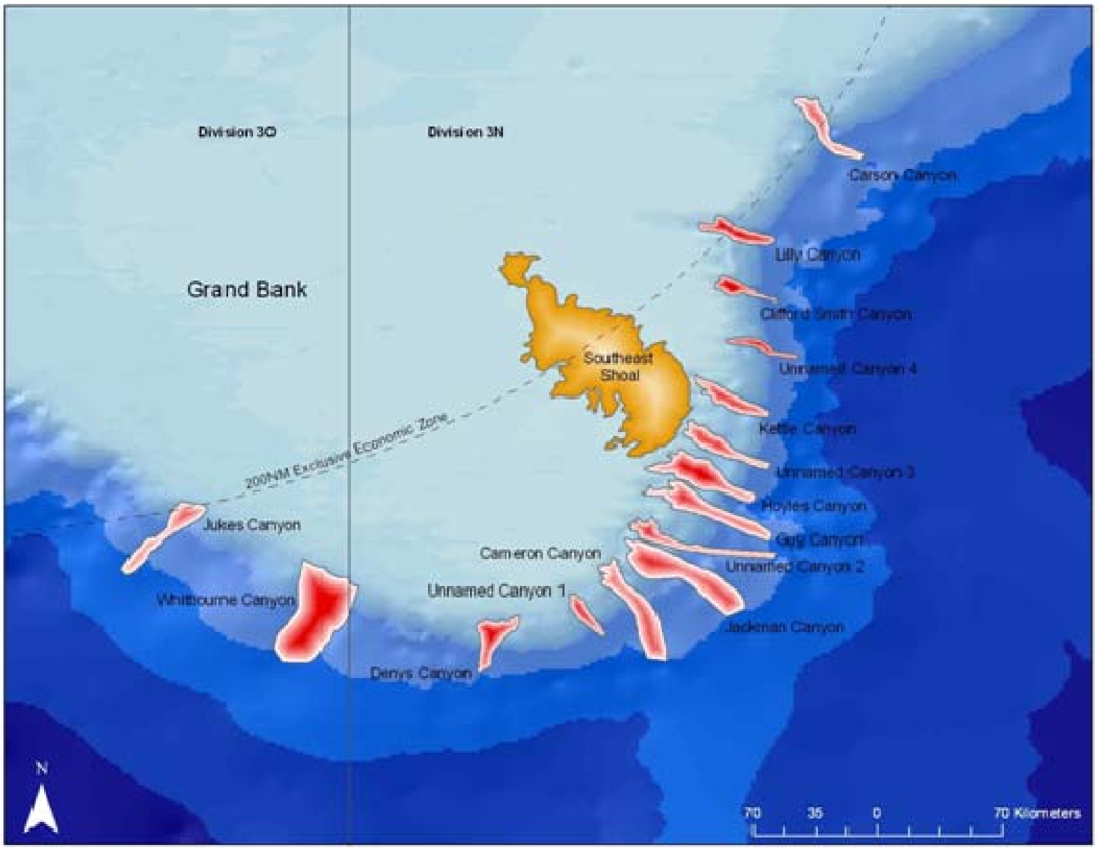

Figure 21: Distinct topographical features on the southern Grand Bank known or likely to support or contain VMEs.

Information on the ecology and species associated with the seamounts and knolls of the NRA is quite limited (Kulka *et al.*, 2007b) but several NAFO Contracting Parties have carried out research and fishing activities on a subset of these features. Vinnechenko (1997) described the deep-sea fishes encountered during periodic Soviet Union/Russian research and commercial activities on the Corner Rise Seamounts since the mid 1970s. The total fish removals between 1976 and 1995 exceeded 19000t, with alfonsino (*Beryx splendens*) being the most abundant species. The catch of alfonsino in 1976 alone was 10 000 t but dropped to less than 800 t the following year indicating that catches from the previous year were not sustainable. Several other fishes were taken in commercial quantities. Very little fishing took place on these seamounts over the following decade.

Duran *et al.* (2005) summarized the catches of deep-sea fish species in experimental one trawl survey on several of the New England and Corner Rise Seamounts in 2004. Alfonsino was the main species caught on the Corner Rise Seamounts during this survey (Duran *et al.*, 2005; Murillo *et al.*, 2008). This species appears to aggregate near certain seamounts in the NRA, making it vulnerable to exploitation, but they are relatively fast growing and not long-lived (10-15 years) and thus do not posses the biological traits typical of many other deep-sea species. Other fishes that were caught in significant amounts during the Spanish survey are slow growing and long-lived, which indicates they are vulnerable to overexploitation. Cardinal fish (*Epigonus telescopus*), for example, are considered highly vulnerable. (See: http://www.fishbase.org/Summary/SpeciesSummary.php?id=2508)

González-Costas and Lorenzo (2007) identified Kukenthal Peak and, more generally, the western portion of the Corner Rise as areas of high fish species diversity and abundance compared to other parts of the Corner Rise Seamounts based on catches collected between 2005 and 2007. The most abundant species encountered were alphonsino, black scabbardfish (*Aphanopus carbo*), and wreckfish (*Polyprion americanus*).

Kulka *et al.* (2007a) reviewed the available information on the occurrence of coldwater corals on seamounts in the NRA. Corals have been documented on the New England (Moore *et al.*, 2001) and Corner Rise Seamounts (Kulka *et al.*, 2007a; Waller *et al.*, 2007) but information on detailed distribution is lacking. Waller *et al.* (2007) explored five of the Corner Rise Seamounts using an ROV and documented pristine coral areas as well as "dramatic evidence of large-scale trawling damage" on the summits of Kukenthal peak and Yukutat Seamount. Murillo *et al.* (2008) described the occurrence structure forming corals and "extremely rough bottom" on two New England Seamounts based on the results of an experimental trawl survey during 2004. Less coral was encountered on the Corner Rise Seamounts (7% of sets contained coral). Large carbonate mounds have been identified through seismic research on Orphan Knoll (Enachescu, 2004).

Despite the lack of detailed survey information, there is evidence of the occurrence of coldwater corals and potentially vulnerable deep-sea fishes on the seamounts of the NRA. Given the presence of these ecosystem components, the seamounts and knolls of the NRA should be considered VMEs.

Southeast Shoal

Defined as the shallowest area on the southeastern Grand Banks, the Southeast Shoal is a candidate VME in the NRA, as identified by its "topographical features known to support vulnerable species, communities, or habitats".

The area's physical characteristics make it unique on the Grand Banks. It was the last area of the Grand Banks above sea level prior to the last glacial period, and as past beach habitat, it supports two possible relict bivalve populations, such as the wedge clam (*Mesoderma deauratum*) (Hutcheson and Steward, 1994). On the Grand Banks, the Southeast Shoal is also the only known offshore area for the spawning of 3NO capelin, a population that is at a low level and under moratorium. The area is important habitat for several other species under moratorium or at risk, including cod, American plaice, and striped wolffish.

Characteristics, such as capelin spawning beds, flatfish (yellowtail flounder and American plaice) nurseries, and occurrence of long-lived bivalve populations, are a consequence of the physical characteristics and related habitat. Maintaining the shallow, sandy habitat is important and one would not want to significantly alter the spawning and nursery areas. It is an area of high productivity and biodiversity, and is an important feeding area for several marine mammals, including humpback whales, as well as for various seabirds. It has been identified by Canada as part of an Ecologically and Biologically Significant Area (EBSA) on the southern Grand Bank.

Although the area is shallow and much of the bottom is comprised of sand, the SE Shoal would still qualify under several of the criteria suggested in the FAO Guidelines for VMEs.

Cold seeps, carbonate mounds and hydrothermal vents in the NRA

A cold seep is an area of the ocean floor where seepage of hydrocarbon-rich (mainly methane) fluid occurs. Such seeps can support endemic species often in the form of entire communities known as extremophiles. These species rely on sustainable matabolism based on a symbiotic relationship with chemoautotrophic bacteria rather than a dependency on light. Unlike hydrothermal vents which are volatile and ephemeral environments, cold seeps emit at a slow and dependable rate, are not high temperature features and are quite stable over time. Predominant species supported by seeps frequently comprise species of tubeworms and clams, many of which are much longer-lived than those inhabiting hydrothermal vents. Some species of tubeworm have a lifespan of between 170-250 years. Cold seeps can develop a unique topography over time, where reactions between methane and seawater create carbonate rock formations frequently referred to as carbonate mounds.

Hydrothermal vents are fissures which release geothermally heated water and are therefore often commonly found near volcanically active places such as areas where tectonic plates are moving apart and in ocean basins. Vents often support communities of extremophiles including tubeworms, clams and shrimps.

The deep-sea in the NRA has not been extensively mapped and information on seeps, carbonate mounds and hydrothermal vents is sparse. There is evidence of seeps and carbonate mounds in the north-eastern area of the Orphan Basin and on the Orphan Knoll (Enachescu, 2004), however, these areas have not been mapped and little is known about the composition of the benthic community present. One mound on the Orphan Knoll, the Einarsson submarine mound, is 1.5 – 2 km wide and around 100 to 200 m in height. This mound is just one element of a larger field of similar features located on the Orphan Knoll and at the north-eastern periphery of the adjacent Orphan Basin. A mixed organic-inorganic origin is proposed by Enachescu, which implies the existence of deep, cold-water marine organisms feeding from either hydrocarbon rich seeps or hydrothermal fluids arising through deep-seated faults. If the mounds support bioherms or colonies around hydrocarbon seeps or hydrothermal vents, it is argued that a Natural Protected Area (NPA) would need to be established.

From the information available to the WG, there appears to be no recorded evidence of other cold seeps and hydrothermal vents in the NRA. However, further mapping is required to confirm this.

6.c – This identification process should draw on relevant international information as may have been developed and as deemed appropriate for this work.

No comment required.

6.d – Mapping locations of vulnerable marine ecosystems, if any, as well bottom substrate features contained therein.

Candidate VME Delineation and Rationale

VMEs in the NRA are mapped according to available data. Some areas show extensions that overlap within the Canadian EEZ and are not under NAFO regulation (Figure 22). Furthermore, the identified VMEs correspond to the NRA and its vicinity (i.e. Grand Bank region *sensu lato*), and their delineation within the Canadian EEZ was made for the sake of representing ecologically coherent units.

1. Flemish Cap East

Rationale: Large gorgonians and high density of sponges (several survey hauls > 1000 kg)
Suggested Depth: 500-1500m
Information: Murillo *et al.* (2008) (EU bottom-trawl survey), WGDEC report (ICES, 2008b).
Comments: Between Flemish cap east and west, area generally unknown but slope steepness and topography suggest area where VME likely to occur. Relatively little fishing in this area. Possible extension to Beothuk Knoll area. High densities of black dogfish, in shallower water (DFO Survey 1995-2004).
Vulnerable Fish Species: black dogfish, smooth skate (DFO trawl survey 1995-2004)

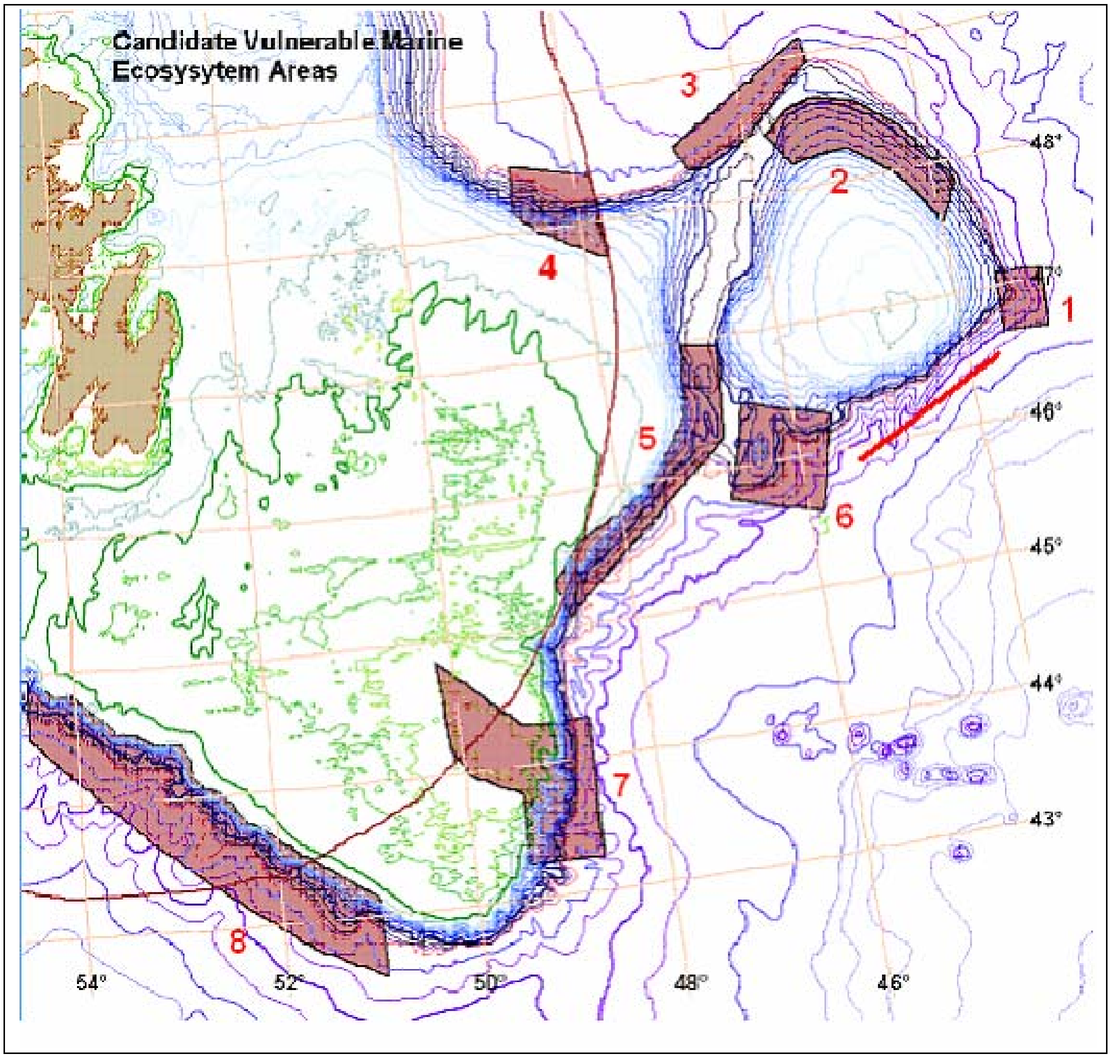

Figure 22. General areas of known Vulnerable Marine Ecosystems in the NAFO regulatory area with some overlap into the Canadian EEZ. Numbers correspond to the text above and the red line indicates an area where potential VMEs for deep-water coral were thought likely. 100, 500, 1000, 2000, 3000, and 4000 m depth contours are depicted as thick lines.

2. Northern Flemish Cap

Rationale: Area of high density of pennatulaceans, alcyonaceans and antipatharians and, to a lesser extent, solitary scleractinians and small gorgonians.
Suggested Depth: 500-1000m
Information: Murillo *et al.* (2008) (EU bottom-trawl survey), Canadian observers (1 trip), WGDEC report (ICES, 2008b).
Comments:
Vulnerable Fish Species: northern wolfish and spiny dogfish (DFO Trawl Survey Data 1995-2004)

3. Sackville Spur

Rationale: High density of sponges; several survey catches > 1000 kg / haul.
Suggested Depth: 1000-1500m
Information: DFO Trawl Survey Data 1995-2007, one record of high density in Murillo *et al.* (2008) (EU bottom-trawl survey), WGDEC report (ICES, 2008b).
Comments:

4. Northeast Shelf and Slope (Within Canadian EEZ)

Rationale: Abundance of gorgonian and antipatharian corals.
Suggested Depth: 500-1500m
Information: DFO Trawl Surveys (1995-2004), Canadian observer data, WGDEC report (ICES, 2008b), Murillo *et al.* (2008) (Spanish bottom-trawl survey).

Comments: Within the Canadian EEZ, not for consideration by the SC or FC at this time.
Associated Fish Species: (fish species analysis for areas within EEZ not included)

5. Southern Flemish Pass to Eastern Canyons

Rationale: Large gorgonians and large survey catches (> 1000 kg/haul) of sponges.
Suggested Depth: 500-1500m
Information: DFO Trawl survey data (1995-2007), Murillo *et al.* (2008) (Spanish bottom-trawl survey), WGDEC report (ICES, 2008b).
Comments: Included in Canadian EBSA (Ecologically and Biologically Significant Areas) identification,
Vulnerable Fish Species: striped wolfish, redfish, spiny tailed skate, northern wolfish, some black dogfish, deep sea cat shark (DFO trawl survey data 1995-2004)

6. Beothuk Knoll

Rationale: Abundant gorgonian corals; large survey catches (> 1000 kg/haul) of sponges.
Suggested Depth: 500-3000m
Information: (EU bottom-trawl survey), DFO trawl survey data, WGDEC report (ICES, 2008b).
Comments:
Vulnerable Fish Species: Northern wolfish, spiny tailed skate, roundnose grenadier, deep sea cat shark, black dogfish.

7. South East Shoal (a) and Adjacent Shelf Edge / Canyons (b)

Rationale: (a) Unique spawning grounds on SE Shoal, marine mammal feeding grounds, long-lived and relict bivalve populations in sandy shoal habitat,
(b) Deep water canyon connectivity, records of corals in canyons. Canyons are megahabitats as identified in the FAO Guidelines Annex 1.
Suggested Depth: The shoal is defined by the 55m isobath. Canyons extend up to 1500m
Information: DFO Trawl Survey 1995-2004, WGDEC report (ICES, 2008b).
Comments: Southeast shoal proposed as protect area by Walsh *et al.* (1995), Brodie (1996), Fuller and Myers (2004). Suggested to divide into two – shoal and canyon areas
Vulnerable Fish Species: spawning capelin (shoal), northern wolfish (canyon), redfish (canyon), striped and spotted wolfish (canyon), roundnose grenadier (canyon), black dogfish (canyon)

8. Division 3O Coral Closure Area

Rationale: Existing Coral Closure, based on coral concentrations, high bycatch of pennatulaceans and solitary scleractinian corals.
Suggested Depth: 200-1500m
Information: Murillo *et al.* (2008) (Spanish bottom-trawl survey), WGDEC report (ICES, 2008b).
Comments: WGDEC (ICES, 2008b) recommendation that the depth of the closure be decreased to 200m. Boundaries reflect that recommendation.
Vulnerable Fish Species: White hake and redfish, black dogfish, smooth skate, deep-sea catshark (DFO Trawl Survey Data 1995-2004).

9. Seamounts and other knolls (New England Seamounts, Corner Rise Seamounts, Newfoundland Seamounts, Fogo Seamounts, and Orphan Knoll)
Rationale: These topographical features constitute mega-habitats and are likely host of VMEs (FAO guidelines) habitats, which include corals, sponges and a range of vulnerable fish species, some of which are considered

to be endemic. Carbonate mounds are found on and around Orphan Knoll but little information is available on associated benthic fauna.
Suggested Depth: All seafloor above 2000m
Information: See Tor 6.d.
Vulnerable fish species: include alfonsino (not long-lived but an aggregating species on seamounts and therefore vulnerable to rapid depletion), orange roughy and silver roughy, wreckfish and cardinal fish.

3. Proposal for Time, Place and Agenda of the Next Meeting

It was proposed that the next meeting take place in the fourth quarter, possibly in late November, as this is a period that does not overlap with other meetings (ICES, NAFO etc.), so it will allow a more dedicated attendance. The Instituto de Investigaciones Marinas in Vigo, Spain, offered to hold the meeting. The next regular meeting of the WGEAFM was suggested for 2009. However this date, or the possibility of an *ad hoc* meeting in the interim time, will reviewed once the Scientific Council had met and dependent on matters arising on the VME agenda through the course of the year to meet the December 2008 UN timeline. The possibility of meeting by correspondence to address urgent or interim issues was also discussed and agreed upon.

Noting that most of the original ToR were not considered in detail, WGEAFM poposses that the agenda for the next meeting contains those ToR:

1: To identify regional ecosystems in the NAFO Convention Area.
2: To make an inventory of current knowledge on the components of each regional ecosystem.
3: To explore the feasibility of different tools (e.g. ecosystem indicators, modelling, etc.) that could be used in management advice in the NAFO area.
4: Data needs and sampling recommendations.

4. Proposal for New Chair

Mariano Koen-Alonso (Canada) and Andrew Kenny (UK-EU) were proposed co-chairs of the WGEAFM.

5. Adoption of Working Group Report

A 15 days deadline was given to identify gaps and make corrections to the report. The report was then approved.

The Chairman thanks the participants for their contribution and valuable work. The Chair thanked the NAFO Secretary for their valuable support. There being no other business, the meeting was adjourned.

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Annex 1. Fish species recorded in DFO research surveys and considered for the identification of VMEs

Common name	Scientific name
alligatorfish, northern	*Agonus decagonus*
lancetfish, shortnosed	*Alepisaurus brevirostis*
lancetfish,longnose	*Alepisaurus ferox*
smoothhead,Agassiz's	*Alepocephalus agassizii*
smoothhead,Baird's	*Alepocephalus bairdii*
alewife (gasperaux)	*Alosa pseudoharengus*
filefish, orange	*Alutera schoepfi*
skate,thorny	*Amblyraja radiata*
sand launce, offshore	*Ammodytes aubius*
wolffish,broadhead	*Anarhichas denticulatus*
wolffish, striped	*Anarhichas lupus*
wolffish, spotted	*Anarhichas minor*
ogrefish	*Anoplogaster cornuta*
daggertooth	*Anotopterus pharao*
hake, blue	*Antimora rostrata*
scabbardfish,black	*Aphanopus carbo*
shark,deepsea cat	*Apristurus profundorum*
cod, polar	*Arctogadus glacialis*
argentine, Atlantic	*Argentina silus*
argentine, striated	*Argentina striata*
hatchetfish, Atl. silver	*Argyropelecus aculeatus*
hookear sculpin (ns)	*Artediellus sp.*
hookear sculpin, Atl.	*Artediellus atlanticus*
hookear sculpin, Arctic	*Artediellus uncinatus*
alligatorfish, common	*Aspidophoroides monopterygius*
alligatorfish, Arctic	*Aspidophoroides olriki*
dragonfish, scaled (ns)	*Astronesthes ap.(richardsoni?)*
blacksmelt, goitre	*Bathylagus euryops*
blacksmelt (ncn)	*Bathylagus genedicti*
feelerfish, notch	*Bathypterois dubius*
skate, spinytail	*Bathyraja spinicauda*
herring, black	*Bathytroctes sp.*
frostfish	*Benthodesmus simonyi*
beardfish,Spinyfins	*Beryciformes (Order)*
cod, Arctic	*Boreogadus saida*
dragonfish, straightline	*Borostomias antarcticus*
menhaden, Atlantic	*Brevoortia tyrannus*
cusk	*Brosme brosme*
bluerunner	*Caranx crysos*
seasnail, longfin	*Careproctus longipinnis*
sea tadpole	*Careproctus ranulus*
seasnail (ncn) Car.Rei.	*Careproctus reinhardi*
manefish, Atlantic	*Caristius groenlandicus*
alfonsino (ncn) Cau.Lon.	*Caulolepis longidens*
dogfish,black	*Centroscyllium fabricii*
shark,Portuguese	*Centroscymnus coelolepis*
sea devils (ns)	*Ceratiidae*
deepsea sngler, big	*Ceratius holboelli*
lanternfish,horned	*Ceratoscopelus maderensis*
shark,basking	*Cetorhinus maximus*
viperfish	*Chauliodus sloani*
black swallower	*Chiasmodon niger*
grenadier, longnose	*Coelorhynchus carminatus*
grenadier, roundnose	*Coryphaenoides rupestris*
deepsea sculpin, Arctic	*Cottunculus microps*
deepsea sculpin, pallid	*Cottunculus thompsoni*
wrymouth	*Cryptacanthodes maculatus*
sea devil, warted	*Cryptosaras couesi*
lumpfish, Arctic	*Cyclopteropsis macalpini*
lumpfish, common	*Cyclopterus lumpus*
anglemouths (ns)	*Cyclothone sp.*
anglemouth,Veiled	*Cyclothone microdon*
anglemouth (ncn) Cyc.Sig	*Cyclothone signata*
batfish,Atlantic	*Dibranchus atlanticus*
spinyfin	*Diretmus argenteus*
dragonfish, smooth(ncn)	*Echiostoma sp.*
fourbeard rockling	*Enchelyopus cimbrius*
fourline snakeblenny	*Eumesogrammus praecisus*
lumpsucker, leatherfin	*Eumicrotremus derjugini*
lumpfish, spiny	*Eumicrotremus spinosus*
spiny lumpsucker	*Eumicrotremus spinosus variabilis*
lumpfish, Newfoundland	*Eumicrotremus terraenovae*
gulper, pelican	*Eurypharynx pelecanoides*
cod, Atlantic	*Gadus morhua*
cod,Greenland (rock)	*Gadus ogac*
threebeard rockling (ns)	*Gaidropsarus sp.*
threebeard rklg, silvery	*Gaidropsarus argentatus*
threebeard rockling	*Gaidropsarus ensis*
witch flounder	*Glyptocephalus cynoglossus*
lanternfish, Cocco's	*Gonichthys coccoi*
anglemouths (ns)	*Gonostoma sp.*
anglemouth, longtooth	*Gonostoma elongatum*
ocean pout, green	*Gymnelis viridis*
sculpin, Arctic staghorn	*Gymnocanthus tricuspis*
mora (ncn) Hal.Aff.	*Halargyreus affinis*
mora (ncn) Hal.Joh.	*Halargyreus johnsonii*
halosaurus (Ns)	*Halosauridae*
chimaera, longnose	*Harriotta raleighana*
blackbelly rosefish	*Helicolenus dacytlopterus*
sea raven	*Hemitripterus americanus*
footballfish, Atlantic	*Himantolophus groenlandicus*
American Plaice	*Hippoglossoides platessoides*
halibut (Atlantic)	*Hippoglossus hippoglossus*
blue angelfish	*Holacanthus bermudensis*

slimehead	*Hoplostethus sp.*
chimaera, deepwater	*Hydrolagus affinis*
halfbeak, common	*Hyporhamphus unifasciatus*
sculpin, twohorn	*Icelus bicornis*
sculpin, spatulate	*Icelus spatula*
sawtailfish, ribbon	*Idiacanthus fasciola*
mako, shortfin	*Isurus oxyrinchus*
porbeagle	*Lamna nasus*
lepidion (ncn)	*Lepidion (Haloporphyrus) eques*
cusk eel	*Lepophidium cervinum*
blenny (ncn) Lep.Mac.	*Leptoclinus maculatus*
yellowtail flounder	*Limanda ferruginea*
flounder, smooth	*Liopsetta putnami*
seasnail, Atlantic	*Liparis atlanticus*
seasnail, gelatinous	*Liparis fabricii*
seasnail, dusky	*Liparis gibbus*
seasnail, striped	*Liparis liparis*
seasnail, kelp(Greenland)	*Liparis tunicatus*
lipogenys	*Lipogenys gillii*
angler, common(monkfish)	*Lophius americanus*
eel blenny, slender	*Lumpenus fabricii*
snake blenny	*Lumpenus lumpretaeformis*
shanny	*Lumpenus maculatus*
wolf Eel (ns)	*Lycenchelys sp.*
wolf eel, northern	*Lycenchelys paxillus*
wolf eel, Sar's	*Lycenchelys sarsi*
wolf eel, Verrill's	*Lycenchelys verrilli*
eelpout (ncn) Lyc.Agn.	*Lycodes agnostus*
eelpout, Atlantic	*Lycodes atlanticus*
eelpout, Esmark's	*Lycodes esmarki*
eelpout (ncn) Lyc.Fri.	*Lycodes frigidus*
eelpout, Laval's	*Lycodes lavalaei*
eelpout, Arctic pale	*Lycodes pallidus*
eelpout, Arctic	*Lycodes reticulatus*
eelpout, seminude	*Lycodes seminudus*
eelpout, Newfoundland	*Lycodes terraenovae*
eelpout, Polar	*Lycodes turneri*
eelpout, Vahl's	*Lycodes vahlii*
eelpout (ncn) Lyc.Mir.	*Lycodonus mirabilis*
tapirfish, shortspine	*Macdonaldia rostrata*
grenadier (ncn) Mac.Aeq.	*Macrourus aequalis*
grenadier, roughhead	*Macrourus berglax*
grenadier (ncn) Mac.Hol.	*Macrourus holotrachys*
pout, ocean (common)	*Macrozoarces americanus*
grenadier, straptail	*Malacocephalus occidentalis*
skate,smooth	*Malacoraja senta*
loosejaw	*Malacosteus niger*
haddock	*Melanogrammus aeglefinus*
eelpout, soft	*Melanostigma atlanticum*
hake, offshore silver	*Merluccius albidus*
hake,silver	*Merluccius bilinearis*
tomcod	*Microgadus tomcod*
whiting, blue	*Micromesistius poutassou*
ocean sunfish	*Mola mola*
ling, blue	*Molva brykelange*
dogfish,smooth	*Mustelus canis*
grubby	*Myoxocephalus aeneus*
sculpin, longhorn	*Myoxocephalus octodecemspinosus*
sculpin, fourhorn	*Myoxocephalus quadricornis*
sculpin, Arctic	*Myoxocephalus scorpioides*
sculpin,shorthorn	*Myoxocephalus scorpius*
hagfish, Atlantic	*Myxine glutinosa*
argentine, large eyed	*Nansenia sroenlandica*
grenadier (ncn) Nem.Arm.	*Nematonurus armatus*
snipe eel, Atlantic	*Nemichthys scolopaceus*
duckbill eel	*Nessorhamphus ingolfianus*
grenadier (ns) Nez.Sp.	*Nezumia sp.*
marlin spike (common)	*Nezumia bairdi*
portuguese manowar fish	*Nomeus gronovii*
tapirfish, large scale	*Notacanthus nasus*
lancetfish, scaled	*Notolepis rissoi kroyeri*
lanternfish,Common (ns)	*Notoscopelus sp.*
lanternfish, Kroyer's	*Notoscopelus elongatus kroyeri*
barracudina, short	*Paralepis brevis (atlantica)*
barracudina, boreal	*Paralepis coregonoides borealis*
seasnail, blacksnout	*Paraliparis copei*
greeneye, longnose	*Parasudis truculentus*
lamprey, sea	*Petromyzon marinus*
gunnel, banded	*Pholis fasciata*
gunnel, rock	*Pholis gunnellus*
searsid, legless	*Platytroctes apus*
pollock	*Pollachius virens*
hatchetfish, silver (ncn)	*Polyipnus asteroides*
butterfish	*Poronotus (Peprilus) triacanthus*
flounder,winter	*Pseudoplueronectes americanus*
skate,abyssal	*Raja bathyphila*
skate,little	*Raja erinacea*
skate,deepwater (round)	*Raja fyllae*
skate,arctic	*Raja hyperborea*
skate,Jensen's	*Raja jenseni*
skate,barndoor	*Raja laevis*
skate,white	*Raja lintea*
skate,soft	*Raja mollis*
skate, winter (spotted)	*Raja ocellata*
Greenland halibut	*Reinhardtius hippoglossoides*
cardinalfish, Sherborn's	*Rhectogramma sherborni*
chimaera, knifenose	*Rhinochimaera atlantica*
salmon, Atlantic	*Salmo salar*

billfish	*Scomberesox saurus*
scopelosaurus (ns)	*Scopelosaurus sp.*
flounder, windowpane	*Scophthalmus (Lophopsetta) aquosus*
redfish,golden (marinus)	*Sebastes marinus*
redfish, deep water	*Sebastes mentella*
snipe eel, shortnose	*Serrivomer beani*
snipe eel (ncn)	*Serrivomer brevidentatus*
snubnose eel	*Simenchelys parasiticus*
shark,Greenland	*Somniosus microcephalus*
dogfish,Spiny	*Squalus acanthias*
hatchetfish, transparent	*Sternoptyx diaphana*
shanny, Arctic	*Stichaeus punctatus*
dragonfish, boa	*Stomias boa ferox*
lanternfish, largescale	*Symbolophorus veranyi*
longnose eel	*Synaphobranchus kaupi*
lizardfish, offshore	*Synodus poeyi*
grenadier, roughnose	*Trachyrhynchus murrayi*
mailed sculpins (ns)	*Triglops sp.*
sculpin, moustache	*Triglops murrayi*
mailed sculpin, Arctic	*Triglops nybelini*
mailed sculpin, northern	*Triglops pingeli*
shanny, radiated	*Ulvaria subbifurcata*
hake, longfin	*Urophycis chesteri*
hake,red (squirrel)	*Urophycis chuss*
hake, white (common)	*Urophycis tenuis*
Atlantic gymnast	*Xenodermichthys (Aleposomus) copei*
John Dory	*Zenopsis ocellata*

Annex 2 – Identification of Deep-water Corals

Subclass Ceriantipatharia: Tube-dwelling Anemones and Black Corals

The subclass Ceriantipatharia includes two orders which are superficially very distinctive. The order Ceriantharia includes the solitary tube-dwelling anemone-like forms with elongate bodies adapted for burrowing in soft bottoms. They can be large (over 40 cm) but most of the tube is below the sediment. Their large size and tendency to form dense aggregations, and occurrence on relatively featureless sandy or muddy bottoms, renders them key structure-forming species (Figure 1). The genus *Cerianthus* is common in the NAFO region.

Late juvenile redfish *Sebastes fasciatus*, (11-20 cm total length) have been associated with dense patches of cerianthid anemones *Cerianthus borealis* in the Gulf of Maine. The small fish may use the cerianthid habitats on an encounter basis or they may serve as a protective corridor for moving between boulder sites (Auster *et al*., 2003).

Although cerianthids can retract into their tubes, they are known to be damaged by bottom tending fishing gear (Bullimore, 1985; Langton and Robinson, 1990; Hall-Spencer *et al*., 1999). Removal of cerianthids may disrupt benthic assemblages as cerianthid predation of scallop and sabellid worm larvae has been hypothesized as an important factor in controlling their spatial distribution (Langton and Robinson, 1990). The strong negative association between predator and prey is broken down by dredging disturbance.

Little is known about the biology of the deep-water cerianthid species. The lifespan of one, *C. lloydii*, has been reported as 11 to 20 years (Manuel, 1988).

Figure 1. *Cerianthus borealis* from the Scotian slope (Photo courtesy of DFO).

The Order Antipatharia includes the Black Corals. These are upright attached colonial corals with polyps arranged around an axial skeleton of black horny material which projects sharp spines. Black coral are listed in Appendix II of the Convention on International Trade in Endangered Species (CITES). Eleven species of black coral from 4 families and 7 genera are included in the WGDEC coral data base (ICES, 2008a) from the northwest Atlantic (Table 1; Figure 2). They are all large, and although some are whip-like, most are branching and sometimes feathery, with some growing several meters high. *In situ* observations have been made along the Scotian and Grand Bank Slopes. Those observations are of single colonies and dense aggregations have not been observed.

Table 1. List of Antipatharian (Black) Corals in the WGDEC Database. These corals are known to occur in the NAFO Area.

Family	Species
Antipathidae	*Antipathes dichotoma*
Antipathidae	*Antipathes erinaceus*
Antipathidae	*Antipathes virgata*
Antipathidae	*Bathypathes patula*
Antipathidae	*Parantipathes hirondelle*
Antipathidae	*Stichopathes dissimilis*
Antipathidae	*Stichopathes flagellum*
Antipathidae	*Stichopathes richardi*
Leiopathidae	*Leiopathes grimaldi*
Myriopathidae	*Antipathella subpinnata*
Schizopathidae	*Stauropathes arctica*

Figure 2. A black coral colony growing on a cliff face on the Scotian slope on the southeastern edge of Banquereau Bank (area generally referred to as the Stone Fence; photo courtesy of DFO).

Black corals have low rates of growth, fecundity, recruitment, and mortality (Grigg, 1989) and can be very long-lived. The oldest recorded living marine invertebrate (4,000 years) is the antipatharian *Leiopathes glaberrima*, a conspecific of *L. grimaldi* found in the NAFO area (http://www.treehugger.com/files/2008/02/oldest_animal_u.php). In the Newfoundland Region, black corals were collected at average depths > 1000 m (Wareham and Edinger, 2007). Sherwood and Edinger (2008) determined radial growth rates of 65-31 µm.yr^{-1}, and vertical growth at 1.34 cm. yr^{-1}, respectively, for black corals collected from the Grand Bank. Based on these extremely slow growth rates recovery of deep-sea corals from fishing induced damage will likely take decades to centuries. This extreme longevity and apparent rarity (note that the preferred depth of these taxa below 1500 m is not well studied) qualify the black corals as vulnerable species.

Symbiotic polychaetes were documented on black corals from Indo-Pacific region (Molodtsova and Budaeva, 2007). On the Corner Rise Seamounts black bottle brush corals (*Parantipathes* sp.) from Lyman Seamount occurred often with *Chirostyliead* sp. (http://oceanexplorer.noaa.gov/explorations/05stepstones/logs/aug14/media/parantipathes.html). Similar *in situ* observations were made during 2007 ROPOS cruise on the Grand Bank where several deep-sea crabs were observed on a large black coral colony.

Subclass Hexacorallia: Stony Corals and Sea Anemones

The relationships within the higher-level groups within the anthozoan subclass Hexacorallia remain unresolved. Three of the six orders occur throughout the NAFO region: Actiniaria (sea anemones), Scleractinia (stony corals), Zoanthidea (zoanthids).

While all of these taxa are important components of benthic communities, the Scleractinia stand out as VMEs based on their lifehistory characteristics, ecological role and vulnerablilty to fishing disturbance. Scleractinian coral are listed in Appendix II of the Convention on International Trade in Endangered Species (CITES).

The stony corals are so named because they form a hard aragonite skeleton external to the polp. They may be solitary or colonial and some species are capable of forming extensive reefs. The major reef-building species in the NAFO area is *Lophelia pertusa* (Figure 3). It occurs along the continental slopes and banks (200 to 1000 m general depth range) of both Canada (as far north as the Laurentian Channel) and the United States (Hourigan *et al*., 2007) but expansive reef structures have not been identified in the NAFO area. A small reef, heavily damaged by the redfish fishery, was found on the Scotian Shelf on SE Banquereau and has been protected as a Coral Conservation Area by Canada.

Figure 3. *Lophelia pertusa* colony in the Gully Marine Protected Area on the Canadian continental slope (Photo courtesy of DFO).

Off Norway, extensive reefs spread over hundreds of kilometers with the living coral growing over the skeletons of previous generations (forming structures called bioherms) (Rogers, 1999; Friewald *et al*., 2004). To the south and west of Ireland several reefs have built mounds of 150 to 200 m height and about 1 km wide (ICES, 2008b). These reefs are home to large numbers of invertebrates and fish who have strong, although rarely obligate, associations with the structures.

In the Norwegian Sea, damage to deepwater coral reefs has been documented in the eastern shelf areas and has resulted in area closures for bottom trawling. It is estimated that 30 to 50% of the coral areas may be damaged or negatively impacted (Fosså *et al*., 2002; ICES, 2008b).

L. pertusa reefs are recognized as a threatened habitat by the OSPAR Commission for the protection of the marine environment in addition to its generic listing under CITES Appendix II.

Various species of solitary cup coral are found throughout the NAFO region. These may be attached as in species of *Desmophyllym* (Figure 4) or free living as in species of *Flabellum*. Cup corals are believed to have a low vulnerability to impacts by fishing gears, at least for those species such as *Flabellum* which live on soft sediments (FAO, 2008). However attached species are vulnerable to trawl and gillnet gears (Wareham and Edinger, 2007) and some of these species, e.g., *Desmophyllym* spp. are very slow growing (0.5-1.0 mm. yr^{-1}) and long-lived (> 200 years; Lazier *et al*., 1999; Risk *et al*., 2002).

Figure 4. The solitary cup coral *Desmophyllym* sp. Photographed in an aquarium after collection from ~1500m on the Scotian slope (Photo courtesy of DFO).

The large sessile sea anemones such as *Actinauge verelli* (Figure 5) are able to contract when contacted by fishing drags or dredges and appear to be undamaged (Freese *et al*., 1999), although other species do not recover from the disturbance within 5 years (Hall-Spencer and Moore, 2000). The common frilled anemone *Metridium senile*, can reach 30 cm in height and is typically gregarious, forming dense fields. Thus they can be considered habitat-forming. These taxa have not been considered as being highly vulnerable to bottom trawling, mainly because they are neither exceptionally long-lived nor rare. However, if they are attached to small cobbles they are vulnerable to capture by trawl gear and may not survive even if returned to the sea.

Subclass Octocorallia: Soft Corals

As in the Hexacorallia, the high order taxonomy of the Octocorallia is not fully resolved. Traditionally six families were recognized, and the European Registry of Marine Species (ERMS) maintains that classification scheme. However the International Taxonomic Information System (ITIS) combines the gorgonian corals with the alcyonaceans reducing the number of families to five. As the gorgonians are amongst the most vulnerable octocorals to fishing impact while the alcyonaceans are among the least, the ERMS system is adopted here, as was done for the recent NOAA publication from the US (Hourigan *et al*., 2007).

Figure 5. The sessile sea anemone *Actinauge verelli*. (Photo courtesy of DFO).

Alcyonaceans

Alcyonaceans are found over most of the NAFO area and are particularly abundant on the banks. They are frequently caught in trawl gear and can survive repeated disturbances (Henry *et al*., 2003), although direct removals as bycatch can quickly depopulate an area (Prena *et al*., 1999). They are not considered VMEs, although they are important ecosystem components. Moreover, Syms and Jones (2001) demonstrated that removal of high densities of soft corals caused no significant changes in the associated fish communities and that the heterogeneity of habitat generated by soft corals was indistinguishable from equivalent habitat formed by rock alone.

Gorgonian corals

Gorgonian corals, or sea fans, meet all of the criteria of VMEs. They are long-lived, slow-growing, have episodic recruitment and are highly vulnerable to fishing gear (cf. Hourigan *et al*., 2007).

Sherwood and Edinger (2008) aged several species of gorgonians (i.e., *Keratoisis ornata*, *Primnoa resedaeformis*, *Paramuricea* sp., *Acanella arbuscula*, and *Paragorgia arborea*) which ranged in age from a few decades up to 200 years for a subfossil colony of *K. ornata*. *Paragorgia arborea* grew at the fastest radial growth rate of 800 µm. yr^{-1}. Based on known slow growth rates recovery of gorgonian corals from fishing induced damage will likely take centuries.

Gorgonians come in a range of sizes from small arborescent forms less than 20 cm (e.g., species of *Acanella*) to large branching "trees" over 3 metres in height (Figure 6). All are colonial and attached but some such as *Acanella* spp. "root" themselves in soft sediment, while others cement to hard substratum.

Marine megafauna over 5 cm in height have been considered as structure-forming and can have a strong influence on biodiversity (Tissot *et al*., 2006), and species greater than 1 m in height can profoundly affect benthic community structure (Lissner and Benech, 1993 in Tissot *et al*., 2006). However, factors such as complexity of morphology and population density, in addition to size determine whether a species can be considered habitat-forming (Tissot *et al*., 2006).

The arboreal-like structure of gorgonians provide unique habitat for both commercial (e.g., Orange roughy) and non-commercial species. Other species such as Squaliformis use gorgonians as potential nurseries as documented in the Gulf of Mexico by Etnoyer and Warrenchuk (2007), as well as observed on samples from the NW Atlantic.

The ICES/NAFO Working group on Deep-water Ecology (WGDEC) following Hourigan *et al*. (2007) and Tissot *et al*. (2006) considers the genera listed in Table 2 to be structure-forming taxa which underpin VMEs based on their presence.

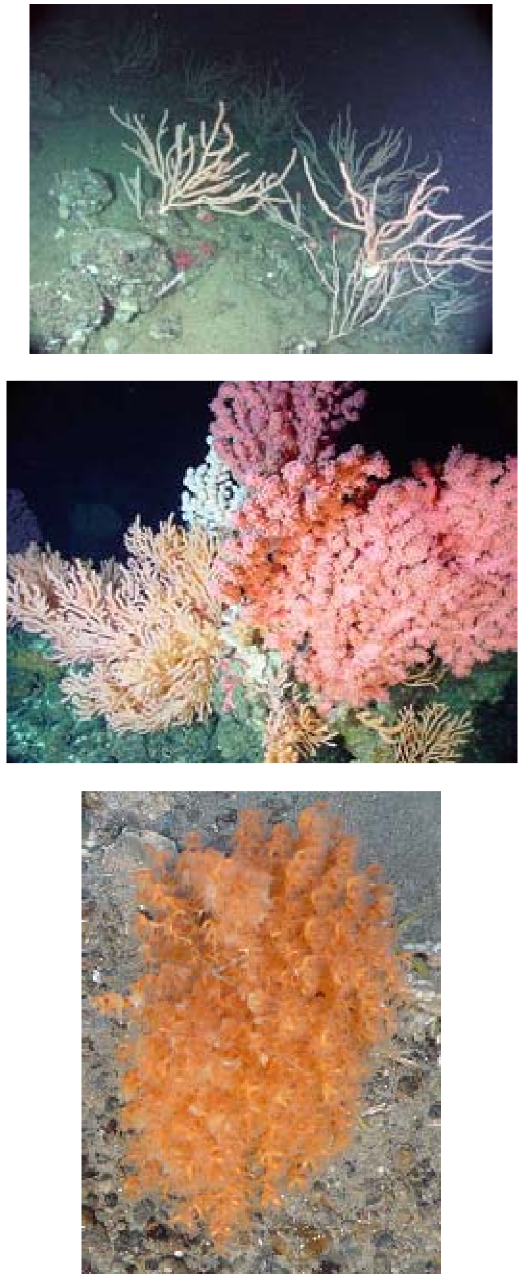

Figure 6. Examples of gorgonian corals considered as vulnerable species which form VMEs. Top: Bamboo coral *Keratoisis* sp.; Middle: *Primnoa* sp. (left) and *Paragorgia arborea* (right); Bottom: the smaller gorgonian *Acanella* sp. (Photos courtesy of DFO).

Table 2. Examples of gorgonian corals known to occur in the NAFO management area (Divisions 1 to 6). This list is for species included in the WGDEC database (ICES, 2008a) and recorded in the Spanish/EU surveys (Murillo *et al*., 2008a; Murillo *et al*., 2008b). Maximum size and propensity for aggregation are indicated for each genus where readily available.

Taxon	Suborder	Family	Size	Gregarious
Acanella arbuscula	Calcaxonia	Isididae	15 cm	yes
Acanella normani	Calcaxonia	Isididae		
Acanella eburnea	Calcaxonia	Isididae		
Callogorgia verticillata	Calcaxonia	Primnoidae	?	?
Candidella imbricata	Calcaxonia	Primnoidae	?	?
Isidella longifera	Calcaxonia	Isididae	?	?
Keratoisis grandis	Calcaxonia	Isididae	130 cm	yes
Keratoisis ornata	Calcaxonia	Isididae		
Keratoisis palmae	Calcaxonia	Isididae		
Lepidisis sp.	Calcaxonia	Isididae		
Narella bellissima	Calcaxonia	Primnoidae	?	?
Narella versluysi	Calcaxonia	Primnoidae		
Nicella granifera	Calcaxonia	Ellisellidae	?	?
Primnoa resedaeformis	Calcaxonia	Primnoidae	100 cm	yes
Thouarella grasshoffi	Calcaxonia	Primnoidae		?
Thouarella hilgendorfi	Calcaxonia	Primnoidae	70 cm	?
Thouarella variabilis	Calcaxonia	Primnoidae		
Calyptrophora josephinae	Calcaxonia	Primnoidae		
Acanthogorgia armata	Holaxonia	Acanthogorgiidae	20-50 cm	?
Acanthogorgia hirsuta	Holaxonia	Acanthogorgiidae		
Acanthogorgia truncata	Holaxonia	Acanthogorgiidae		
Bebryce mollis	Holaxonia	Plexauridae	?	?
Chelidonisis aurantiaca	Holaxonia	Isididae	?	?
Chrysogorgia agassizii	Holaxonia	Chrysogorgiidae	20 cm	?
Eunicella dubia	Holaxonia	Gorgoniidae	?	?
Iridogorgia sp.	Holaxonia	Chrysogorgiidae	?	?
Muriceides furcata	Holaxonia	Plexauridae	20 cm	?
Muriceides lepida	Holaxonia	Plexauridae		
Muriceides paucituberculata	Holaxonia	Plexauridae		
Paramuricea biscaya	Holaxonia	Plexauridae	50 cm	no
Paramuricea candida	Holaxonia	Plexauridae		
Paramuricea grandis	Holaxonia	Plexauridae		
Paramuricea placomus	Holaxonia	Plexauridae		
Placogorgia intermedia	Holaxonia	Plexauridae	10 cm	yes
Placogorgia massiliensis	Holaxonia	Plexauridae		
Placogorgia terceira	Holaxonia	Plexauridae		
Radicipes gracilis	Holaxonia	Chrysogorgiidae	50 cm	yes
Swiftia pallida	Holaxonia	Plexauridae	< 20cm	yes
Villogorgia bebrycoides	Holaxonia	Plexauridae	?	?
Metallogorgia melanotrichos	Holaxonia	Chrysogorgiidae	45+ cm	?
Anthothela grandiflora	Scleraxonia	Anthothelidae		
Corallium johnsoni	Scleraxonia	Coralliidae	20-50 cm	?
Corallium niobe	Scleraxonia	Coralliidae		
Paragorgia arborea	Scleraxonia	Paragorgiidae	300+ cm	yes
Paragorgia johnsoni	Scleraxonia	Paragorgiidae		
Titanideum obscurum	Scleraxonia	Anthothelidae	70 cm	?

Sea pens

Sea pens belong to the order Pennatulacea. Unlike other octocorals, a sea pen's polyps are specialized to specific functions: a single polyp develops into a rigid, erect stalk (the rachis) and loses its tentacles, forming a bulbous "root" or peduncle at its base which anchors it in the soft sediments of the sea floor (Williams, 1995). The stalks can be over 1.5 metres long with larger species reaching up to 50 yrs (Wilson *et al*., 2002). Usually sea pens stay in one spot but they are able to uproot themselves and relocate. Some can also forcibly expel water out of themselves propelling deep into the sediments (e.g., *Protoptilum carpenteri*). Consequently, they are not as vulnerable as gorgonian corals to damage by trawl gear. However, sea pen bycatch is an issue and the extensive aggregations formed by some species (Figure 7), known as sea pen fields, are recognized as ecological and biologically significant habitats (DFO, 2005). Aggregations of sea pens may provide important structure in low-relief sand and mud habitats where there is little physical habitat complexity. Also, these organisms may provide refuge for small planktonic and benthic invertebrates, which in turn may be preyed upon by fishes. They also may alter water current flow, thereby retaining nutrients and entraining plankton near the sediment (Tissot et. al, 2006).

Sea pens are recognized as important habitat for both fish and invertebrates (DFO, 2005) and belong to the Initial OSPAR List of Threatened and/or Declining Species and Habitats. A list of species occurring in the NAFO area and for which positional data are available is provided in Table 3.

Table 3. Examples of sea pens known to occur in the NAFO management area (Divisions 1 to 6). This list is for species included in the WGDEC database (ICES, 2008a) and those identified subsequently from 2007 surveys in the Newfoundland region (V. Wareham pers. comm.).

TAXON	Suborder	Family
Funiculina quadrangularis	Sessiliflorae	Funiculinidae
Kophobelemnon stelliferum	Sessiliflorae	Kophobelemnidae
Kophobellemnon macrospinosum	Sessiliflorae	Kophobelemnidae
Distichoptilum gracile	Sessiliflorae	Protoptilidae
Protoptilum sp.	Sessiliflorae	Protoptilidae
Protoptilum carpenteri	Sessiliflorae	Protoptilidae
Scleroptilum grandiflorum	Sessiliflorae	Sleroptilidae
Umbellula durissima	Sessiliflorae	Umbellulidae
Umbellula encrinus	Sessiliflorae	Umbellulidae
Umbellula lindahli	Sessiliflorae	Umbellulidae
Umbellula thompsoni	Sessiliflorae	Umbellulidae
Anthoptilum grandiflorum	Subselliflorae	Anthoptilidae
Anthoptilum murrayi	Subselliflorae	Anthoptilidae
Halipteris spp.	Subselliflorae	Halipteridae
Halipteris finmarchia	Subselliflorae	Halipteridae
Pennatula aculeata	Subselliflorae	Pennatulidae
Pennatula borealis	Subselliflorae	Pennatulidae
Pennatula phosphorea	Subselliflorae	Pennatulidae
Crassophyllum spp.	Subsessiliflorae	Pennatulidae

Figure 7. A sea pen field on the southwest Grand Banks. (Photo courtesy of DFO).

Location of Coral VMEs

The report of WGDEC adequately identifies the general location of coral VMEs in the NAFO region. Further information on their distribution and suggestion of additional VME locations based on the Spanish and Russian contributions is presented as maps in other sections of this report.

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Appendix 1. Agenda

1. Opening - Introductions, meeting arrangements (Chair – A. Vázquez)

   1.1 – Appointment of rapporteur
   1.2 – Adoption of agenda
   1.3 – Plans to implement EA in NAFO
   1.4 – Available documentation
   1.5 – Plan of work

2. Terms of Reference

   2.1 – To identify regional ecosystems in the NAFO Convention Area.
   2.2 – To make an inventory of current knowledge on the components of each regional ecosystem (i.e. physical oceanography, primary production, zooplankton and secondary production, benthos and large invertebrates, fish and fish assemblages, seabirds, marine mammals, turtles, and fisheries).
      2.2.a – extant data sets
      2.2.b – known data gaps
      2.2.c – spatial and temporal coverage of data
      2.2.d – documentation
      2.2.e – the management context (national, regional, and international) in terms of systems and governance)
      2.2.f – a list of all targeted species, management plans thereof, and associated issues (e.g. bycatch, gear disturbance, etc.)
   2.3 – To explore the feasibility of different tools (e.g. ecosystem indicators, modelling, etc.) that could be used in management advice in the NAFO area.
      2.3.a – Criteria for the identification of VME (Vulnerable Marine Ecosystems).
      2.3.b – Adverse impacts of bottom fishing activities on VMS.
      2.3.c – Methods for the longer term monitoring of the health of VME.
      2.3.d – Ecosystem indicators, or how to translate model outputs and empirical indicators into management advice.
      2.3.e – Identification of major questions that need to be addressed in each region and across NAFO at large.
      2.3.f – extant multispecies, MRM (extended SS), food web, aggregate, biophysical, and full ecosystem modelling efforts.
   2.4 – Data needs and sampling recommendations.
   2.5 – To comment on necessary on the ICES/NAFO WG on Deep-water Ecology's report on its relation to the NAFO area.
   2.6 – Review FC Document 08-2, Serial No. N5493: Supplementary Request to Scientific Council (attached)

3. Proposal for time, place and agenda of the next meeting.

4. Proposal for new Chair.

5. Adoption of Working Group Report.

NOTES

Item 2.3 has been implemented taking into account item 10 of the Fisheries Commission request for advice 2008, which says:

a) Develop initial methodologies for the identification of VME and assessment of individual fishing activities, drawing on relevant international information and objective standards and guidelines as may have been developed, as deemed appropriate for this work;

b) Assess, at least on a preliminary basis, using the best available scientific information and assessment methodology, whether individual bottom fishing activities would have significant adverse impacts on identified vulnerable marine ecosystems, with a view to reporting these findings to the Fisheries Commission and ensuring that additional conservation and management measures, where required, are recommended, through a Working Group of Fishery Managers and Scientists on Ecosystems Management, to the Fisheries Commission at its September 2008 meeting.

c) Develop appropriate scientific methods for the longer term monitoring of the health of VME.

Annex 1. Supplementary Request to Scientific Council (FC Doc. 08/02, Serial No. N5493)

At the 2007 Annual Meeting, Fisheries Commission requested Scientific Council advice as follows:

10. Recognizing the initiatives on vulnerable marine ecosystems (VME) Fisheries Commission requests the Scientific Council to:

a) Develop initial methodologies for the identification of VME and assessment of individual fishing activities, drawing on relevant international information and objective standards and guidelines as may have been developed, as deemed appropriate for this work;

b) Assess, at least on a preliminary basis, using the best available scientific information and assessment methodology, whether individual bottom fishing activities would have significant adverse impacts on identified vulnerable marine ecosystems, with a view to reporting these findings to the Fisheries Commission and ensuring that additional conservation and management measures, where required, are recommended, through a Working Group of Fishery Managers and Scientists on Ecosystems Management, to the Fisheries Commission at its September 2008 meeting;

c) Develop appropriate scientific methods for the longer term monitoring of the health of VME.

Fisheries Commission further requests the Scientific Council to provide supplementary advice with respect to commitments related to UNGA Resolution 61/105 by:

For the NAFO Regulatory Area and using existing information:

1. Identifying vulnerable species and habitat-forming species that are documented/considered sensitive and likely vulnerable to deep-sea fisheries.
2. Identifying areas (mega-habitats) which are topographical, hydro-physical or geological features (including fragile geologic structures) known to support vulnerable species, communities, or habitats.
3. This identification process should draw on relevant international information as may have been developed and as deemed appropriate for this work.
4. Mapping locations of vulnerable marine ecosystems, if any, as well bottom substrate features contained therein.

Additionally, the following VME Data Collection Protocol is referred to Scientific Council for review and advice.

Completion of this work is requested by September 2008 to facilitate a meeting of the Working Group of Fishery Managers and Scientists on Vulnerable Marine Ecosystems.

Vulnerable Marine Ecosystem (VME) Data Collection Protocol

1.0 Observers on fishing vessels in the NAFO Regulatory Area who are deployed pursuant to Chapter III, Article 24 shall:

i. Monitor any set for evidence of VME and the presence of vulnerable marine species.
ii. For VME generally, record Species Code, Trip#, Set#, Vessel Name, Gear Type, Latitude/Longitude, Depth, Date and Name of Observer on datasheets, if possible,

- Live animals should be measured and released, dead animals measured and sexed
- Samples may be collected and frozen (eg: gonads from dead specimens), when requested by Scientific Council or the scientific authority in a Contracting Party

iii. For deep-sea coral species, also collect as many samples as practicable for use in confirmation of species identification, genetic and geochemistry composition:

- Collect a small (~5 cm) piece of each coral species and freeze in plastic bag, with a pre-printed waterproof label indicating Species Code, Trip#, Set#, Vessel Name, Gear Type, Latitude/Longitude, Depth, Date and Name of Observer.
- For species with large skeletons (Primnoa, Paragorgia, Paramuricea, Bathypathes), collect as large a piece of the coral as possible, label with total weight and sub-sample weight, and freeze.

iv. Samples should be provided to the scientific authority in a Contracting Party at the end of the fishing trip.

Observer and masters should refer to the NAFO Coral Species Identification Guide and other material provided by Scientific Council.

Appendix II. List of Participants

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Acronyms

EAF – Ecosystem Approach for Fisheries Management
MPA – Marine Protected Area
NRA – NAFO Regulatory Area
NCA – NAFO Convention Area
ToR – Terms of Reference
UNGA – United Nations General Assembly
VME – Vulnerable Marine Ecosystem
VMS – Vessel Monitoring System