Northwest Atlantic Fisheries Organization

Serial No. N5592 **NAFO SCS Doc. 08/24**

SCIENTIFIC COUNCIL MEETING – OCTOBER 2008

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

Response to Fisheries Commission Request 9.a

CONTENTS

INTRODUCTION

The Working Group on the Ecosystem Approach to Fisheries Management (WGEAFM) met by correspondence to provide background information to Scientific Council regarding the Fisheries Commission request for advice on the distribution of corals within the NRA (see "Request" below). WGEAFM agreed to provide the information requested in 9a by 24 October 2008. Information requested for June 30, 2009 will be provided by May 31, 2009.

FISHERIES COMMISSION REQUEST

(NAFO, 2008b)

9. Recognizing the initiatives on vulnerable marine ecosystems (VME), and with a view to completing fishery impact assessments at the earliest possible date, Fisheries Commission requests the Scientific Council to:

a) Provide, as soon as possible in 2008, delineations, if any, of significant concentrations of corals in the NAFO Regulatory Area, by species, for the identification of VMEs. This should include the size and catch characteristics of corals obtained respectively from commercial fishing vessels and fisheries research vessels and the assessment of significant adverse impacts, with a particular focus on those species which involve interactions with commercial fisheries. The data should include absence/presence of corals as well as density.

b) Provide, by June 30, 2009, delineations, if any, of significant concentrations of sponges in the Regulatory Area by species, including the size and catch characteristics of sponges obtained respectively from commercial fishing vessels and fisheries research vessels, with a particular focus on those species which involve interactions with commercial fisheries. The data should include absence/presence of sponges as well as density.

c) With respect to corals and sponges in canyons denoted in the Scientific Council's response on the area denoted as "Southern Flemish Pass to Eastern Canyons", provide detailed information as soon as practicable or at least a report on progress by June 30, 2009, with a particular focus on those species which involve interactions with commercial fisheries.

BACKGROUND

The WGEAFM was asked to map locations of vulnerable marine ecosystems as part of its ToRs for its May 2008 meeting (NAFO, 2008a). The WGEAFM produced a map delineating candidate VMEs based on known and potential occurrence of vulnerable species, including corals, sponges and fish (Figure 1). Eight areas were delineated, although one (Area 8) has already been given protection by Canada and NAFO, and another (Area 4) lies entirely within the Canadian EEZ. Of the remaining six areas, Area 7 was selected for its proximity to the Southeast Shoal and presence of canyon features, and Areas 1 and 3 were selected for high records of sponge bycatch (>1000 kg). In Area 1, important coral catch was also recorded. Four areas were chosen primarily on the basis of known or suspected presence of significant coral habitat (Areas 1, 2, 5, 6). The description of these four areas as provided in the WGEAFM report (NAFO, 2008a) is as follows:

Area 1. Flemish Cap East

Rationale: Large gorgonians and high density of sponges (several survey hauls >1000 kg)

Suggested Depth: 500-1500 m

Information: Murillo *et al.* (2008a) (EU bottom-trawl survey), WGDEC report (ICES, 2008).

Area 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: 500-1000 m

Information: Murillo *et al.* (2008a) (EU bottom-trawl survey), Canadian observers (1 trip), WGDEC report (ICES, 2008).

Area 5. Southern Flemish Pass to Eastern Canyons

Rationale: Large gorgonians and large survey catches (>1000 kg/haul) of sponges.

Suggested Depth: 500-1500 m

Information: DFO Trawl survey data (1995-2007), Murillo *et al.* (2008a) (Spanish bottom-trawl survey), WGDEC report (ICES, 2008).

Area 6. Beothuk Knoll

Rationale: Abundant gorgonian corals; large survey catches (>1000 kg/haul) of sponges.

Suggested Depth: 500-3000 m

Information: (EU bottom-trawl survey), DFO trawl survey data, WGDEC report (ICES, 2008).

WGEAFM (NAFO, 2008a) also identified areas (mega-habitats) which are topographical, hydro-physical or geological features (including fragile geologic structures) known to support vulnerable species, communities, or habitats**.**

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 2). 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 (NAFO, 2008a).

The WGEAFM also noted other seamounts and knolls in the NRA which have not been protected by NAFO: the Fogo Seamounts and Beothuk Knoll. Physical characteristics of these areas are noted in Kulka *et al.* (2007). Data on corals from the Corner Rise and New England seamounts, currently protected by NAFO, were provided to the WGEAFM by the Instituto Español de Oceanografia (IEO) (Murillo *et al.*, 2008b).

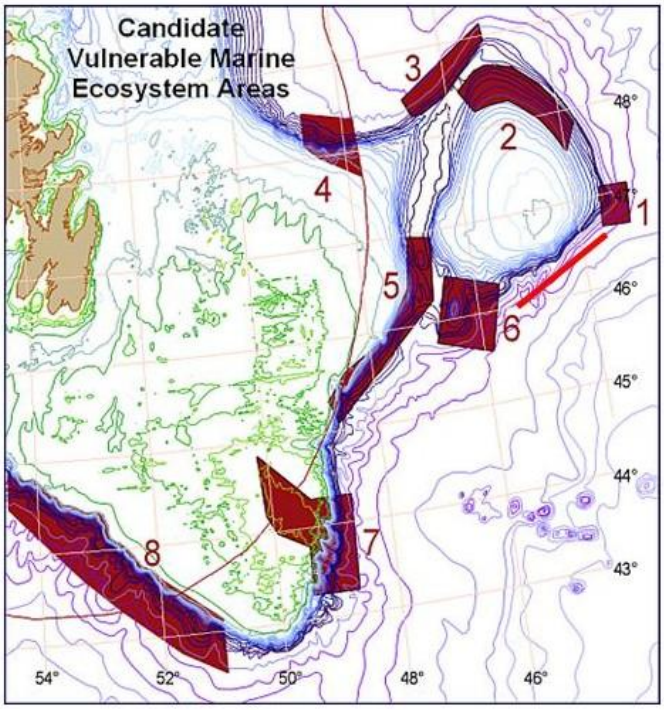


Figure 1. Location of the candidate Vulnerable Marine Ecosystems Areas in the NAFO regulatory area with some overlap into the Canadian EEZ. Numbers correspond to the text above and the red line indicates an area where potential VMEs for deep-water coral were thought likely. 100, 500, 1000, 2000, 3000, and 4000 m depth contours are depicted as thick lines (From WGEAFM report, NAFO, 2008a).

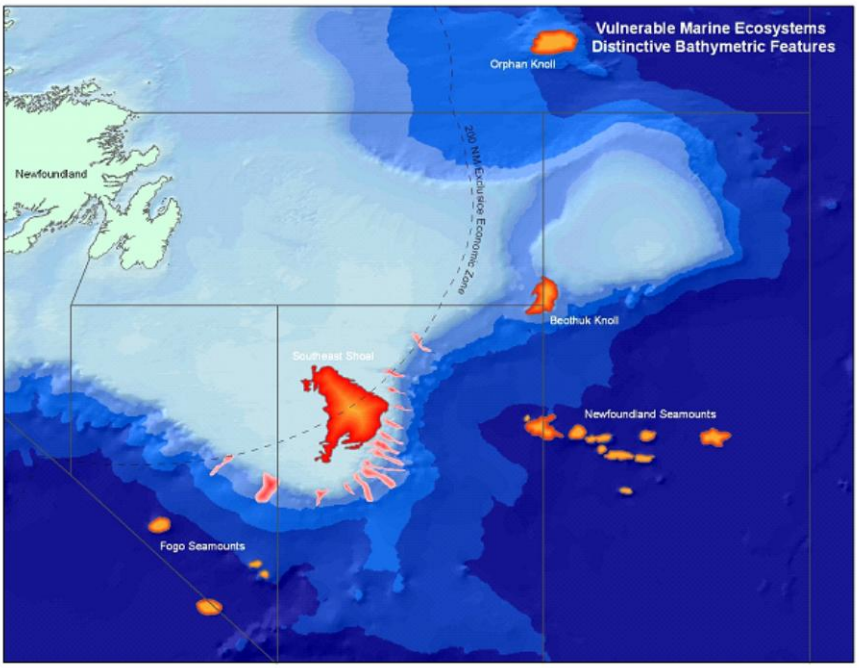


Figure 2. Map of topographical features in the northern portion of the NRA that are known or likely to support or contain VMEs.

APPROACH TO ADDRESSING ITEM 9A

The WGEAFM stands by its previous delineation of candidate VME areas but understands that this request asks for the identification of *key locations* within the candidate areas where known concentrations of corals (and later sponges) exist. We will use here the term *key location* in reference to specific sites were significant coral concentrations have been found. Ecologically functional VMEs necessarily need to be larger than these *key locations*; the actual boundaries of true VMEs are expected to lie somewhere in between the candidate areas initially proposed by WGEAFM and the *key locations* where VME-defining species are known to occur in higher concentrations. However, the WGEAFM recognized that without a properly planned habitat mapping exercise based on wide-area acoustic surveys (e.g. multibeam surveys) with adequate visual ground-truthing (Durán Muñoz *et al.* 2008a), it is impossible to precisely delineate VME areas on the NRA as has been done for other areas such as Hatton Bank. Nevertheless, analyses of the available catch data, particularly from groundfish surveys (Research Vessel-RV), allowed the WGEAFM to assess significant concentrations of corals and to subsequently plot *key locations* based on this information. In order to address this Item the working group took the following work program:

1. Identified data sources;

2. Identified coral species of concern;

3. Defined what a significant concentration of coral is;

4. Mapped the known distribution of significant concentrations of corals;

5. Provided boundaries that encapsulate nearby locations and could inform the process of providing protection to these key locations.

Given the nature and potential limitations of the available data, all assessments, analyses and recommendations were made within the framework provided by the precautionary principle.

DATA SOURCES

List of Surveys

Data on sea pens, gorgonian and antipatharian corals were available from the following sources:

1. DFO NL Groundfish Surveys (Research Vessel Campelen Bottom Trawl): 2000-2007 (Div. 3LMNO): 1448 records of coral from 791 tows and 4479 sets from these surveys contained no corals between 46 and 1450 m (provided by Vonda Wareham and Bill Brodie, DFO NWAFC);

2. DFO Fisheries Observer Program NL 2004-2007 (Div. 3LMNO): 1102 records with presence of corals from 1099 tows between 31 and 1491 m (provided by Vonda Wareham, DFO NWAFC);

3. IEO Platuxa Survey (Research Vessel Campelen 1800 Bottom Trawl): 2005-2007 (Div. 3NO): 170 records of coral from 349 tows covering the 'Tail' of the Grand Banks (NRA) between 40 and 1500 m depth, (provided by IEO);

4. EU Flemish Cap Survey (Research Vessel Lofoten Bottom Trawl): 2006-2007 (Div. 3M): 277 records of coral from 355 tows covering all the Flemish Cap (NRA) between 130 and 1450 m (provided by IEO);

5. IEO Fletán negro Survey (Research Vessel Campelen 1800 Bottom Trawl): 2006-2007 (Div. 3L): 154 records of coral from 180 tows covering the 'Nose' of the Grand Banks and Flemish pass (NRA) between 110 and 1450 m (provided by IEO);

6. Canada EEZ Survey (Research Vessel Campelen 1800 Bottom Trawl): 2007 (Div. 3L): 26 records of coral from 26 tows carried out by IEO within the Canadian EEZ (provided by IEO).

Research Vessel Survey Data

Canadian and Spanish/EU Research Vessel Survey Data were analyzed. Both surveys have a good coverage for the NRA portion of Div. 3LNO, but only EU surveys cover all of the currently trawlable area of Flemish Cap (Div. 3M). Data from these research vessel surveys likely represent a wide range of coral sampling efficiency; however these sources represent the best available scientific information at this time. There are no estimates of catchability or catch efficiency of corals in relation to their population density.

The Canadian survey tows are conducted with a target of fifteen minutes duration while the Spanish/EU tows are of a targeted thirty minutes. In order to use these two data sets together it must first be established whether the catch is significantly different between the two. The catch distribution is highly skewed towards large numbers of small catches with few large ones (see below). These may represent isolated corals caught in the trawl path, or a trawl swath through a narrow dimension of the community. Larger catches may occur when the trawl and the coral distribution are aligned, when the gear is not handled properly and digs into the seabed, or they may represent large and more significant concentrations. Whatever the situation, it is unlikely that these corals would be caught in high concentration for long periods of time simply because the patch sizes are not that large (less than 500 m) (Beazley, 2008). Nevertheless, the probability of catching other coral patches increases with the tow duration, as well as the probability to catch several isolated colonies not necessarily indicative of significant coral concentrations.

Bearing these issues in mind, the goal sought by merging these research survey datasets needs to be made clear. Even though the effort made by different towing times will affect the probability of finding corals in any given tow, once the corals are caught, the amount collected will be more a function of how the tow crossed the coral patch than a function of the patch size. For this reason, it was believed that the actual duration of the Canadian and Spanish research tows (15 and 30 minutes respectively) would not have a significant effect on the amount of coral collected, especially if the analysis is performed on taxa groupings (*e.g.* large gorgonians as opposed to all corals). Since the objective of this exercise is to define catch thresholds that could allow identifying areas where these catch levels are high, then what is needed before merging these datasets is to see if the actual amounts collected per tow differ in any significant way. If these amounts are similar (both in distribution and central tendency), then the specific amounts of the catches can be regarded as independent of towing time (remember that in all cases the towing time is really short). If they are different, then an adjustment for towing time may be required before analyzing the data as a single dataset.

Therefore, to determine whether the Canadian and Spanish/EU data should be used separately or combined, a Kolmogorov-Smirnov test based on cumulative distribution functions for each data set was used to test whether the two distributions are different. A second test, the Wilcoxon Rank-Sum (Mann-Whitney) test for two independent samples was also applied. These results are presented in Table 1. The total catch distributions are not comparable although the selected components: Large gorgonians, pennatulaceans, and *Acanella arbuscula*, representing small gorgonians, are.

Table 1. Comparison of the distribution of coral catch from the Canadian 15 minute RV tows and the Spanish/EU 30 minute RV tows for each of 4 groups (N Can, N Spain/EU) by Kolmogorov-Smirnov (K-S) and Wilcoxon Rank-Sum tests.

	Canada, Spain	K-S	P	Wilcoxon	P
Large Gorgonians	N=42, N=53	0.136	0.778	1062	0.705
Pennatulaceans	N=145, N=328	0.093	0.346	23398.5	0.781
Acanella arbuscula	N=83, N=83	0.157	0.261	3899	0.142
All Corals Combined	N=791, N=628	0.154	<0.001	208596.5	<0.001

Fisheries Observer Data

The only data from commercial vessels comes from the Canadian Fisheries Observer Program. Coral data was gathered opportunistically by fisheries observers, commencing in 2004. Observers are deployed in most fisheries in the region covering a broad array of depths extending from Baffin Basin to southern Newfoundland and the Flemish

Cap. Prior to collecting corals, all observers were equipped with coral identification guides, and given training in identification.

Coral data were collected from April 2004 through to December 2007. Observer coverage at sea varied between 0–100% depending on the fishery, quota allocation, gear type, and NAFO division, with limited geographical coverage for the NAFO Regulatory Area.

Sampling protocol required each observer to submit at least one sample of each coral species encountered on each trip, and to record all other occurrences of each coral species on set/catch data sheets. Samples and records were tracked to assess accuracy of data from each observer. Coral distribution data from fisheries observers presented here include identified samples and records that could be compared with an identified sample previously submitted by the individual observer reporting the record.

Data from fisheries observers has many limitations and should only be used as indicative of presence, but not absence, of coral species. Consequently we had no data from the commercial fleet with which to compare RV results with.

IDENTIFICATION OF CORAL VMES

In its report to the NAFO Scientific Council in May of 2008, the WGEAFM was asked to identify criteria for the identification of VMEs in NAFO regulatory waters (NAFO, 2008a). In identifying coral VME components WGEAFM considered the size, structural complexity, gregariousness, fragility, vulnerability to fishing gears, rarity, longevity, role in the ecosystem (associated species, biodiversity) and international recognition of status. Full details of the information used to assess these criteria are provided in a separate document (Fuller *et al.*, 2008). WGEAFM considers the following groups of corals as indicators and key components of VMEs:

- Antipatharians
- Gorgonians
- Cerianthid anemone fields
- *Lophelia* and other reef building corals
- Sea pen (Pennatulacea) fields

Of these, we have no information on cerianthid anemone fields in the NRA and the reef building coral *Lophelia* has thus far not been reported, although a recent theoretical modeling exercise based on analysis of eco-geographical variables (*e.g.*, temperature, aragonite saturation, *etc*.) by Davies *et al.* (2008) indicates that environmental conditions which could support this species are present in the NRA. Antipatharians are rare at the depths currently fished and are not as gregarious as some other corals. Therefore we recorded their presence in the vicinity of significant concentrations of the other taxa and used this information in considering the boundaries of the key locations.

Delineation of significant concentrations of corals in Research Surveys in the NAFO Regulatory Area for the Identification of VMEs

In order to address this part of the request a definition of ‘significant concentrations” is required. The NAFO FC used a value of 100 kg of corals to define a significant encounter by a fishing vessel. However the WGEAFM feels that this threshold is too high to offer protection to deepwater coral species. In fact this level of catch was never observed in any of the above data sets including both research and observer data.

The three coral taxa identified above (Antipatharia, Gorgonia, Pennatulacea) all have different body weights and morphology which means that different levels of significance must be defined from the catch data. They also co-occur resulting in mixed species catch which means that significance should be also assessed at a community level if coral species are highly associated with one another.

One approach is first to examine the association of coral species in the catch and then, if strong associations exist, to look at the distribution of the catch weights for these associations to determine whether suitable levels can be established to define a significant amount for mixed catches.

Given the rudimentary knowledge we currently have in terms of functioning of deep sea communities and the precise roles that corals play in them, it is impossible at the present time to define absolute magnitudes of catch that can be associated to functionally relevant coral concentrations in ecological terms. Nonetheless, current knowledge allows recognizing that provision of structural habitat is a significant ecological feature that corals provide, while in terms of protection of biodiversity, many of these species require particular attention due to their slow growth rates and intrinsic fragility and sensitivity to perturbations (Fuller *et al.,* 2008). For these reasons, and until more detailed surveys and studies become available, the basic premise to identify a significant concentration has been a relative one. The WGEAFM have used available empirical distributions for these corals in the NRA to identify what constitutes a high concentration within this area, and in combination with current knowledge of these species and/or groups, defined thresholds that can provide protection to these locally high concentrations. These thresholds should be considered precautionary and should be re-assessed when additional research becomes available.

Habitat mapping studies for NE Atlantic (Durán Muñoz *et al*., 2008a,b) indicate that, in the absence of detailed habitat knowledge (*e.g.* multibeam maps), the poor geographic resolution of commercial catch information can lead to significant mismatches between the actual location of corals and their estimated locations. Some of the reasons for these mismatches include the length of commercial hauls (up to 20 nm) and the difference between gear and vessel position (observers record vessel position). These mismatches could lead to the designation of areas without corals, while leaving the actual concentrations outside their boundaries. For this reason, and until detailed mapping becomes available, designation of areas must consider appropriate buffer zones.

For those locations where high concentrations of corals have been identified, a two step process was employed to provide a buffer zone around them. The first step was to consider an error margin in the identified location due to differences between gear and vessel positions, accuracy in the GPS positioning, *etc*. It was considered that a 2 nm radius around the putative position provided a safe margin on these grounds. This distance was taken from the Interim Encounter Provisions "move away protocols" proposed at the recent FC meeting. In addition to this, an additional 2 nm buffer zone was applied to allow for protection of the site. In total, this process rendered a full error+buffer zone of a 4 nm radius around the reported key location. These values are considered precautionary until detailed mapping of these areas and/or additional research on buffer areas becomes available. In order to facilitate the application of protection measures, simple polygons were drawn to enclose nearby key locations.

Coral Associations

Data from the RV surveys from both Spain/EU and Canada were used. The data were transformed to presence/absence and a Bray-Curtis similarity matrix was constructed using Primer 6.0 software. The similarity matrix was clustered using an average linkage algorithm. The results show weak structure in the data set, however some coral taxa co-occur 40 percent of the time (Figure 3). These are: *Halipteris finmarchica*, *Anthoptilum grandiflorum*, *Funiculina quadrangularis*, *Acanella arbuscula*, and *Pennatula* spp., a group of sea pens and a small bushy gorgonian (*A. arbuscula*). The sea pens all have a similar gross morphology but *A. arbuscula* is bushy with multiple branching. From this analysis the WGEAFM concludes that grouping the sea pens into one category for mapping is appropriate. The gorgonian corals have much less association with one another in the trawl catch. However they are not closely grouped with the sea pens which is consistent with what is known of their habitat preferences.

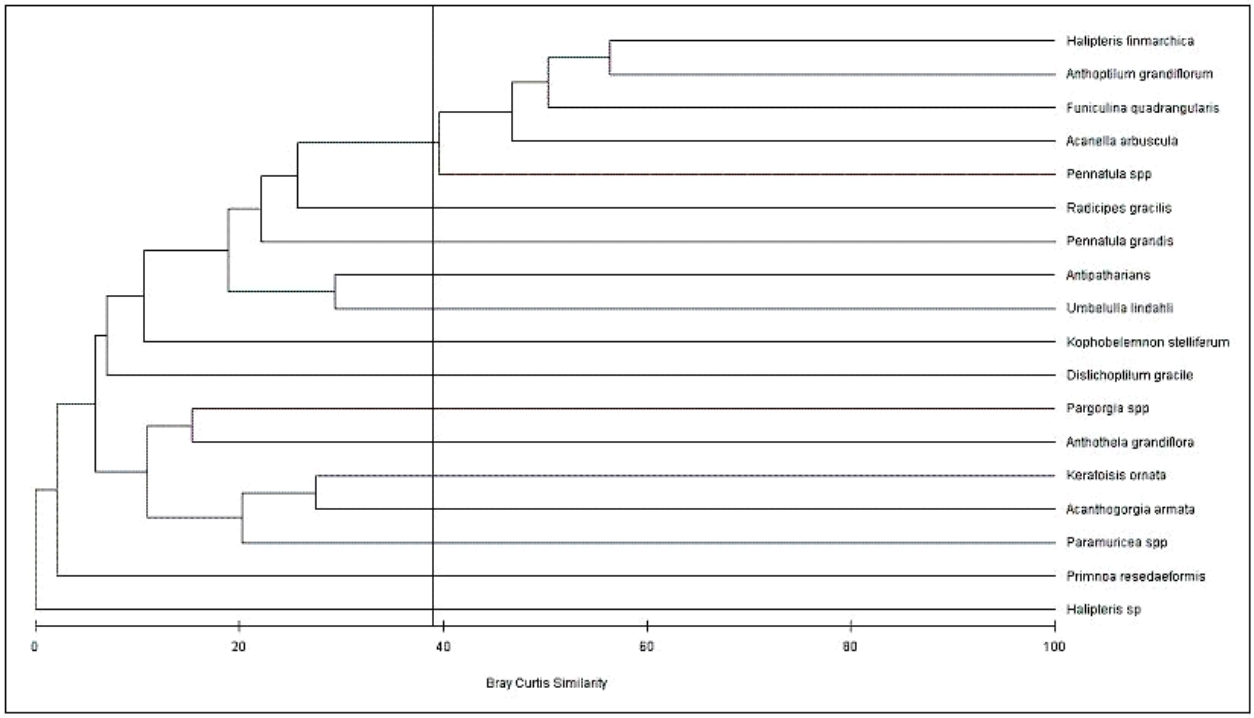


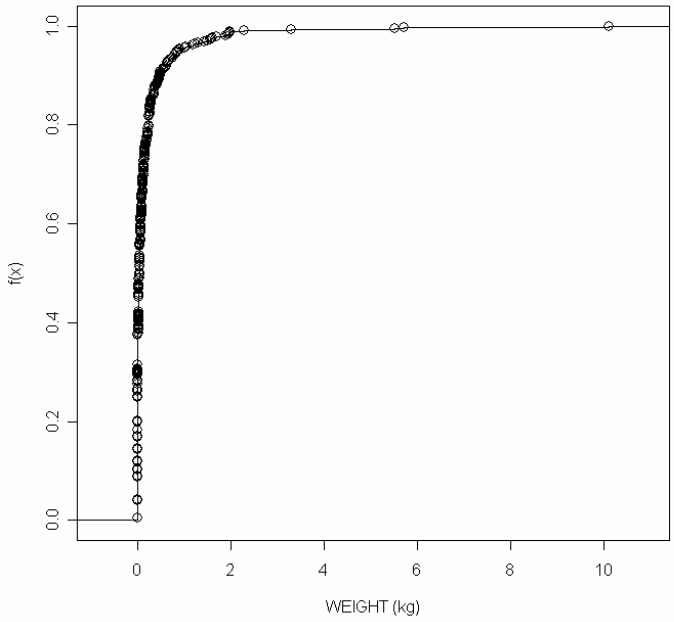
Figure 3. Coral associations determined by a Bray Curtis similarity calculated from presence/absence data in trawl survey catch.

Determining What Constitutes a Significant Catch of Sea Pens and Small Gorgonians in Research Surveys

The distribution of sea pen catch (kg) is highly skewed. The large catches form rare events at the tail of the distribution. The quantiles for this taxon show that the median catch is 0.05 kg. The 75% quantile is 0.17 kg while the 90% quantile is only 0.48 kg. Choosing a point to define when the catches go from relatively small to large is subjective. The 97.5% quantile marks the upper bound of the two-sided 95% confidence intervals around the mean. Therefore, this value is chosen as the indicator of when a significant concentration has been identified. For sea pens the 97.5% quantile occurs when the haul brings in 1.6 kg per tow (Figure 4).

A similar calculation for the small gorgonian *Acanella arbuscula* (Figure 5) shows that catches of 0.2 kg per tow would match the 97.5% quantile. One potential issue for this species is the low threshold found in this analysis. Although this value corresponds to research survey sets, it would be expected than any regulatory threshold for commercial sets will also be relatively low in magnitude.

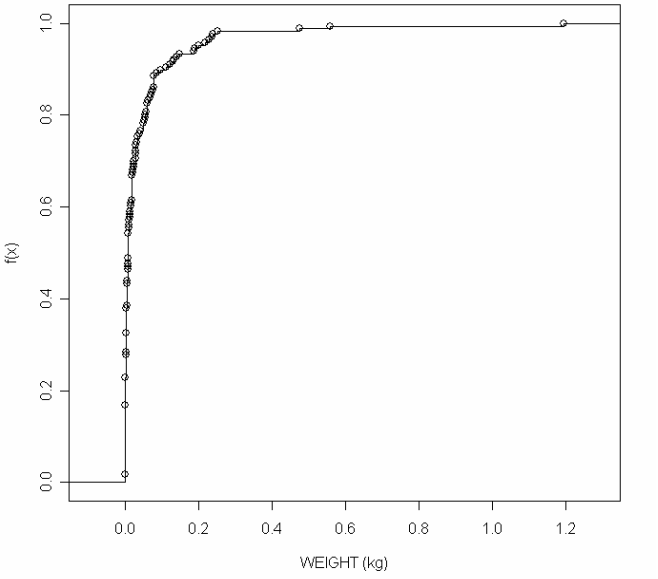
Measuring these low biomasses in high-seas scenarios, considering the limitations in the precision of balances, will pose implementation challenges should these thresholds be used for other purposes, such as for encounter protocols. One possible solution for this issue is to consider some thresholds for potential encounter protocols in terms of numbers instead of weights. There is data available to explore this issue further if requested.



Weight Quantiles

100.0 %	maximum	10.116000
99.5 %		4.718880
97.5 %		**1.602200**
90.0 %		0.484600
75.0 %	quartile	0.170000
50.0 %	median	0.049000
25.0 %	quartile	0.010500
10.0 %		0.003094
2.5 %		0.001000
0.5 %		0.001000
0.0 %	minimum	0.000100

Figure 4. Cumulative distribution of pennatulacean (sea pen) catch (kg) from the RV surveys (N=473). The values of catch weight are presented as quantiles.



Weight Quantiles

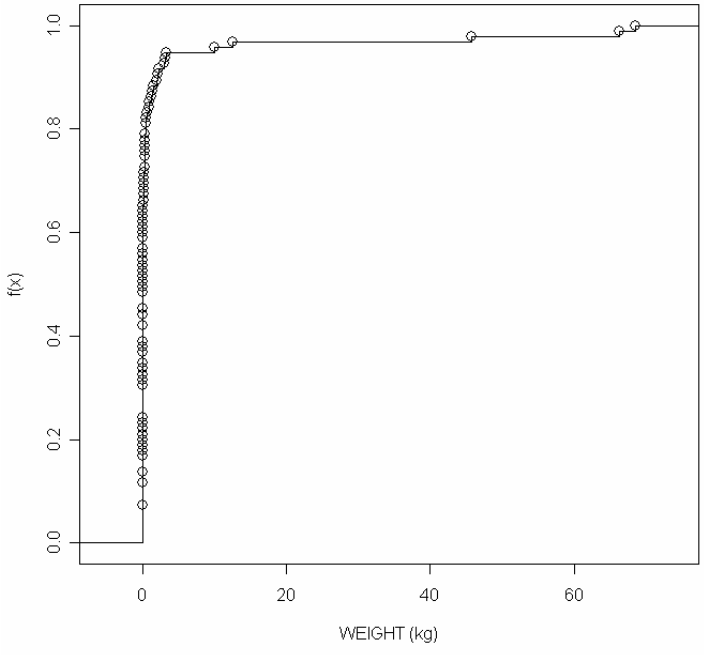
100.0 %	maximum	1.195300
99.5 %		0.669198
97.5 %		**0.239704**
90.0 %		0.103750
75.0 %	quartile	0.035000
50.0 %	median	0.010000
25.0 %	quartile	0.003000
10.0 %		0.001000
2.5 %		0.001000
0.5 %		0.000100
0.0 %	minimum	0.000100

Figure 5. Cumulative distribution of *Acanella arbuscula* catch (kg) from RV surveys (N=166). The values of catch weight are presented as quantiles.

Determining What Constitutes a Significant Catch of Large Gorgonians in Research Surveys

Both the Spanish/EU and DFO Research trawlers did not encounter a large number of large gorgonians. These species are also more prone to breakage than the sea pens and *A. arbuscula* and so the data are compromised by colony fragments. *In situ* observations of *Paragorgia arborea* on the Scotian slope show a strongly clumped distribution over scales of tens of meters (Beazley, 2008). Therefore there is a high probability that single colonies or fragments in the catch do not equate to a non-significant encounter.

Nevertheless, data for the large gorgonians *Paragorgia* spp, *Primnoa resedaeformis*, *Keratoisis ornata*, *Acanthogorgia armata* and *Paramurciea* spp. were combined and their catch weight distribution analyzed (Figure 6). The results indicate that a precautionary threshold for these large gorgonians would be approximately 2 kg per tow. This value is found in the 90% quantile (1 in 10 of the tows with large gorgonians met this target). The more stringent quantile was selected to be more precautionary for these corals given the considerations noted above.



Weight Quantiles

100.0 %	maximum	68.580000
99.5 %		67.484900
97.5 %		34.118850
90.0 %		**2.066280**
75.0 %	quartile	0.325000
50.0 %	median	0.030000
25.0 %	quartile	0.010000
10.0 %		0.002000
2.5 %		0.001000
0.5 %		0.001000
0.0 %	minimum	0.001000

Figure 6. Cumulative distribution of large gorgonians *Paragorgia* spp., *Primnoa resedaeformis*, *Keratoisis ornata*, *Acanthogorgia armata*, and *Paramurciea* spp. catch (kg) from RV surveys (N=95). The values of catch weight are presented as quantiles.

Summary of Significant Threshold Calculations for Research Surveys

The WGEAFM considered the above information and applied three precautionary threshold levels for the evaluation of a significant concentration of corals in NRA based on groundfish surveys catches:

Pennatulaceans (sea pens)	1.6 kg per tow (this report)
Small gorgonians	0.2 kg per tow (this report)
Large gorgonians	2 kg per tow (this report)

Key Locations of Significant Concentrations of Corals in the NAFO Regulatory Area

Significant concentrations of coral based on groundfish surveys catches, are illustrated in the map provided in Figure 7. The analysis shows that Areas 1, 2, 5 within the NRA (NAFO, 2008a) hold significant concentrations of corals.

Two additional locations, one in Area 7 and another outside Area 8, but along its general longitudinal direction, also show concentrations of small gorgonians above the threshold. Unlike the observations on Areas 1, 2, and 5, where several nearby sets have shown catches above the thresholds, these last two locations are based on catch of *A.arbuscula* (small gorgonian) in single sets (amounts of 0.23 and 0.24 kg) and without any other significant catches nearby (Figure 8). Although the presence of catches above the threshold in these locations warrant a closer exploration of these areas, the isolated nature of these catches and the borderline nature of the catch levels does not allow us to give these sites a clear *key location* status as applied to the other areas. The presence of only two isolated sets with *A. arbuscula* above the threshold could suggest that there are no significant concentrations of this species in the NRA; most high concentration sites for this species are in Area 8 (within Canadian waters). However, the existence of other sites with high concentrations of *A. arbuscula* in the NRA cannot be dismissed.

Among the four candidate VME areas originally identified by WGEAFM on the main basis of presence of coral habitat (Areas 1, 2, 5 and 6), three have emerged from this analysis as containing key *locations* of corals (Areas 1, 2, and 5). Area 6, Beothuk Knoll, has no identified *key locations* at the present time. However, the original designation of this area as candidate VME was based on Russian data (Vinnichenko and Sklyar, 2008, see NAFO, 2008a for details) that was not available during this analysis. This situation does not diminish the original WGEAFM consideration that Area 6 is important as coral habitat or its status as WGEAFM candidate VME.

All the geographical databases were referenced to the WGS 1984 UTM Zone 23N. Moreover, bathymetric curves were exported as shapefiles (ArcMap format) from GEBCO Digital Atlas, nevertheless, these are not totally precise for detailed maps.

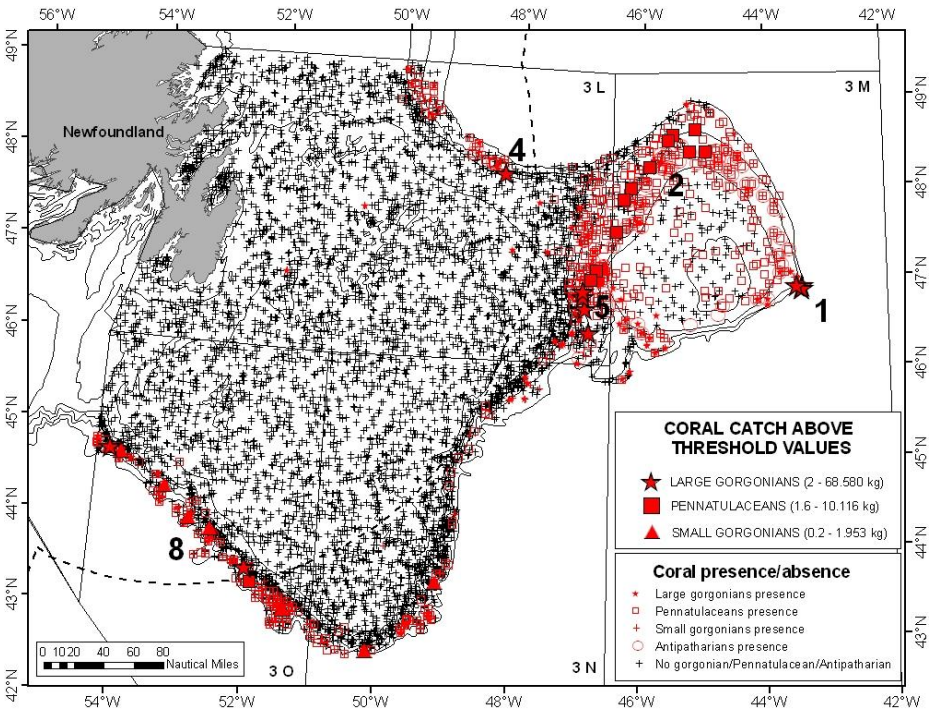


Figure 7. Significant concentrations of coral taxa as determined from research vessel survey data. The numbers refer to the WGEAFM numbering of their candidate VME locations (Figure 1). As indicated in the figure itself, large red symbols indicate key locations while small ones denote presence of corals below threshold levels.

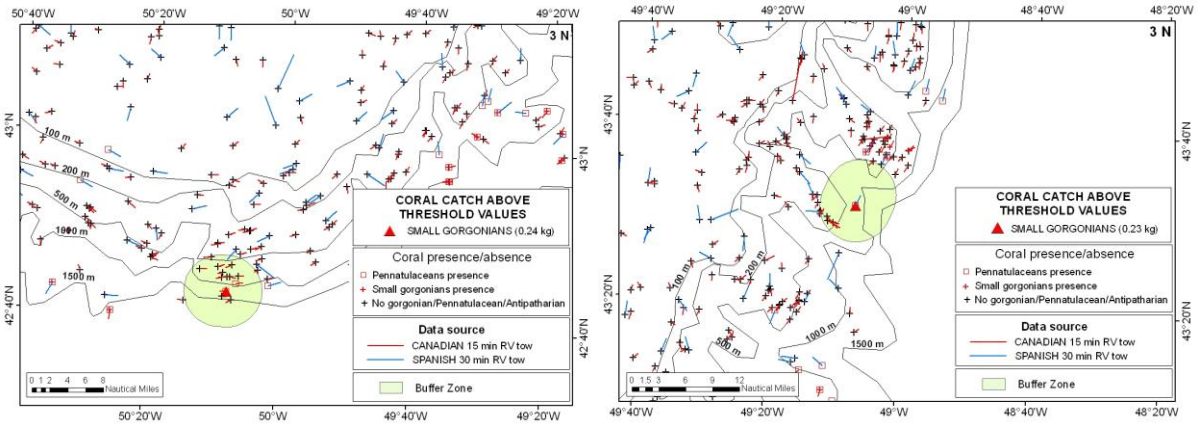


Figure 8. Close-up of the two sites on the tail of the Grand Bank where concentrations of small gorgonians (*A. arbuscula*) were found above the threshold. A 4 nm buffer zone around each location is also indicated.

Proposed Coordinates for the Delineation of Significant Concentrations of Corals of Key Locations in Areas 1, 2 and 5

The following figures show a close-up on each one of the key locations identified in Areas 1, 2, and 5. Each figure is composed of three maps - one indicating the locations of significant concentrations of corals, another one showing the 4nm buffer around each tow where the significant concentration was found and the polygons drawn to encapsulate nearby sites, and finally a simpler map with only the point locations and the polygons delineating the key location of the corals within the VME. The exact coordinates corresponding to these polygons are detailed in Table 2.

Area 1: Large Gorgonians

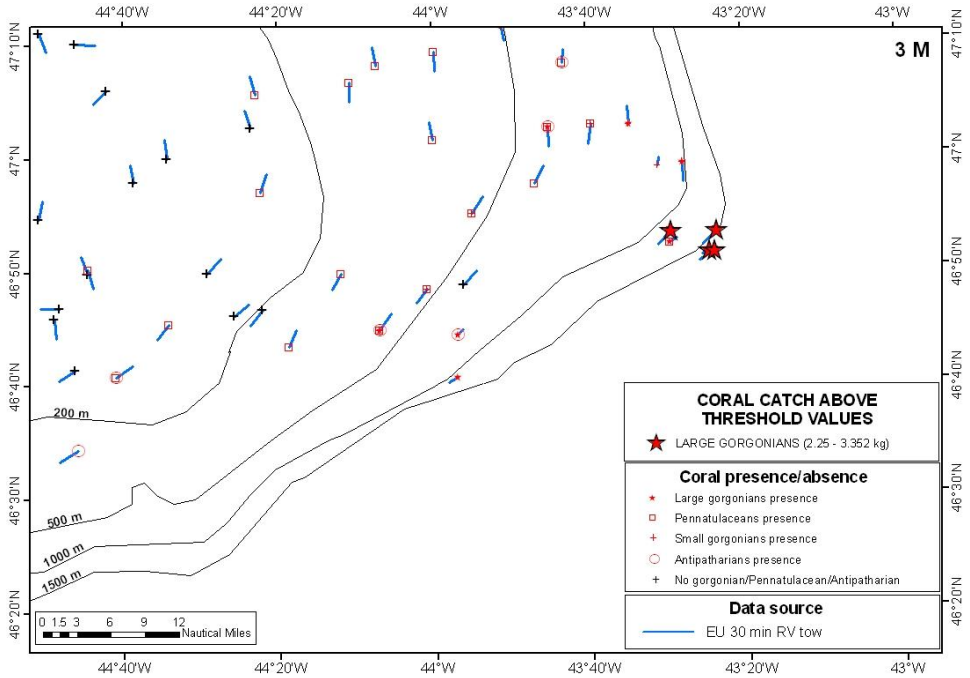


Figure 9a. Significant concentrations of large gorgonian corals in candidate VME Area 1.

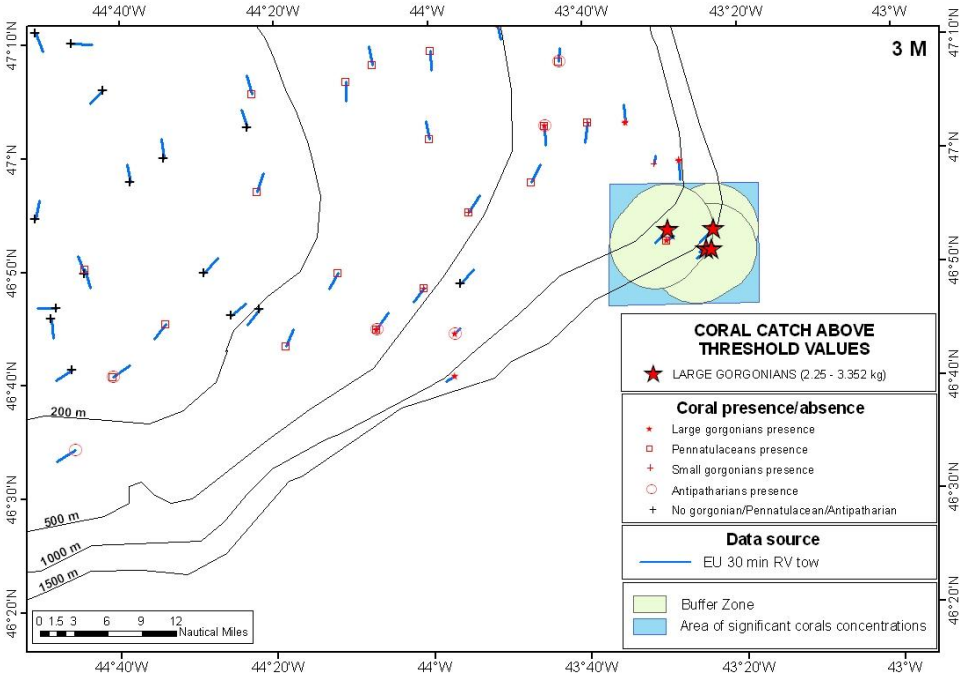


Figure 9b. Buffer zones around the significant concentrations of large gorgonians in candidate VME Area 1 and proposed polygon to encapsulate the key location.

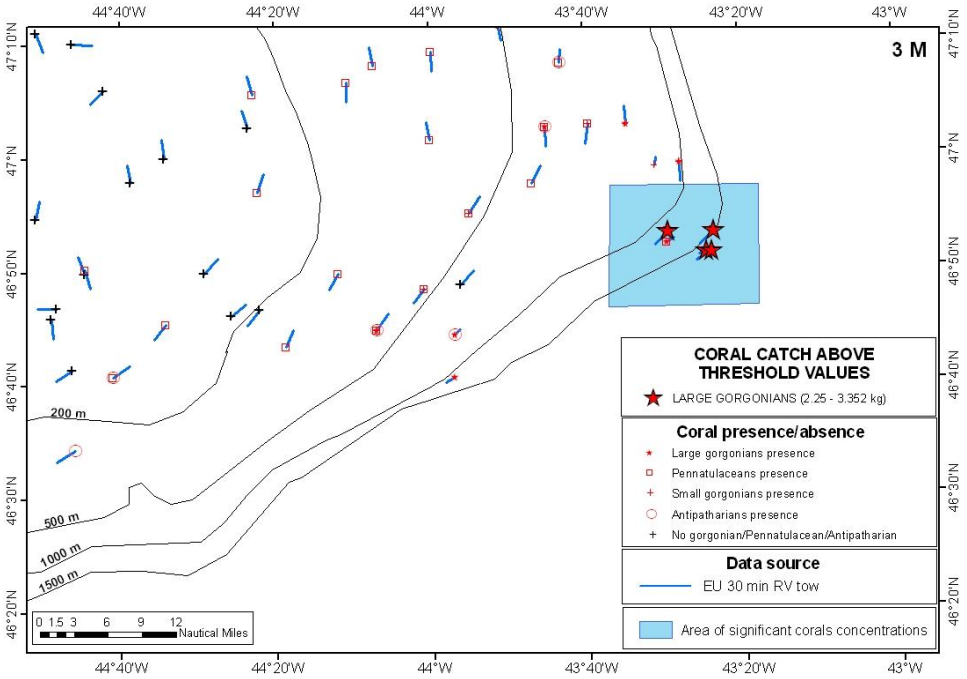


Figure 9c. Key location of large gorgonians and proposed polygon delineating significant concentrations of these corals for candidate VME Area 1.

Area 2: Pennatulaceans

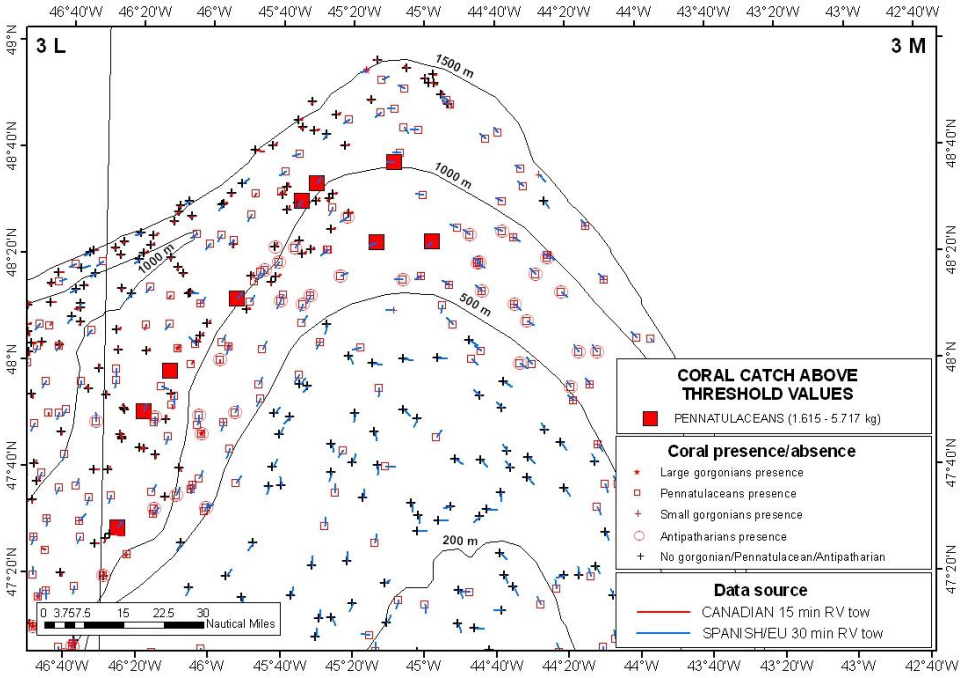


Figure 10a. Significant concentrations of pennatulaceans (sea pens) in candidate VME Area 2.

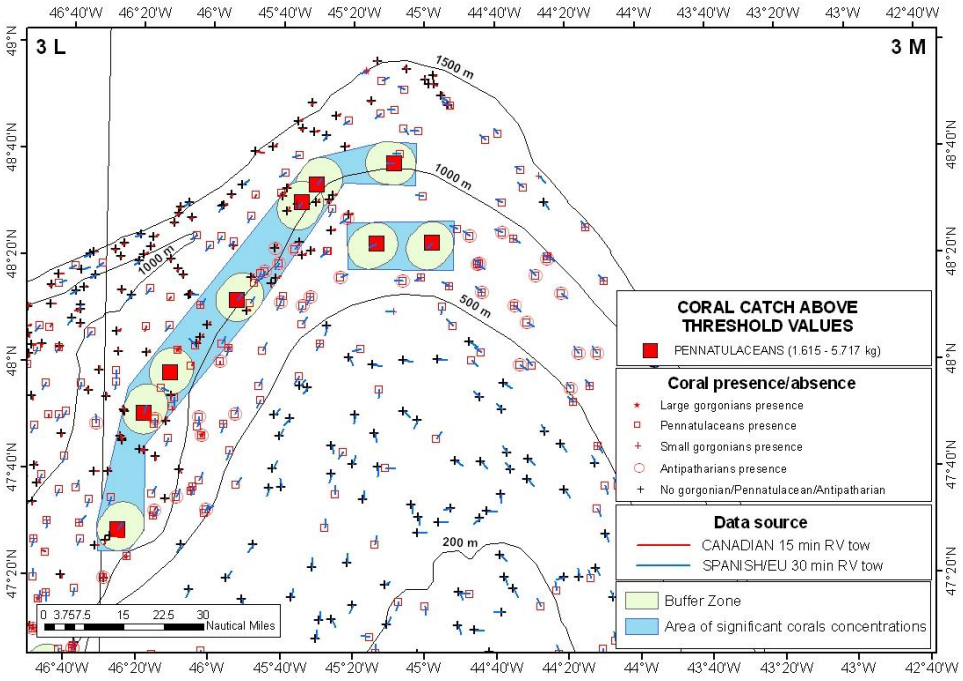


Figure 10b. Buffer zones around the significant concentrations of pennatulaceans (sea pens) in candidate VME Area 2 and proposed polygon to encapsulate the key locations.

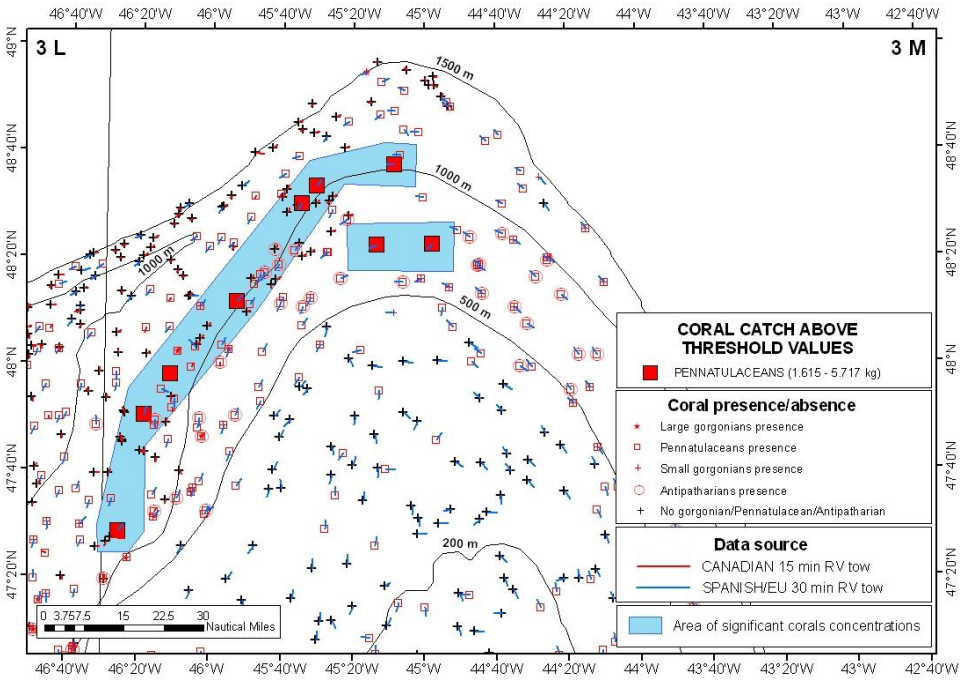


Figure 10c. Key locations of pennatulaceans (sea pens) and proposed polygons delineating significant concentrations of these corals for candidate VME Area 2. In Table 2, the polygon to the left is labeled "Polygon Area 2.1" and the one to the right "Polygon Area 2.2".

Area 5: Large Gorgonians and Pennatulaceans

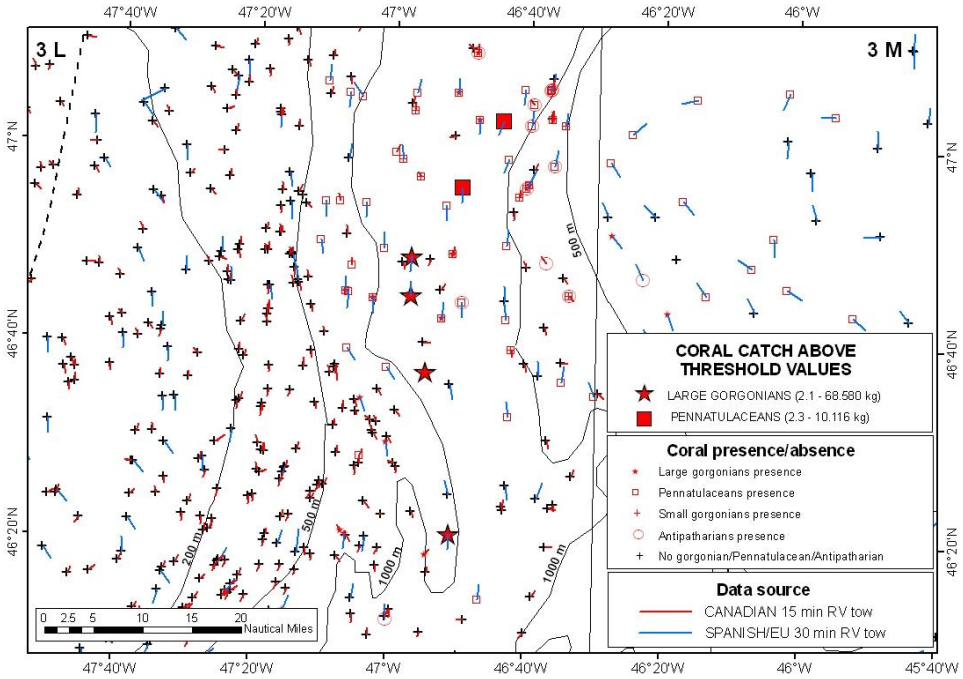


Figure 11a. Significant concentrations of large gorgonian corals and pennatulaceans (sea pens) in candidate VME Area 5.

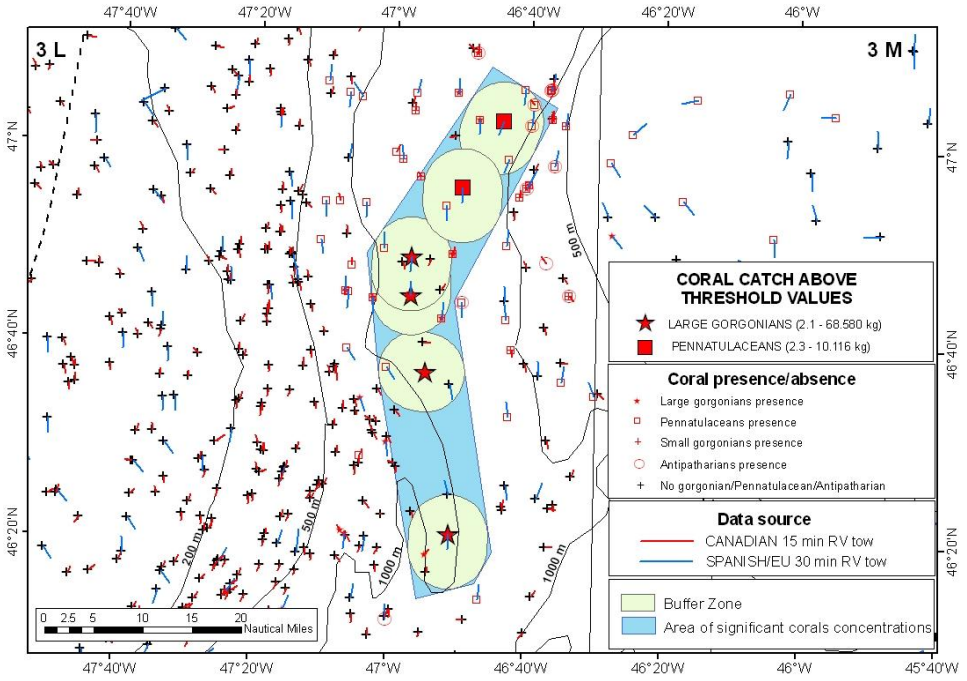


Figure 11b. Buffer zones around the significant concentrations of large gorgonians corals and pennatulaceans (sea pens) in candidate VME Area 5 and proposed polygon to encapsulate the key location.

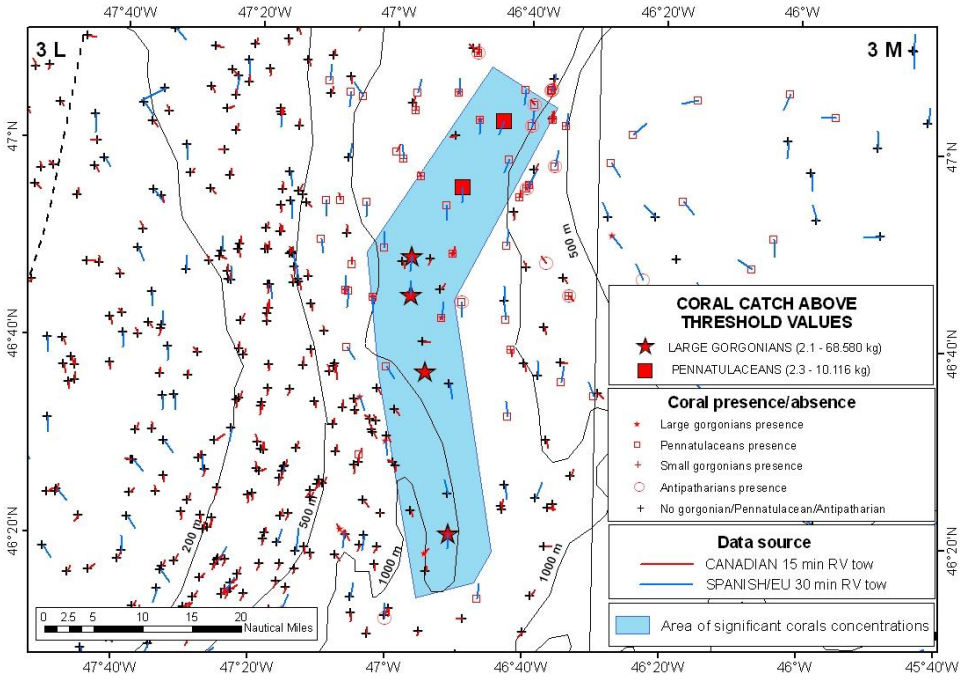


Figure 11c. Key location of large gorgonian corals and pennatulaceans (sea pens) and proposed polygon delineating significant concentrations of these corals for candidate VME Area 5.

Table 2. Coordinates for the proposed polygons delineating the Areas of Higher Coral Concentrations.

Area	Polygon	Latitude	Longitude
1	Polygon Area 1.1	46º 46' 35" N	43º 37' 05" W
		46º 46' 40" N	43º 17' 48" W
		46º 57' 11" N	43º 17' 30" W
		46º 57' 18" N	43º 36' 39" W
2	Polygon Area 2.1	47º 24' 37" N	46º 30' 52" W
		47º 24' 39" N	46º 22' 24" W
		47º 28' 29" N	46º 17' 59" W
		47º 29' 37" N	46º 31' 17" W
		47º 44' 36" N	46º 18' 16" W
		47º 55' 27" N	46º 23' 17" W
		48º 10' 47" N	45º 46' 35" W
		48º 33' 41" N	45º 02' 38" W
		48º 34' 12" N	45º 22' 52" W
		48º 38' 39" N	45º 32' 44" W
		48º 41' 41" N	45º 02' 19" W
		48º 42' 02" N	45º 11' 20" W
2	Polygon Area 2.2	48º 17' 52" N	44º 51' 52" W
		48º 17' 54" N	45º 21' 41" W
		48º 26' 45" N	45º 22' 03" W
		48º 27' 01" N	44º 51' 46" W
5	Polygon Area 5.1	46º 14' 28" N	46º 55' 40" W
		46º 16' 05" N	46º 47' 15" W
		46º 19' 16" N	46º 44' 41" W
		46º 36' 51" N	47º 01' 52" W
		46º 44' 36" N	46º 50' 56" W
		46º 49' 18" N	47º 04' 02" W
		47º 04' 16" N	46º 36' 17" W
		47º 08' 18" N	46º 45' 59" W

REFERENCES

Beazley, L. 2008. Reproductive Strategies as the Determinant of Spatial Structure of Deep-Water Corals of the Northeast Channel. Honours Thesis, Biology Department. Dalhousie University, 69 p.

Davies, A.J., Wisshak, M., Orr, J.C. and Roberts, J.M. 2008. Predicting suitable habitat for *Lophelia pertusa*. *Deep-sea Research,* **55**: 1048-1062.

Durán Muñoz, P., F.J. Murillo, A. Serrano, M. Sayago-Gil, S. Parra, V. Díaz del Río, M. Sacau, T. Patrocinio and J. Cristobo. 2008a. A case study of available methodology for the identification of Vulnerable Ecosystems/Habitats in bottom deep-sea fisheries: Possibilities to apply this method in the NRA in order to select Marine Protected Areas. *NAFO SCR Doc.* No. 6, Serial No. N5491, 20 p.

Durán Muñoz, P., Sayago-Gil, M., Cristobo, J., Parra, S., Serrano, A., Díaz Del Río, V., Patrocinio, T., Sacau, M., Murillo, J., Palomino, D., Domínguez, M. and Fernández-Salas, L.M. 2008b. A practical example of mapping in order to select closed areas to protect cold-water corals in the high seas (Hatton bank ICES VIb1 & XIIb). ICES CM 2008/G:01. 33 pp.

Fuller, S.D., F.J. Murillo Perez, V. Wareham and E. Kenchington. 2008. Vulnerable Marine Ecosystems Dominated by Deep-Water Corals and Sponges in the NAFO Convention Area. *NAFO SCR Doc*. No. 22, Serial No. N5524, 24 p.

ICES. 2008. Report of the ICES-NAFO Joint Working Group on Deep-water Ecology (WGDEC). 10-14 March 2008, Copenhagen, Denmark. *ICES CM 2008*/ACOM:45. 122 pp.

Kulka, D., N. Templeman, J. Janes, A. Power, and W. Brodie. 2007. Information on seamounts in the NAFO Convention Area. *NAFO SCR Doc.* No. 61, Serial No. 5414, 17 p.

Murillo, J., P. Durán Muñoz, M. Sacau, D. González-Troncoso, and A. Serrano. 2008a. Preliminary data on cold-water corals and large sponges by-catch from Spanish/EU bottom trawl groundfish survey in NAFO Regulatory Area (Divs. 3LMNO) and Canadian EEZ (Div. 3L): 2005-2007 period. *NAFO SCR Doc.* No. 10, Serial No. N5501, 28 p.

Murillo, F.J., P. Durán Muñoz, M. Mandado , T. Patrocinio, and G. Fernández. 2008b. By-catch of cold-water corals from an Experimental Trawl Survey in three seamounts within NAFO Regulatory Area (Divs. 6EFG) during year 2004. *NAFO SCR Doc.* No. 6, Serial No. N5491, 20 p.

NAFO. 2008a. Report of the WGEAFM Meeting May 26-30, 2008. *NAFO SCS Doc.* No. 10, Serial No. N5511, 70 p.

NAFO. 2008b. Fisheries Commission's Request for Scientific Advice on Management in 2010 and beyond of Certain Stocks in Subareas 2, 3 and 4 and other matters. *NAFO FC Doc*. No. 19, Serial No. N5581, 4 p.

Vinnichenko, V.I., and V.V. Sklyar. 2008. On the issue of areas closure to protect vulnerable marine habitats in the NAFO Regulatory Area. *NAFO SCR Doc.* No. 79, Serial No. N5613, 7 p.

LIST OF PARTICIPANTS

Canada

Brodie, Bill	Dept of Fisheries and Oceans, P. O. Box 5667, St. John's, NL	bill.brodie@dfo-mpo.gc.ca
Kenchington, Ellen	Dept of Fisheries and Oceans, P.O. Box 1006, Dartmouth, NS	kenchingtone@mar.dfo-mpo.gc.ca
Koen-Alonso, Mariano	Dept of Fisheries and Oceans, P. O. Box 5667, St. John's, NL	mariano.koen-alonso@dfo-mpo.gc.ca
Kulka, Dave	Dept of Fisheries and Oceans (retired)	dave.kulka@dfo-mpo.gc.ca
Power, Don	Dept of Fisheries and Oceans, P. O. Box 5667, St. John's, NL	don.power@dfo-mpo.gc.ca
Stenson, Garry	Dept of Fisheries and Oceans, P. O. Box 5667, St. John's, NL	garry.stenson@dfo-mpo.gc.ca
Wareham, Vonda	Dept of Fisheries and Oceans, P. O. Box 5667, St. John's, NL	vonda.wareham@dfo-mpo.gc.ca

European Union

Belgrano, Andrea	Swedish Board of Fisheries, Institute of Marine Research, Lysekil, Sweden	andrea.belgrano@fiskeriverket.se
Durán Muñoz, Pablo	Instituto Español de Oceanografía, P. O. Box 1552, Vigo, Spain	pablo.duran@vi.ieo.es
Kenny, Andrew	CEFAS, Lowestoft Laboratory, Lowestoft, UK	andrew.kenny@cefas.co.uk
Large, Phil	CEFAS, Lowestoft Laboratory, Lowestoft, UK	phil.large@cefas.co.uk
Murillo, Javier	Instituto Español de Oceanografía, P. O. Box 1552, Vigo, Spain	javier.murillo@vi.ieo.es
Vázquez, Antonio	Instituto de Investigaciones Marinas, Vigo, Spain	avazquez@iim.csic.es

USA

Fogarty, Mike	Northeeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543	michael.fogarty@noaa.gov

Ecological Action Centre

Fuller, Susanna	Ecology Action Centre, Halifax, NS, Canada (Dalhousie University, Halifax, NS, Canada)	marine@ecologyaction.ca

WWF

King, Marty	WWF, Halifax, NS, Canada	mking@wwfCanada.org