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Summary of the location of VME indicators on the Flemish Cap slope based on *in situ* benthic imagery analysis

by

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Abstract

In 2009 and 2010, *in situ* benthic video and photographic transects were collected by the Department of Fisheries and Oceans, Canada as part of the NEREIDA program to identify VME indicator species in the NAFO Regulatory Area. These transects were subsequently analyzed for the abundance of epibenthic megafauna and the presence of VME indicator taxa. Here we present data on the presence of VME indicators and black corals on each of these transects on the Flemish Cap slope. Of the 9 VME indicator groups listed in NAFO (2012), 6 were present in the area. Black corals were present on the fewest number of transects, while large-sized sponges were present on nearly all transects. Transects located on the southern slope of the Flemish Cap and which currently do not fall within a closed area, had the highest number of VME indicator groups present, suggesting that this area may be a hotspot for the presence of VMEs.

Introduction

In 2009 and 2010, the Department of Fisheries and Oceans, Canada collected benthic imagery from the Flemish Cap slope while onboard the Canadian Coast Guard Ship *Hudson* as part of the NEREIDA program to identify vulnerable marine ecosystems (VMEs) from the NAFO Regulatory Area (NRA). These transects (location shown in Fig. 1) were subsequently analyzed for the abundance of epibenthic megafauna and the presence of VME indicator taxa. Previous works describing the megafaunal community and VMEs from specific areas of the Flemish Cap slope have been derived from this analysis (see Beazley et al., 2013), and are currently in preparation (Beazley et al., in prep). For the purposes of review of the current NAFO closed areas, information from this analysis provides *in situ* ground truthing for observations derived from the groundfish surveys, and provides information on the natural habitat for smaller VME indicator taxa not adequately sampled by trawl gear.

Methods

In 2009, nine photographic transects were collected and subsequently analyzed from the Sackville Spur and western Flemish Cap slope/Flemish Pass region (called the Flemish Pass area herein) using the 4K camera ('4KCam') and Campod (Table 1). The 4KCam (Fig. 2a) can operate down to 4000-m depth, and houses a high-resolution digital camera and two flashes inside an aluminum roll cage. The system hovers along the seabed until it is lowered via a winch to trigger the camera and flashes. Campod (Fig. 2b) is a tripod camera system that is equipped with two video cameras, one oblique-facing and one downward-facing, and a single digital camera for high resolution photos (downward-facing). Campod is controlled on deck via a winch, and hops along the seabed collecting video continuously and images at a predetermined interval. Although video footage of the seabed was continuously recorded on the 'Campod transects', only the still photos were analyzed as part of this study.

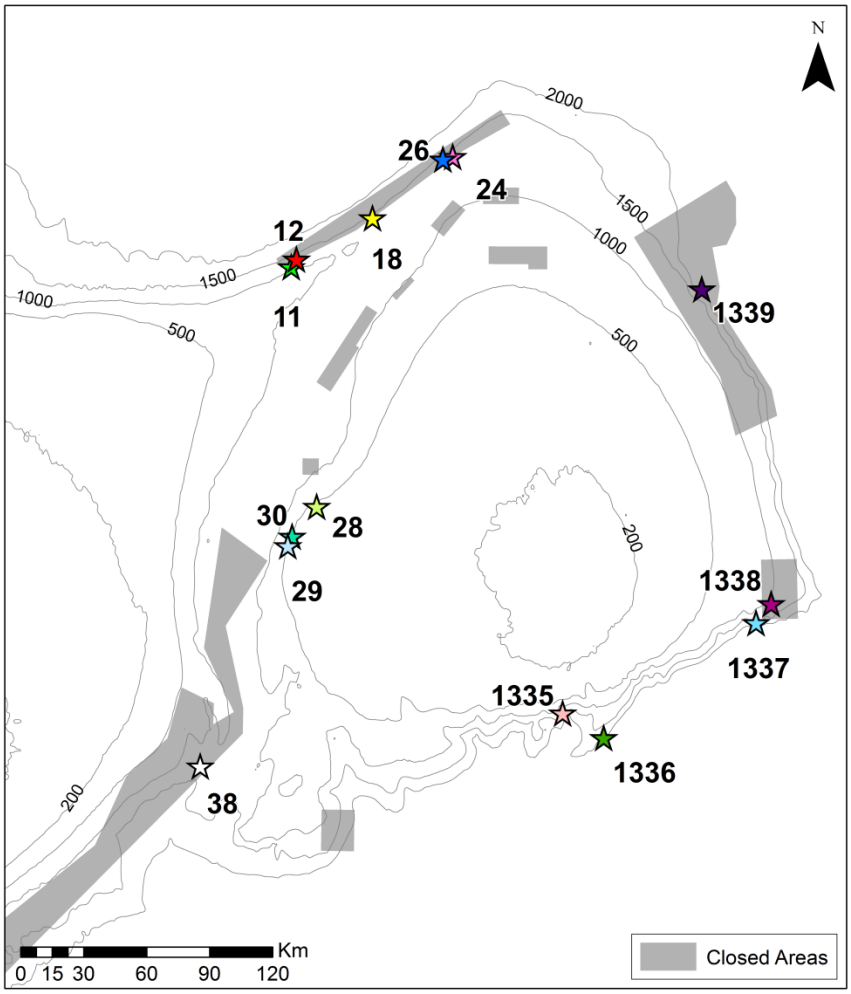

Figure 1. Location of benthic imagery transects collected and analyzed as part of the NEREIDA program. Transects are labelled with their consecutive operation number. Details of each transect are outlined in Tables 1 & 2.

Table 1. Summary of the benthic imagery collected and analyzed from the *Hudson* 2009 cruise to the Flemish Cap area.

Location	Transect ID	Inside closure?	Gear	Transect length (m)	Depth range (m)	# Photos
Sackville Spur	11	Mostly	4KCam	6 211	1080 – 1545	167
	12	Yes	4KCam	6 343	1313 – 1723	172
	18	Yes	4KCam	5 238	1336 – 1478	92
	24	Yes	4KCam	4 974	1290 – 1427	145
	26	Yes	4KCam	3 212	1381 - 1409	38
Flemish Pass area	28	No	Campod	2 431	461 - 479	92
	29	No	Campod	3 197	444 - 471	132
	30	No	4KCam	6 101	455 - 940	174
	38	Yes	4KCam	2 978	1328 - 1411	75

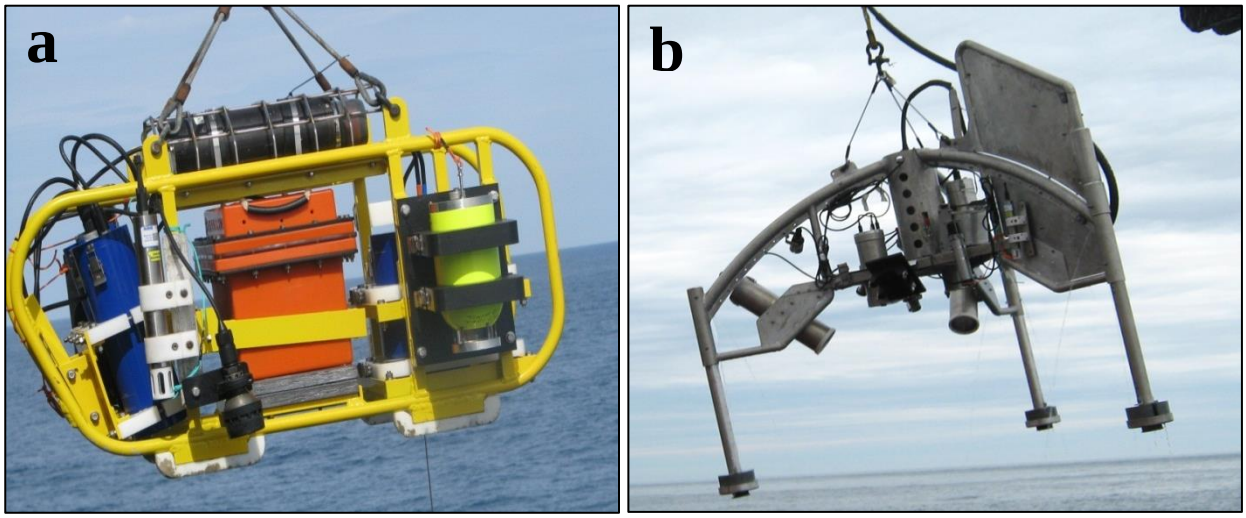

Figure 2. a) 4K camera (4KCam) and b) Campod camera systems used to collect benthic imagery during the 2009 *Hudson* cruise on the Flemish Cap.

Table 2 summarizes the details of the analyzed transects that were collected using the ROV ROPOS (Fig. 3a) during the *Hudson* 2010 cruise to the Flemish Cap. ROPOS (Remotely Operated Platform for Ocean Science), a tethered submersible, was used to collect high-resolution video and images of the seabed. Downward- and forward-facing video was continuously recorded for each ROPOS dive (note that only downward-facing video was analyzed for this study). Depending on the objective of the ROPOS dive, some ROPOS transects were split into different 'modes' ('transect' and 'explorer' mode; see Fig. 3b for example). During 'transect mode', the ROV was kept at a constant speed and distance from bottom, and travelled towards a predetermined waypoint without stopping. During 'explorer mode', the route to the waypoints was directed by the investigators and was biased towards interesting observations. During 'explorer mode' the ROV was often stopped to collect photographs and specimens.

Due to their different objectives, the method used to analyze each transect varied. For instance, on transect 1335 and the explorer mode portions of transect 1337, only those megafauna that were large (~10 cm) and clearly visible were recorded. Transect 1336 was not analyzed in detail after its collection, and thus only the megafauna recorded during the *in situ* collection of the video was summarized. For transect 1338, three sections of the transect (one trawled line, two untrawled lines; ~ 3 km in total) were analyzed every 10 m for corals and sponges only, but non-coral and sponge VME indicators were extracted from the *in situ* collection of the video. All visible megafauna were analyzed from the entire length of transect 1339.

Table 2. Summary of the benthic video collected and analyzed using the ROV ROPOS in 2010 during the *Hudson* cruise to the Flemish Cap (FC) area.

Location	Transect ID	Inside closure?	Transect length (m)	Depth range (m)	Analysis details
Southern FC slope	1335	No	8 292	873 - 1853	Explorer mode. Analyzed in detail; frame by frame.
	1336	No	11 555	2212 – 2970	Explorer mode. Transect not analyzed in detail ('live' recordings summarized).
Southeast FC slope	1337	No	14 475	1011 – 2191	Transect and explorer mode. Explorer mode analyzed frame by frame; every 10 m analyzed for transect modes.
	1338	Yes	11 195	1029 - 1088	Explorer and transect. Three sections were analyzed (1 trawled, 2 untrawled) every 10 m for the abundance of sponges and corals. Non-coral and sponge observations extracted from 'live' recordings.
Northeast FC slope	1339	Yes	8 624	1344 - 2462	Explorer mode. Data extracted from 10 m intervals.

Only epibenthic megafauna, defined as the group of organisms ≥ 1 cm living on or close to the seabed, were recorded for both the 2009 photographic and 2010 video analysis. Organisms were identified down to the lowest taxonomic classification possible. Taxonomic identifications were aided by voucher specimens collected during the ROPOS 2010 and the 2009/2010 NEREIDA surveys onboard the RV *Miguel Oliver*. The Integrated Taxonomic Information System was used as the taxonomic authority. Organisms that could not be identified down to the species level were given mutually exclusive morphotype designations at the genus level or higher based on superficial features.

All potential VME indicator taxa were extracted for each transect. These taxa were grouped into broad categories based on the common name of its taxonomic group following Table 1 of NAFO (2012). Taxa identified to the family level and above that could possibly represent VME indicator species were included in the analysis. For instance, all members of the Family Polymastiidae were included as they may potentially be Polymastia spp., a VME indicator taxon.

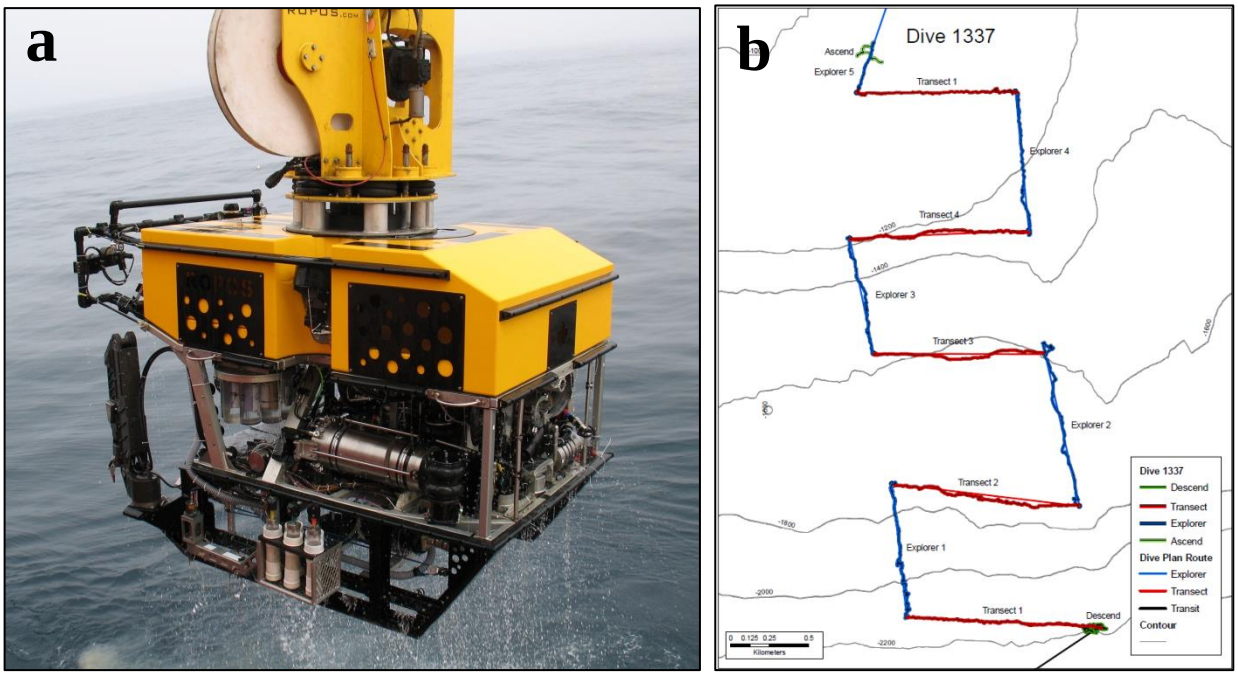

Figure 3. a) ROV ROPOS used to collect benthic imagery during the *Hudson* 2010 cruise to the Flemish Cap; b) example of a ROPOS transect consisting of both transect (red) and explorer (blue) modes.

Results

Of the 9 VME indicator groups listed in NAFO (2012), 6 were represented on the transects in the Flemish Cap area. Observations on the presence of each group are discussed in detail below. No taxa from the sea squirt, erect bryozoan, and stony coral VME indicator groups were observed on any of the transects. Although black corals are no longer considered VME based on their broad distribution in the NRA and low impact on ecosystem functioning (discussed in Murillo et al., 2011a), given their low rates of growth, fecundity, and recruitment (Grigg, 1989), and extreme longevity (Roark et al., 2009), their presence on the transects was assessed. For the purposes of consistency, black corals are referred to as a VME indicator group in this document along with the other 6 groups observed.

Due to the difference in sampling gear and thus area sampled between the 2009 and 2010 data, only VME group presence, not abundance, is displayed. However, notable comments on the abundance of each VME indicator group and their constituent taxa are made.

Small gorgonian corals

Records of small gorgonians (Fig. 4) consisted almost entirely of *Acanella arbuscula*, with a single unknown isidid coral observed in the Flemish Pass area. *A. arbuscula* occurred in low

abundances on nearly all transects and were absent from the majority of the Sackville Spur. However, this species had a continuous distribution near the end of transect 1335 on the southern Flemish Cap slope.

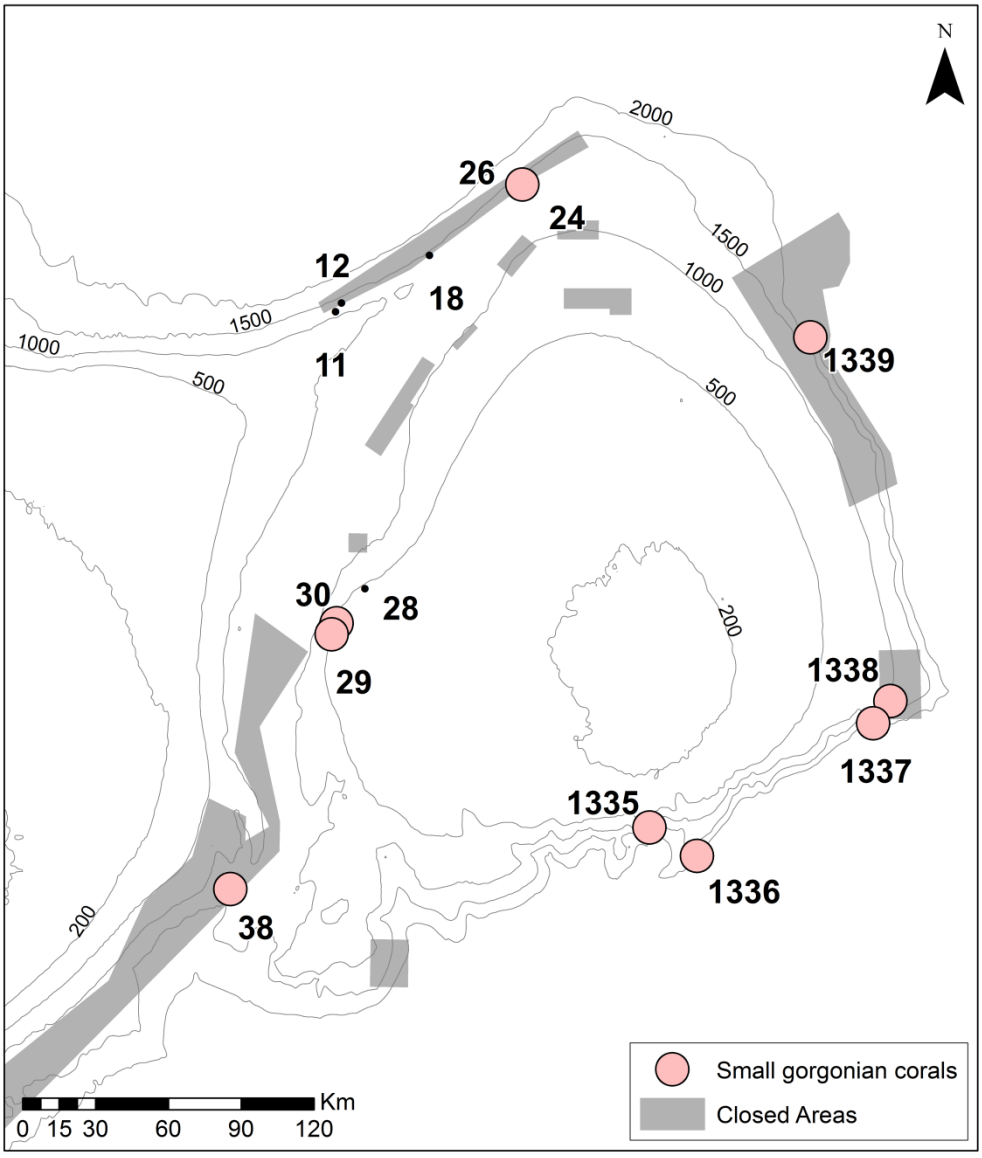

Figure 4. Presence of small gorgonian corals (pink circles) on each transect. Small circles indicate the absence of small gorgonians on the transect.

Large gorgonian corals

Large gorgonians were not observed in the Flemish Pass area, but were present on the two westerly Sackville Spur transects and all transects from the northeast, southeast, and southern

Flemish Cap slope (Fig. 5). All taxa belonging to this group were observed in low abundances. Some species observed included *Primnoa resedaeformis*, *Keratoisis* sp., *Paramuricea* spp., and *Acanthogorgia* sp. Three *Parastenella atlantica* colonies were observed on transect 1337, and several *Corallium* sp. colonies were observed on transects 1337 and 1339. *Paragorgia johnsoni* was observed on transect 1339, which may represent the northerly-most record of this species in the northwest Atlantic (see Murillo et al., 2011b for previous record). A more northerly record of *P. johnsoni* may exist for the northeast Atlantic (see Copley et al., 1996).

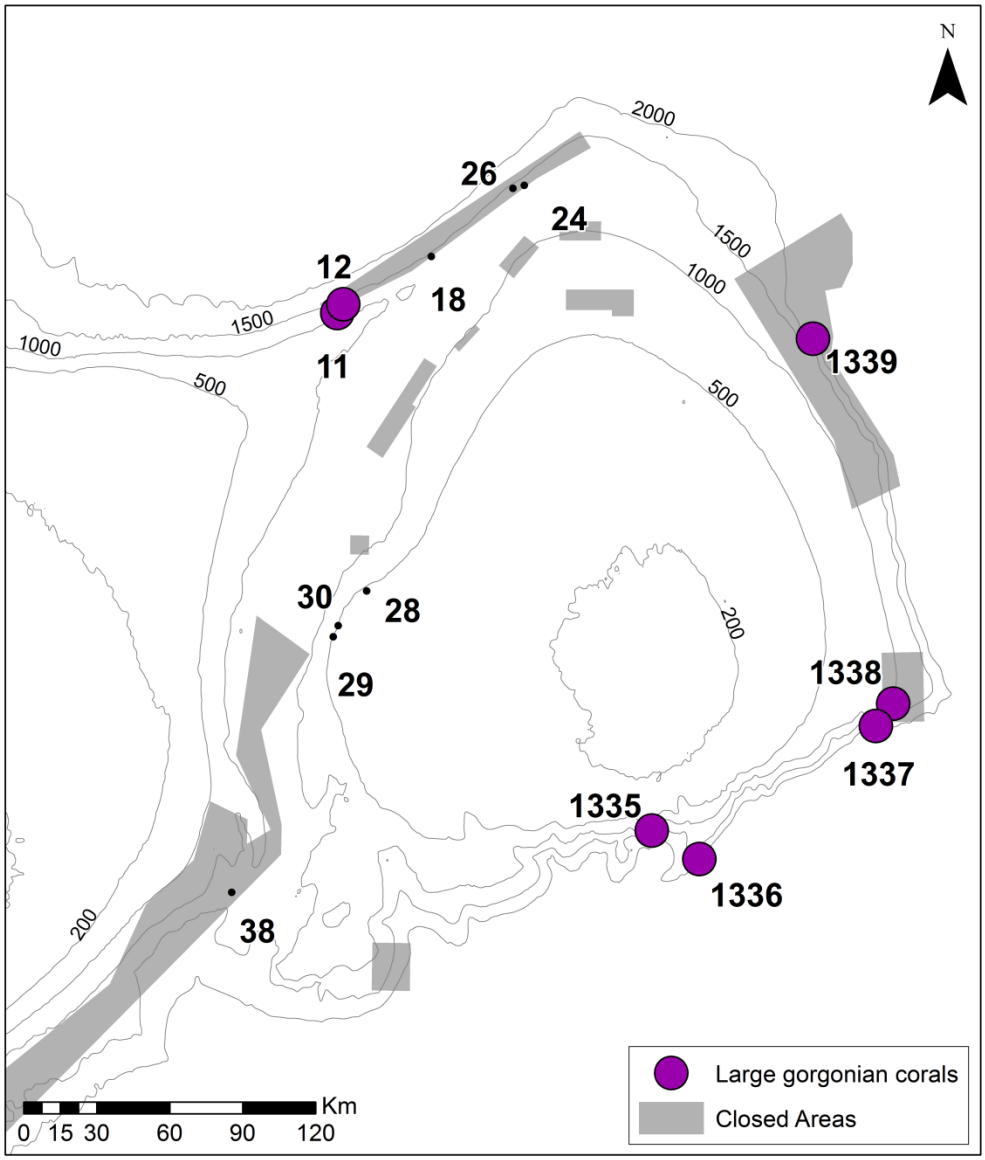

Figure 5. Presence of large gorgonian corals (light purple circles) on each transect. Small circles indicate the absence of large gorgonians on the transect.

Black corals

Black corals were present in low abundances (1-2 colonies) on several transects in the Flemish Pass area and southern Flemish Cap slope (Fig. 6). *Stauropathes magna* was observed in the Flemish Pass, while a single record of *Telopathes magna*, a newly described species of black coral (Macisaac et al. 2013), was observed on transect 1335 on the southern Flemish Cap slope.

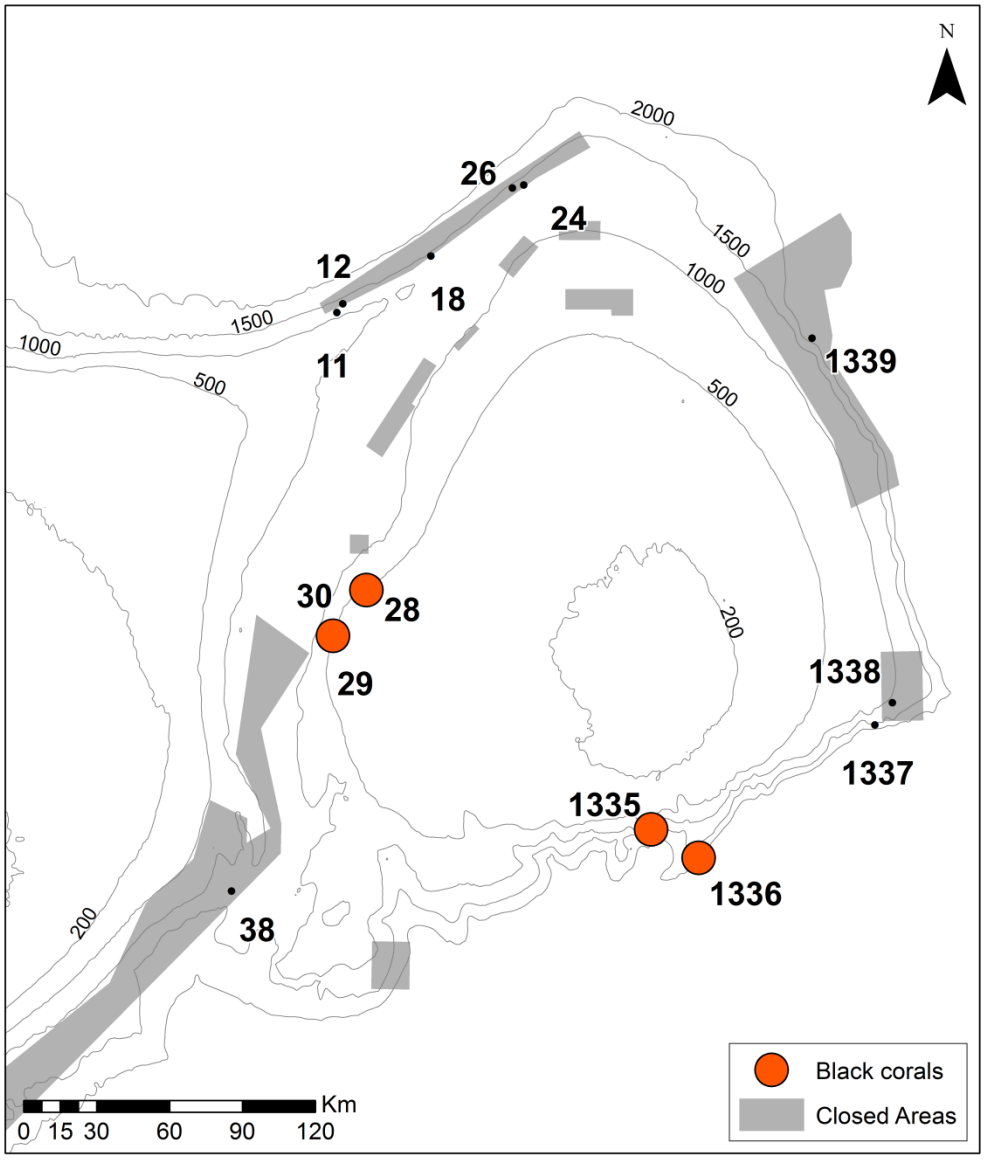

Figure 6. Presence of black corals (orange circles) on each transect. Small circles indicate the absence of black corals on the transect.

Sea pens

Several species of sea pens were observed in the Flemish Cap area (Fig. 7). However, no species occurred in dense concentrations and therefore do not constitute VMEs. *Kophobelemnon* sp. was the most abundant of all sea pens observed, and occurred on transect 30 in the Flemish Pass. *Pennatula* spp., *Anthoptilum* sp., and *Halipteris* sp. were also observed in the area.

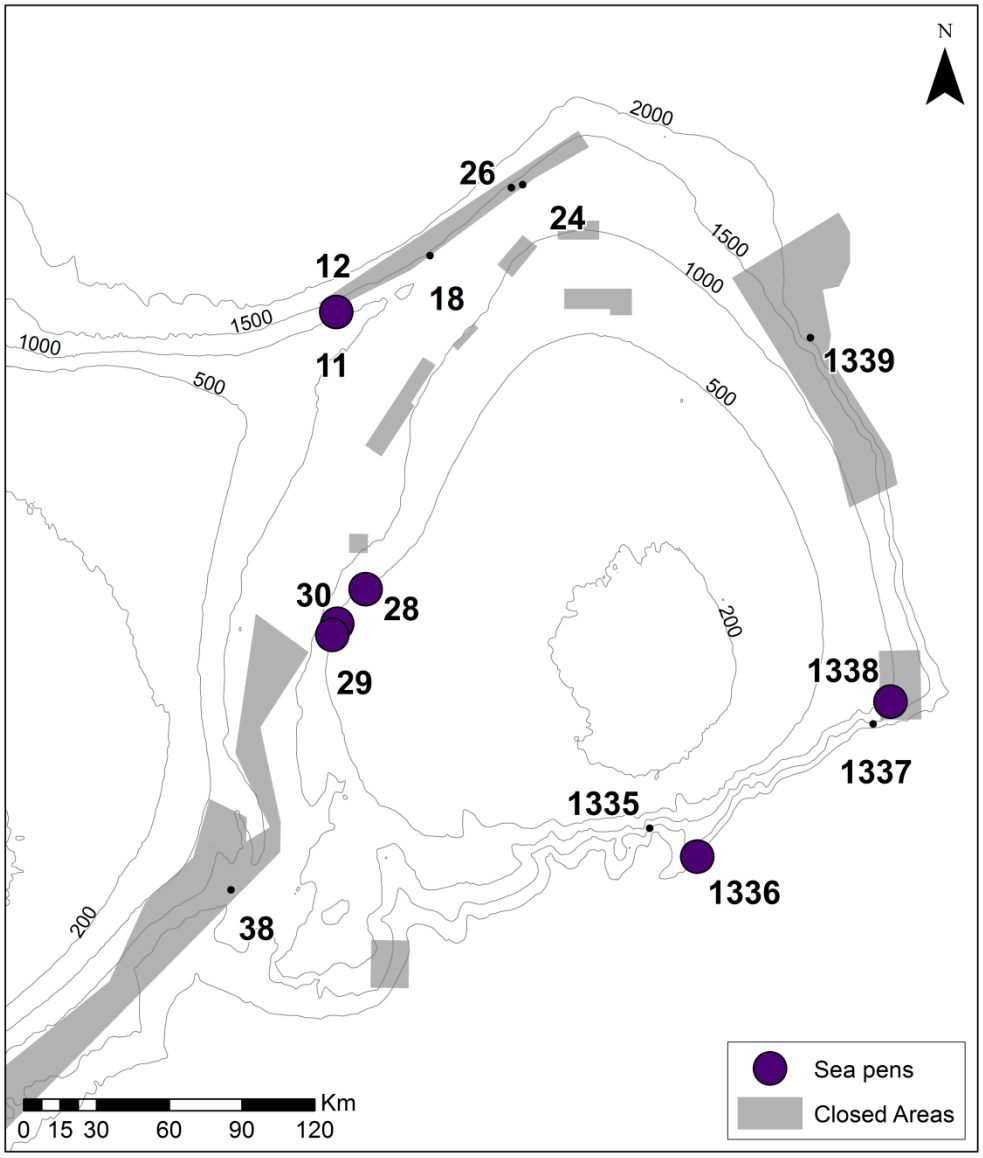

Figure 7. Presence of sea pens (dark purple circles) on each transect. Small circles indicate the absence of sea pens on the transect.

Tube-dwelling anemones

Tube-dwelling anemones were observed on several transects across the Flemish Cap (Fig. 8). The lack of taxonomic details from the photographs and video prevented the identification of these organisms past the family level (Cerianthidae). However, these cerianthids were not large, erect species, and do not appear to be the VME indicator species listed in NAFO (2012), *Pachycerianthus borealis*. Although their ability to form complex habitat for other species may be limited, these cerianthids formed dense fields (Fig. 9) on the southern Flemish Cap slope that may indicate VMEs, particularly if their bioturbation activities significantly affect infaunal community structure.

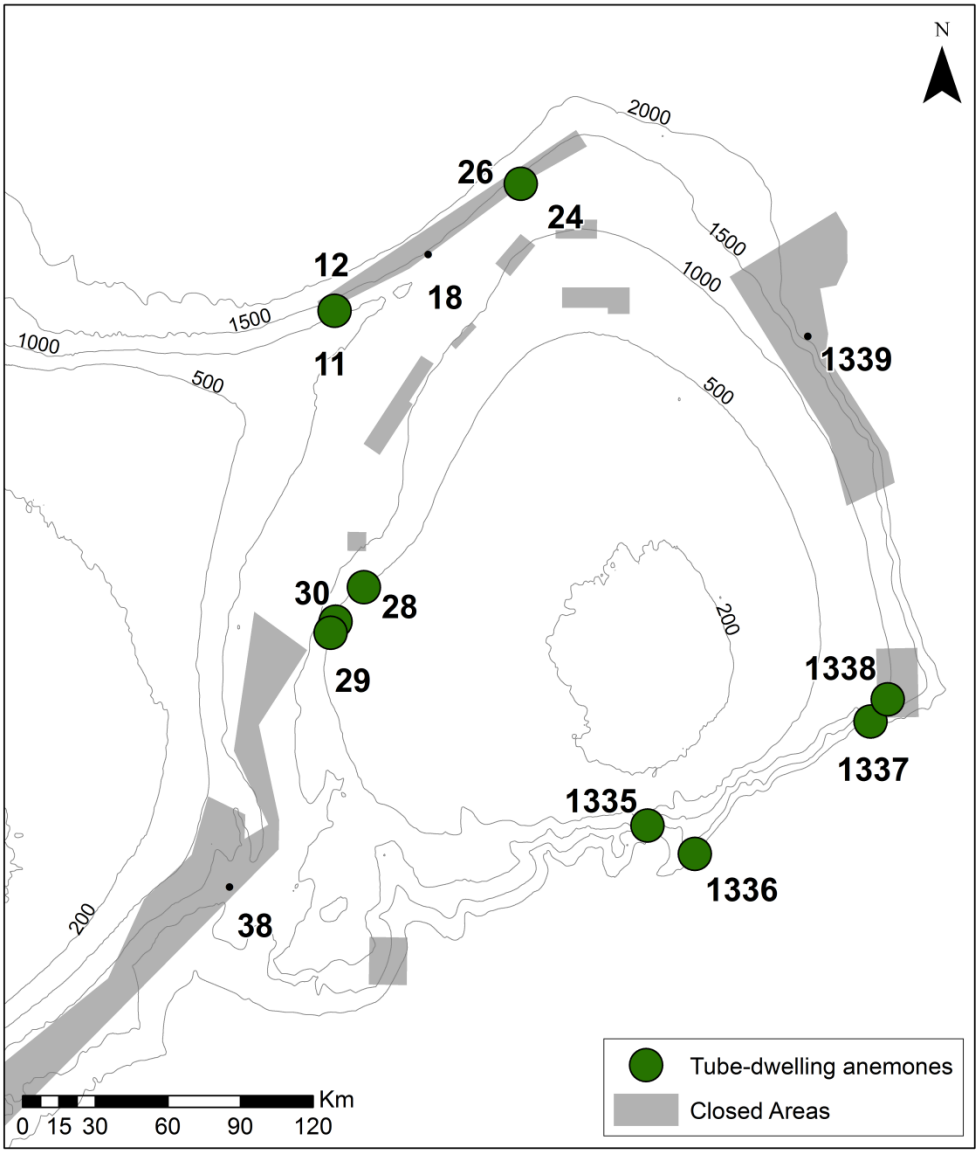

Figure 8. Presence of tube-dwelling anemones (green circles) on each transect. Small circles indicate the absence of tube-dwelling anemones on the transect.

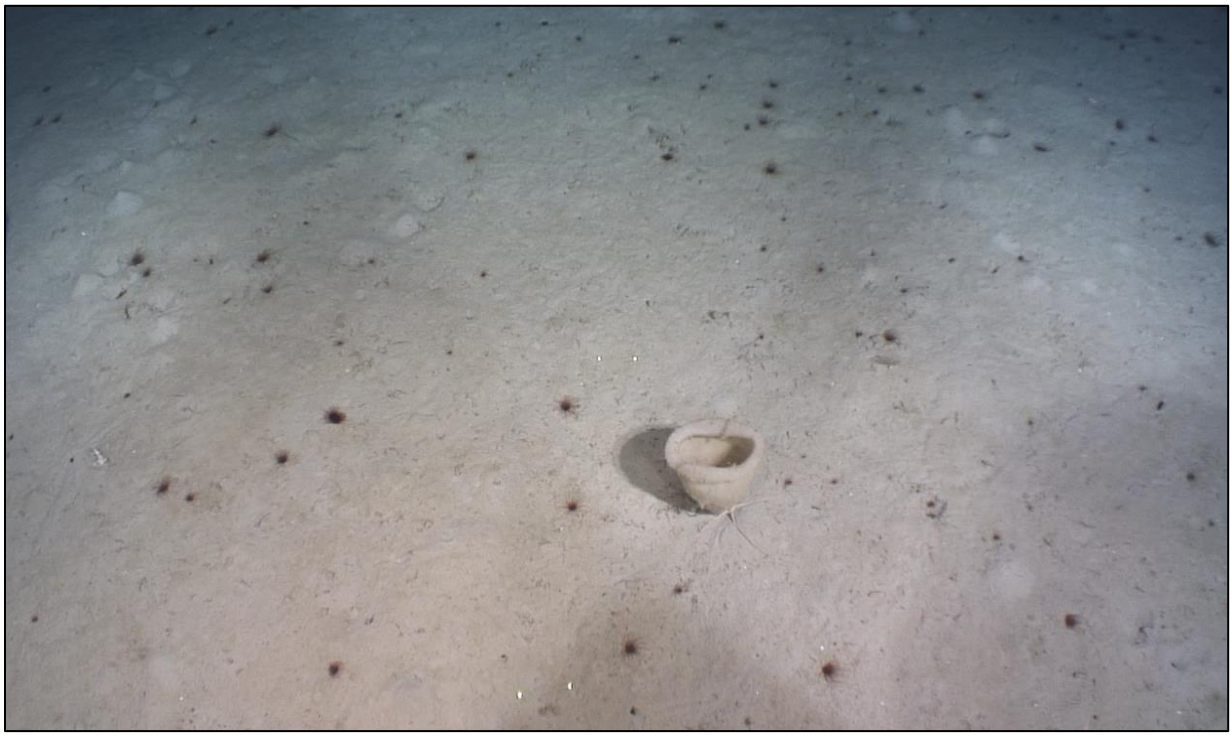

Figure 9. Field of cerianthid anemones on the southern Flemish Cap slope (transect 1335). Also shown is a vase sponge of the Family Rosselidae.

Large-size sponges

Dense aggregations of structure-forming sponges were observed at depths below 1300 m on the Sackville Spur, Flemish Pass, and on the Flemish Cap slope (Fig. 10). The main taxa forming these sponge aggregations were members of the Family Geodiidae. Unknown members of the Order Astrophorida were present in high abundances on the ROPOS 2010 transects. At shallower depths sampled in the Flemish Pass (~450 – 950 m), fan-shaped sponges (Family Axinellidae) and polymastiid sponges were the dominant structure-forming taxa. Large-sized sponges were not observed on transect 1336. However, this may be due to the low taxonomic resolution of the identifications of taxa on this transect and the grouping of structure-forming sponges with other sponges at the phylum level.

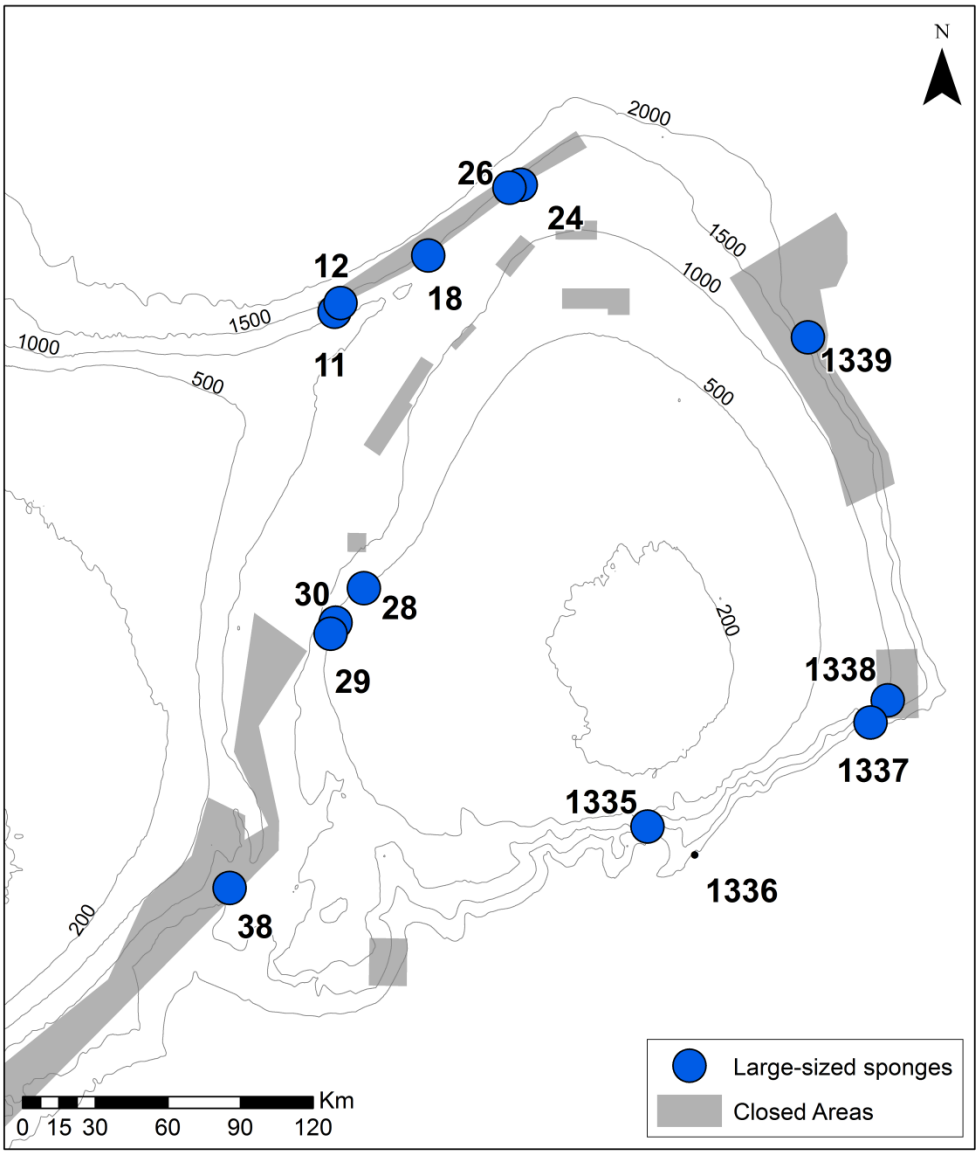

Figure 10. Presence of large-sized sponges (blue circles) on each transect. Small circles indicate the absence of large-sized sponges on the transect.

Sea lilies (*Crinoidea*)

The stalked crinoid *Conocrinus lofotensis*, a VME indicator species, was observed in high abundances on the Sackville Spur, but was completely absent from the Flemish Pass area. Video analysis revealed dense fields of the stalked crinoid *Gephyrocrinus grimaldii* on the southern, southeastern, and northeastern slope of the Flemish Cap. This species was completely absent on transects from the Sackville Spur and Flemish Pass area. Unstalked crinoids were not observed in high abundances on any transect analyzed.

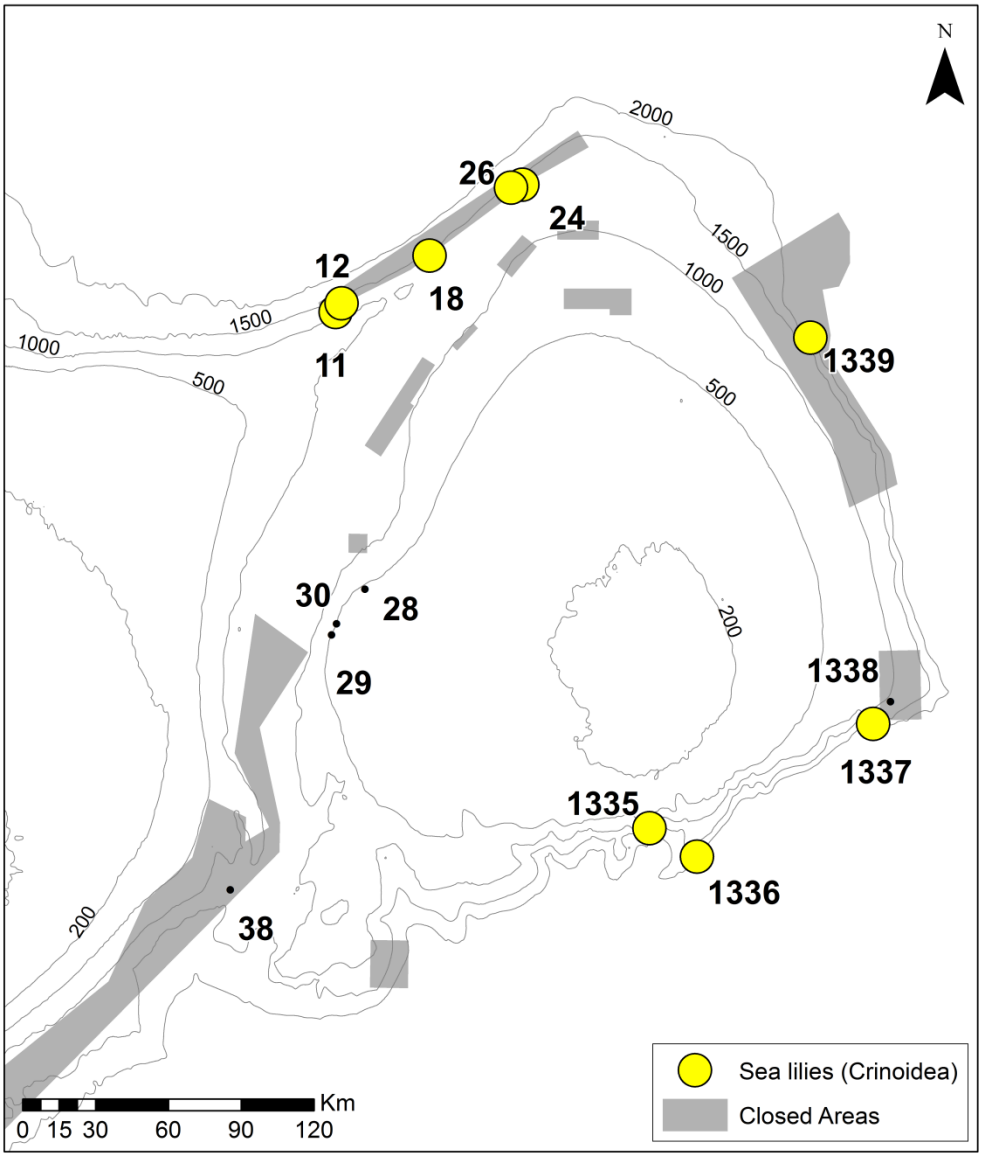

Figure 11. Presence of sea lilies (Crinoidea; yellow circles) on each transect. Small circles indicate the absence of sea lilies on the transect.

Summary

The presence of the 6 VME indicator groups on each transect is shown in Table 3. This table allows for the comparison of the VME indicator groups observed within and outside of the NAFO closed areas. Of all VME groups, black corals were present on the fewest number of transects, while large-sized sponges were present on nearly all transects. Transect 18 in the Sackville Spur and transect 38 in the Flemish Pass, both located in closed areas (Areas 6 and 2, respectively), had the fewest VME indicator groups present (2 of 7). The two transects on the southern slope of the Flemish Cap (1335 and 1336), which currently do not fall within a closed

area, had the most VME groups present (6 of 7), with sea pens absent from 1335, and large-sized sponges absent from 1336, although the latter could be a function of the low resolution of the taxonomic identifications on this transect (see Table 2 and text under the ‘Large-sized sponges’ header). Overall this suggests that the southern Flemish Cap slope may be a hot spot for the presence of potential VME indicators.

Table 3. Presence of potential VME indicator taxa grouped by their common name as per NAFO (2012). Transects are grouped by location with respect to the closed areas. Note that transect 11 falls partially outside of closure area 6.

	Transect	Closure area description	Location	VME Common Name						
				Small gorgonian corals	Large gorgonian corals	Black corals	Sea pens	Tube-dwelling anemones	Large-sized sponges	Sea lilies (Crinoidea)
Inside Closure	11	Sackville Spur (Area 6)	Sackville Spur		X		X	X	X	X
	12				X				X	X
	18								X	X
	24			X				X	X	X
	26								X	X
	38	Flemish Pass/Eastern Canyon (Area 2)	Southern Flemish Pass	X					X	
	1338	Eastern Flemish Cap (Area 4)		X	X		X	X	X	
	1339	Northeast Flemish Cap (Area 5)	Northeast FC slope	X	X				X	X
Outside Closure	28		Flemish Pass area			X	X	X	X	
	29			X		X	X	X	X	
	30			X			X	X	X	

1335	Southern FC slope	X	X	X		X	X	X
1336		X	X	X	X	X		X
1337	Southeast FC slope	X	X			X	X	X

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