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Report of the Working Group on Deep-water Ecology (WGDEC), 4-7 December 2005, Miami, USA.

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International Council for the Exploration of the Sea

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Contents

1 Introduction

1.1 Participation

The following members of the Working Group on Deep Water Ecology (WGDEC) participated in producing this report (see Annex 1 for addresses).

Peter Auster*	USA
Robert Brock	USA
Sabine Christiansen	Germany
Anthony Grehan	Ireland
Jason Hall-Spencer	UK
Kerry Howell	UK
Emma Jones*	UK
Gui Menezes*	Portugal
Pål Mortensen*	Norway
Karine Olu	France
Murray Roberts	UK
Steve Ross	USA
Sigmar Steingrímsson	Iceland
Mark Tasker (chair)	UK

* = unable to be in Miami, but contributed from afar.

1.2 Terms of Reference

The 2005 Statutory meeting of ICES gave the Working Group on Deep Water Ecology the following terms of reference:

a) compile a list of seamounts in the OSPAR area and classify them initially on the basis of physical attributes;

b) on the basis of evidence to be sought from fisheries managers and other sources, review the distribution of fishing activity on seamounts;

c) review possible classifications of deep-water habitats in the North Atlantic and frameworks for describing sensitivity to fishing activities;

d) examine possible ways of describing fish communities on seamounts;

e) report on new information on the distribution and status of cold water corals in the North Atlantic and recommend ways by which information on the occurrence of these species might be made more easily available and kept up to date;

A further term of reference requested that the Chairs of WGDEC and WGDEEP cooperate to ensure that expertise on cold-water corals and on deep-water fishing was available at the meeting.

1.3 Justification of Terms of Reference

The group's first report provided scientific background to advice requested by OSPAR on threats to seamount habitats in the NE Atlantic. The group encountered a number of problems in responding to the relevant terms of reference on this issue. The first two and the fourth of this year' terms of reference address these difficulties.

1.4 Overview by the chair

The definition of "seamount" remains controversial. From a geological/geophysical perspective, such features are reasonably straightforward to describe, however biological (and more particularly biological conservation) perspective, there are a number of difficult issues. We know that the communities of organisms growing on or living near some seamounts are characteristically different from the surrounding seas in a similar way to communities on land mountains are different from those on the surrounding plains. Some of these seamounts protrude sufficiently high above the surrounding seabed and approach close enough to the sea surface that they may be accessible to fisheries – and the collateral environmental damage that can accompany fisheries. This combination of features – unusual or unique marine communities, coupled with risk of damage from fishing - means that seamounts have become important areas to protect and conserve in the eyes of those wishing to safeguard marine biodiversity. However, it is plain that not all seamounts are the same, either a biodiversity aspect or from a vulnerability to fishing pressure. In addition the number of "seamounts" will vary depending on the precise definition used. In an ideal world, all seabed communities on seamounts and elsewhere would be surveyed and mapped and then a representative proportion could be chosen for protective measures. Such an ideal though is never likely to be achieved, so a proxy using known physical properties may be a way forward. To this end, the report classifies seamounts (using the current OSPAR definition) on the basis of a number of physical properties. A start has also been made on understanding the likely fishing pressure on these. A full review (and mapping) of fishing pressure on all OSPAR area seamounts would be possible, but not without considerably more resources than are available to the working group at present.

Two further terms of reference looked at ways of classifying deep-water habitats and fish communities on seamounts in the North Atlantic.

Our final term of reference this year was to report on new information on cold water corals in the North Atlantic. Compared with some previous years, rather little information was forthcoming to the working group, but we know that further information has been gained from surveys and research projects that was not made available to the group. We hope to describe this information in future years.

1.5 Acknowledgements

We would like to thank NEAFC, SEERAD and JNCC for access to the VMS data. Bernd Christiansen, Stefan Hain, Stephanie Blouin, Filipe M. Porteiro, Andreia Braga Henriques and Oscar Ocaña of the Department of Oceanography and Fisheries, University of the Azores all helped by providing information or interpretation.

2 A list and classification of seamounts in the OSPAR Area

Term of Reference: compile a list of seamounts in the OSPAR area and classify them initially on the basis of physical attributes.

2.1 Summary

2.1.1 Definitions

In the context of OSPAR, seamounts are defined as undersea mountains, with a crest that rises more than 1,000 metres above the surrounding sea floor (originally Menard, 1964). Seamounts can be a variety of shapes, but are generally conical with a circular, elliptical or more elongate base. Seamounts are volcanic in origin, and are often associated with seafloor ‘hot-spots’ (thinner areas of the earth’s crust where magma can escape). Seamounts, often with a slope inclination of up to 60°, provide a striking contrast to the surrounding ‘flat’ abyssal plain. Their relief can have profound effects on the surrounding oceanic circulation, with the formation of trapped waves, jets, eddies and closed circulations known as Taylor columns (Taylor, 1917).

This definition is primarily topographical and geological. This has its difficulties in the context of conservation of biodiversity. There is nothing particularly important biologically about any specific height above the seabed, or shape. A consequence of this is that the term seamount has begun to be applied to structures of a lower elevation above the sea floor, including those of only a few tens of metres high (e.g., Epp and Smoot, 1989; Rogers, 1994). A forthcoming book (which is biological rather than geological) defines a seamount as any topographically distinct seafloor feature that is at least 100 meters high but which does not break the sea surface, excluding large banks and shoals (e.g. Georges Bank, Porcupine Bank) as well as topographic features on continental shelves. We review these definitions in the following sub-sections.

All definitions based on physical characteristics (e.g. height) are equally as arbitrary as the original 1000m height definition, but widening any definition brings with it the added complication that not all seabed in the OSPAR area has been surveyed and certainly has not been classified. If there were many habitat locations, it would also seem unlikely that there would be any evidence that could justify the habitat thus defined as a whole as being threatened and declining.

2.1.1.1 OSPAR

Based on Menard (1964, quoted and confirmed in a review of seamount literature by Rogers 1994), OSPAR uses the following criteria for defining seamounts (for mapping purposes):

- structures rising more than 1000 m from the seafloor,
- of volcanic origin, often associated with seafloor “hot-spots”
- of a variety of shapes, but generally being conical, circular or more elongate base

The shape and slope angles encountered at seamounts (up to 60°) are expected to exert a significant influence on oceanic circulation and possibly productivity. Enhanced currents contribute in keeping sediment veneer low on the basaltic hard substrate sediment. Therefore seamounts are considered to constitute a particular habitat, in difference to the habitats of the surrounding flat abyssal plains.

OSPAR received site nominations from its Contracting Parties and observers and checked the 1000m elevation criterium using available bathymetry data. Of 39 nominated features only 24 were considered for being a seamount according to the OSPAR working definition, 9 of them in areas beyond national jurisdiction.

2.1.1.2 The General Bathymetric Chart of the Oceans (GEBCO)

Most of the seamounts mapped by OSPAR were identified as a “seamount" in earlier versions of the GEBCO ‘Undersea features’ database published by the International Hydrographic Organisation and the Intergovernmental Oceanographic Commission (see http://www.ngdc.noaa.gov/mgg/gebco/). The GEBCO terminology is standardised and both terminology and features listed are regularly updated. The recent list of undersea features was published in December 2005.

The GEBCO terminology guidelines (2001) define seamounts as:

- a discrete (or group of) large isolated elevation(s), greater than 1000m in relief above the sea floor, characteristically of conical form. Guyots are those seamounts having a comparatively smooth flat top. The database and maps identify individual seamounts, seamount chains (a linear or arcuate alignment of discrete seamounts, with their bases clearly separated) and seamount provinces. Further, knolls and hills are distinguished, both seafloor elevations of less than 1000m.

The GEBCO definition does not distinguish between seamounts of volcanic origin and those of continental or tectonic origin. Some structures considered as seamounts in earlier versions of GEBCO, such as Josephine Seamount, were considered as a bank in 2005. The GEBCO definition of a bank is:

- An elevation of the sea floor, over which the depth of water is relatively shallow, but sufficient for safe surface navigation.

This means that the term seamount is applicable also to banks, if the other criteria (see above) are met.

2.1.1.3 Epp and Smoot (1989)

Epp and Smoot (1989) in an analysis of multi-narrow-beam bathymetric data from the US Naval Oceanographic Office used the term seamount for all circular or elliptical features of volcanic origin, regardless of size, including those where flanking rift zones or slumping alter the basic circular or elliptical shape. They identified 810 seamounts of a minimum height of 50 fathoms (93 m) in the North Atlantic between the equator and 70°N.

2.1.1.4 Kitchingman & Lay (2004)

Kitchingman & Lay (2004) inferred a potential global seamount distribution from a set of algorithms applied to a digital global elevation map, derived from satellite gravimetry data and distributed by the U.S. National Oceanographic and Atmospheric Agency (NOAA). They assumed that a possible seamount should have a rise of 1000m or more from the seabed and should be roughly circular or elliptical in shape. The occurrence of volcanic activity was not a defining parameter. Ground truthing was performed on a dataset of known seamounts set at a 30-minute resolution and produced from a combination of data from the US Department of Defence Gazetteer of Undersea Features (1989) and SeamountsOnline (see http://seamounts.sdsc.edu). It was found that approximately 60% of the known seamounts were within 30 minutes (=30 nm) of predicted seamounts.

This method overcomes the limitations of global bathymetry data coverage, however the result of the analysis is highly dependent on the inclination (or degree of change in depth), deviation from ideal shape and summit area allowed. Ridge-like structures were excluded. A conservative approach was taken, indicating that the 2700 seamounts identified for the whole Atlantic Ocean are rather an under- than an overestimate.

2.1.2 Classification

The discrepancies between the various maps of NE Atlantic seamounts, either derived from satellite gravimetry or produced from traditional bathymetry, point to the significance of resolution and scale of the bathymetric information. Swathmapping is available from only a few areas of limited extent. Most of the bathymetric information therefore stems from point measurements, accumulated over the last 120 years. Data coverage is poor in some areas and, in particular where elevation changes rapidly, insufficient for the resolution of topographic structures of limited extent. In addition, bathymetric information of topographic features may be scattered over various labs and not readily available, although recently there has been some effort to collate information about seamounts in central databases.

Due to the unreliability of satellite-derived bathymetry, we made a conservative approach to compile the new list of seamounts >1000 m in the OSPAR region (Table 2.1.2.1), mapped in Figure 2.1.2.1 with Figures 2.1.2.2 – 2.1.2.4 showing details from specific regions. The list is based mainly on the latest GEBCO undersea features list. Since information about the geological origin is not available for all seamounts, we did not apply this criterion. Additional information was gathered from various sources, including a.o. GEBCO charts 508 and 973, International Bathymetric Chart of the Arctic Ocean (IBCAO), WWF/Rogers 2001, EarthRef Seamount Catalogue, IFREMER Bathymetric Chart of the Eastern North Atlantic. Names and synonyms from other lists of seamounts are provided. It is likely that further local names exist for some of the seamounts and we had difficulty matching some local names with locations used in this table, especially in the Azores area. The list is categorised into eight divisions

- summit inside euphotic zone
- summit above daytime depth of deep scattering layer
- summit below daytime depth of deep scattering layer but at a depth of less than 2000m
- summit depth more than 2000 m
- insufficient or unclear information
- unnamed seamounts identified from GEBCO/IBCAO bathymetry
- seamounts named on IFREMER chart
- immediately south of OSPAR boundary at 36°

The first four of these categories provide a possible biologically-meaningful classification, while the following three could hopefully one day be reclassified as one of the first four. Note that the submerged slopes of oceanic islands, many of which have the same origins as seamounts, have many geological and ecological features in common with seamounts.

Table 2.1.2 provides further information that might be used for classification including bottom depth, summit depth, general indication of size and shape and what is known of surface rock and overlying sediments.

The list is grouped in categories basically according to summit depth, as proposed in Pitcher *et al*. (in prep.). The list features three shallow seamounts with their summits reaching into the euphotic zone. The summit of 14 intermediate seamounts is above daytime depth of deep scattering layer. The total of 45 deep seamounts is subdivided into 21 with summits shallower than 2000m, i.e. potentially within reach of the fishing industry, and 24 with summits below 2000m. For eight seamounts there was insufficient information available. We added four unnamed features as examples for undersea elevations which probably qualify for the term seamount, but have not been accepted for the GEBCO list yet. The last category includes seamounts of the Horseshoe range lying just south of the OSPAR region.

From an ecological point of view, and taking into account what makes seamounts vulnerable to human activities, the criteria of greater than1000m height and of volcanic origin are of doubtful utility. There is still debate about whether some of the seamounts are of volcanic, continental or tectonic origin, and not all seamounts have been sampled geologically so far. Certainly the distribution of hard and soft substrates is more important for the ecological characteristics of undersea elevations than their geological origin. Note that oceanic islands, many of which have the same origins as seamounts, share many common features and ecological effects on their submerged slopes.

Finally, we will classify seamounts as being large or small, depending on whether their heights exceed 1500m (regardless of depth). This height separation is useful in isolating large seamounts, whose global distribution is well resolved by satellite altimetry, from small seamounts whose distribution must be inferred from local, acoustic mapping and therefore remain poorly sampled.

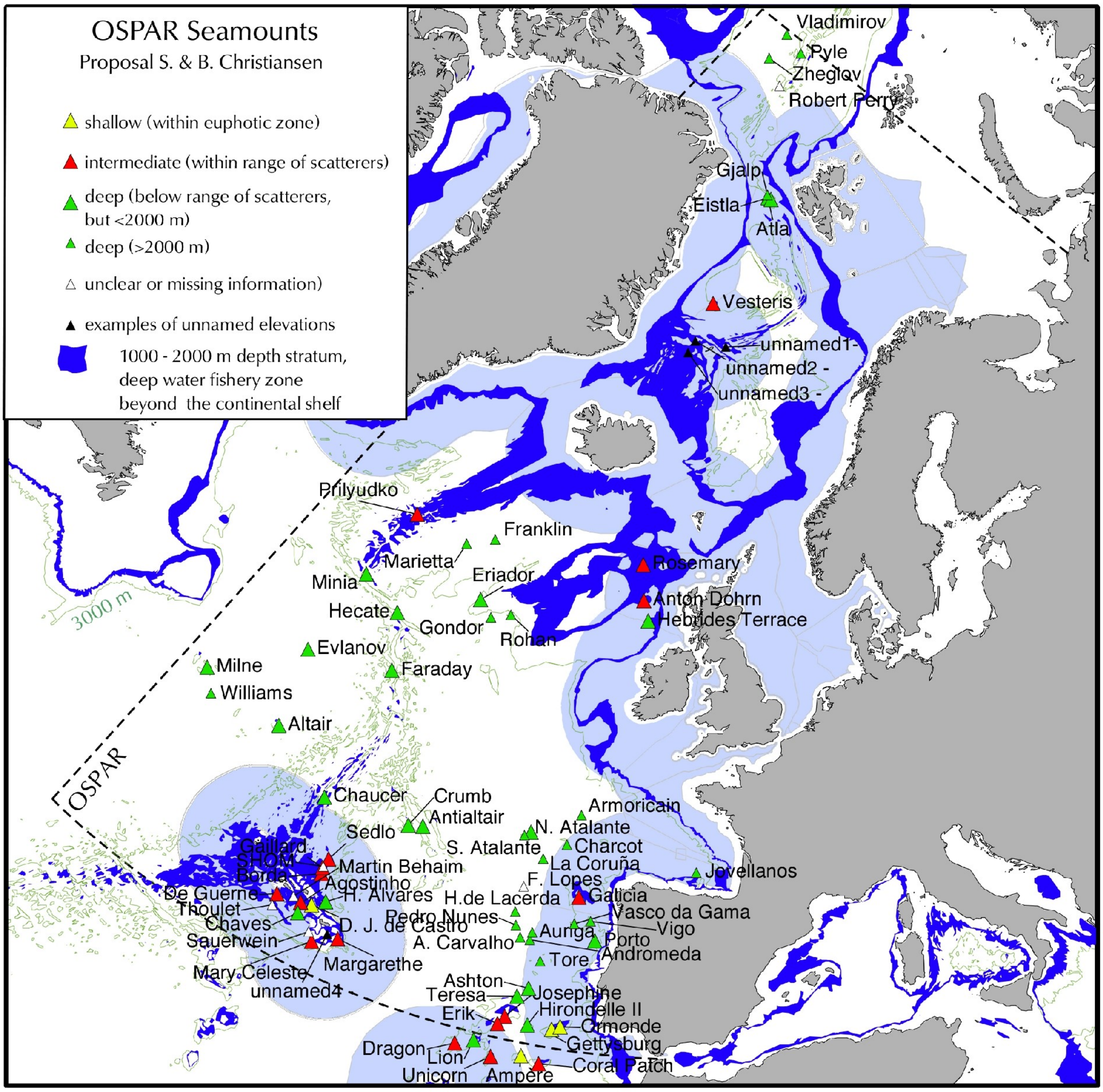

Figure 2.1.2.1 Seamounts in the OSPAR region

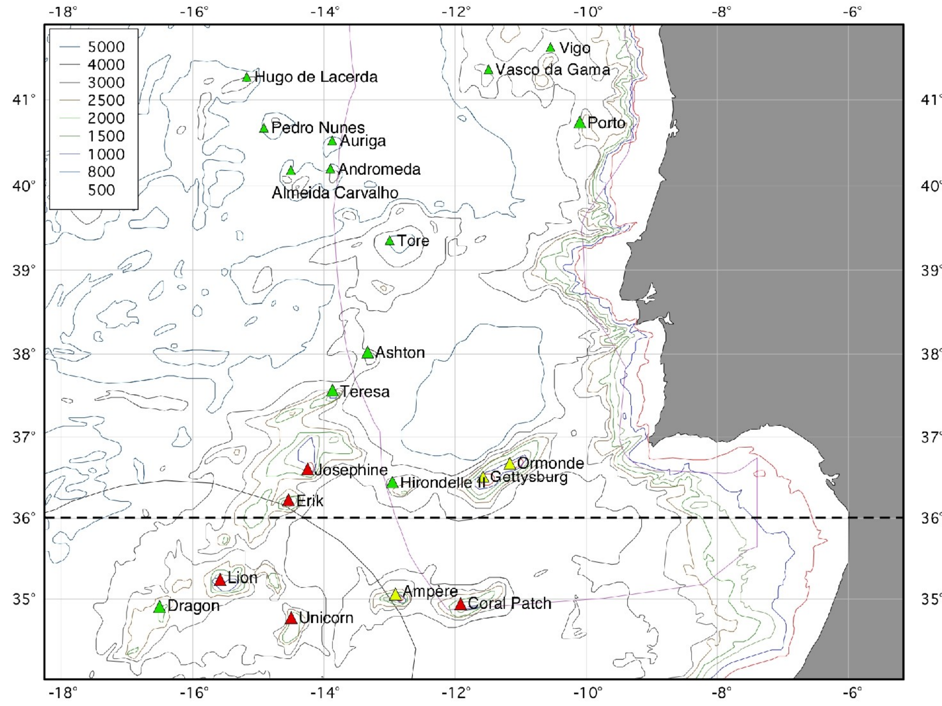

Figure 2.1.2.2. Detailed chart of seamounts in the Tore-Horseshoe region to the west of the Iberian peninsula. Legend as in Figure 2.1.2.1.

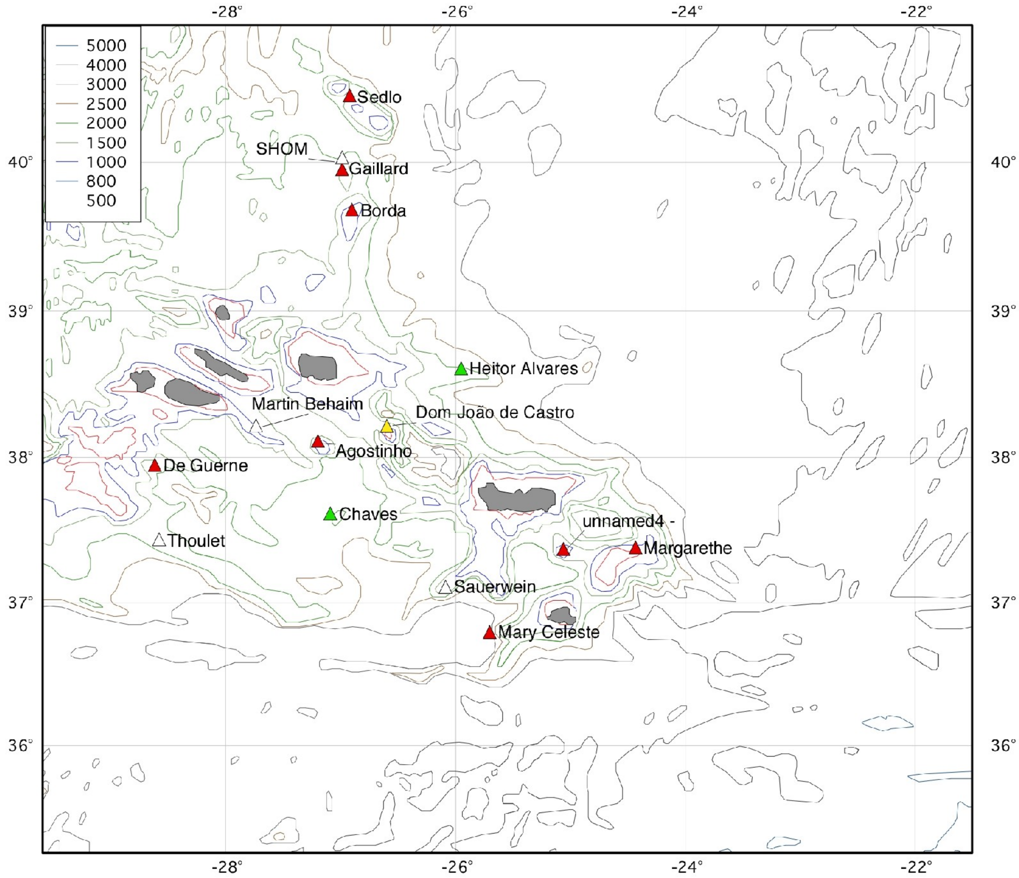

Figure 2.1.2.3 Detailed chart of seamounts in the Azores region. Legend as in Figure 2.1.2.1

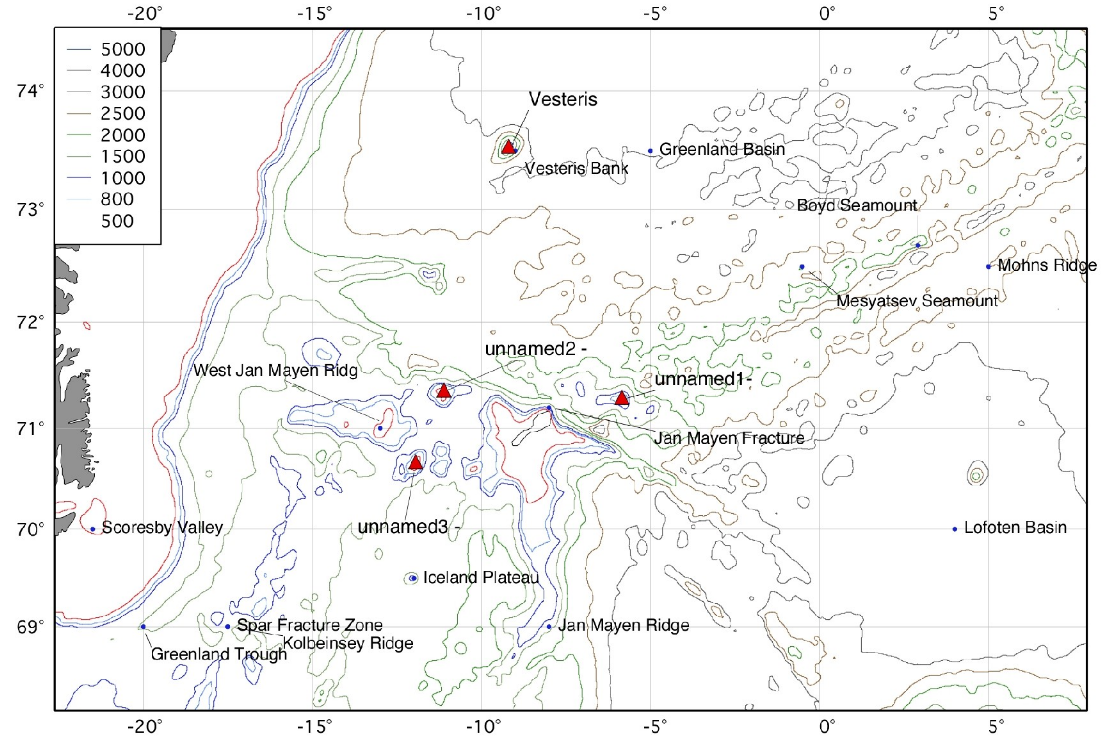

Figure 2.1.2.4 Detailed chart of seamounts in the Jan Myen-Vesteris region. Legend as in Figure 2.1.2.1

Table 2.1.1. List of known seamounts in the OSPAR area, categorised by depth of summit below sea surface.

		New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
Categories	No	Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
Category 1: summit inside euphotic zone	1	Dom Joao de Castro (Bank)	38.22	-26.63	Azores		Bank	Shown as Dom João de Castro Reef in ACUF Gazetteer.	x			Joao de Castro Bank
	2	Gettysburg	36.50	-11.58	Portugal	one of the two peaks of Gorringe ridge	Smt		x	x		Gettysberg Seamount
	3	Ormonde	36.67	-11.17	Portugal	one of the two peaks of Gorringe ridge	Smt		x	x		
Category 2: summit above daytime depth of deep scattering layer	1	Vesteris	73.50	-9.17	Greenland	GEBCO coordinates fit to available bathymetry	Smt	Shown as Bank in ACUF Gazetteer (December 1985).	x	x		Vesteris Seamount
	2	Josephine (Bank)	36.58	-14.25	High Seas		Bank	Shown as Seamount in ACUF Gazetteer, and on INT Charts 11-12-14.	x	x		Josephine Bank
	3	Rosemary (Bank)	59.20	-10.25	UK		Bank		x	x		
	4	De Guerne	37.93	-28.62	Azores	.	Smt					
	5	Margarethe (Seamounts)	37.37	-24.43	Azores	several other elevations < 500 m summit depth nearby	Smts					

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
	6	Mary Celeste (Seamounts)	36.78	-25.70	Azores	wrong position? If taken as unnamed peak NW of Margarethe	Smts					
	7	Anton Dohrn	57.42	-11.17	UK	on cont. Shelf	Smt		x	x		Anton Dohrn Seamount
	8	Galicia (Bank)	42.60	11.60	Spain	separated from the continental shelf by a channel that is between 2,500m and 3,000m deep.	Bank		x			Galicia Bank
	9	Prilyudko	57.02	-34.15	High Seas	outer Reykjanes ridge, region with several small elevations < 1000 m summit depth	Smt	Least depth : 607 m				
	10	Sedlo	40.42	-26.92	Azores		Smt	Min. depth : 667 m	x	x		Sedlo Seamount
		L'Espérance (Seamounts)	40.40	-26.90	Portugal	corresponds to the 3 Sedlo summits	Smts		x			

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
	11	Erik	36.20	-14.54	High Seas/Portugal	from Hoernle *et al*. 2001 SSW of Josephine, can be identified on GEBCO chart, and present but unnamed on Madeira fishery chart. Minimum depth derived from fishery chart						
		Horseshoe (Seamounts)	36.00	-13.00	Portugal/High Seas	center of "curved grouping of near-surface reaching seamounts": includes Gorringe, Josephine, Erik, Lion, Ampere, Coral Patch	Smts		x	x		
	12	Agostinho	38.10	-27.20	Azores		Smt					
	13	Borda	39.67	-26.90	Azores		Smt					

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
	14	Gaillard	39.95	-27.00	Azores	near Sedlo, same as SHOM?, not isolated, but rather hill on high plateau	Smt					
		Princesse Alice Bank					Bank					Princesse Alice Bank
Category 3: summit below daytime depth of deep scattering layer - a - summit depth less than 2000 m	1	Antialtair	43.58	-22.42	High Seas		Smt		x	x		Antialtair Seamount
	2	Hecate	52.28	-31.00	High Seas	ridgelike feature of at least 2 peaks, one less than 1000 m - closed area	Smt		x	x		
	3	Minia	53.05	-34.83	High Seas	on outer Reykjanes ridge, somewhat exceeding the other structures; exact position doubtful, must be 53.03; -34.94 according to new bathymetry	Smt		x	x		
	4	Teresa	37.54	-13.87	High Seas	from Hoernle *et al*. 2001 - can be identified on GEBCO chart						

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
	5	Hebrides Terrace	56.42	-10.42	UK	elevation on cont. Shelf	Smt	Shown as Hebrides Seamount in ACUF Gazetteer.	x	x		Hebrides Terrace Seamount
	6	Heitor Alvares	38.60	-25.95	Azores	EarthRef data, unclear feature on GEBCO charts	Smt	Accepted as "Seamount" instead of "Seamounts" suggested by the proposer.				
	7	Evlanov	48.38	-35.19	High Seas		Smt	Min. depth 1,230 m.				
	8	Chaucer (Seamounts)	42.83	-28.92	High Seas	on MAR, looks like many other features in the area	Smts	Shown as Bank on the INT Charts.				Chaucer Seamount
	9	Faraday	49.67	-29.08	High Seas	rather a range than an individual Smt	Smt	Shown as Seamounts in ACUF Gazetteer.	x	x		
	10	Ashton	38.00	-13.33	Portugal		Smt	depth range acc. EarthRef, GEBCO insufficient.	x		x	Ashton Seamount
	11	Eriador	54.83	-25.33	High Seas		Smt	on westermost edge of Hatton Plateau	x		x	Eriador Seamount
	12	Chaves	37.60	-27.08	Azores	looks more like a hill or bank	Smt	relief 1100 m (SCUFN 2002)				
	13	Eistla	79.45	1.94	Spitsbergen	Atla, Gjalp and Eistla appear as small cluster on IBCAO-chart	Smt	Relief : ~ 1,700 m.				

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
	14	Gjalp	79.64	2.00	Spitsbergen	Atla, Gjalp and Eistla appear as small cluster on IBCAO-chart	Smt	Relief : ~1,700 m				
	15	Milne (Seamounts)	44.75	-40.00	High Seas	large structure with 4 peaks; coordinates mark midst of several elevations	Smts	May include Milne Bank (shown on INT charts as "Existence Doubtful") at 43°40' N-38°36' W.	x	x		
	16	Altair	44.58	-33.83	High Seas		Smt		x	x		
	17	Atla	79.36	2.95	Spitsbergen	Atla, Gjalp and Eistla appear as small cluster on IBCAO-chart	Smt	Relief : ~1, 900 m				
	18	Crumb Seamount	43.47	-23.25	High Seas	similar to other unnamed features in the area			x	x		
	19	Porto (Hill)	40.72	-10.10	Portugal		Hill		x	x		
	20	Hirondelle II	36.42	-12.95	Portugal/High Seas	clearly separate in GEBCO and TOPEX, position confirmed in Hoernle *et al.*	Smt		x		x	
Category 4: summit depth	1	Franklin	57.90	-26.50	High Seas		Smt		x		x	Franklin Seamount

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
more than 2000 m	2	Gondor	54.25	-23.83	High Seas		Smt					Gondor Seamount
	3	Marietta	57.03	-28.68	High Seas		Smt		x		x	
	4	Pyle	86.62	40.92	High Seas	unclear bathymetry, elevation on Gakkel ridge	Smt	Isolated elevation on "Gakkel Ridge".Accepted on HMRG 100-010 evidence.				
	5	Rohan	54.75	-22.33	High Seas		Smt					
	6	Vigo	41.58	-10.53	Portugal		Smt	This feature may be in fact a Guyot.	x	x		
	7	Tore	39.33	-12.83	Portugal	position of centre: 39.34 / -12.83(after GEBCO Bathymetry) or 39.42 / -12.87 after GEBCO USF old); 3 positions given in GEBCO 204/2005, indicating area of smt?	Smts		x		x	
	8	Almeida Carvalho (Seamounts)	40.17	-14.50	High Seas	rather small feature	Smts					
	9	Biscay Seamount	45.42	-10.58	Spain	same as Charcot?			x	x		

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
	10	Charcot (Seamounts)	44.83	-13.00	Spain	coordinates corresp. to South Charcot; same as Biscay?	Smts		x	x		Charcot Seamounts
	11	Hugo de Lacerda	41.25	-15.17	High Seas		Smt					Jovellanos Seamount
	12	Jovellanos	44.47	-4.25	Spain	Bay of Biscay.	Smt		x		x	
	13	La Coruña	43.95	-14.33	Spain		Smts		x		x	Marietta Seamount
	14	North Charcot Seamount	45.12	-13.00	Spain	North and South Charcot as Charcot seamounts in 2004 db			x	x		
	15	South Charcot Seamount			Spain					x		Tore Seamount
	16	Vasco da Gama (Seamounts)	41.33	-11.50	Portugal		Smts					Vigo Seamount
	17	Vladimirov	87.91	43.50	High Seas	unclear bathymetry, elevation on Gakkel ridge	Smt	Small isolated feature. Relief 1,300 m.				
	18	Williams Seamount	43.95	-38.72	High Seas	position doubtful			x	x		
	19	Andromeda	40.18	-13.90	High Seas/Portugal	rather small feature	Smt		x			
	20	Pedro Nunes (Seamounts)	40.67	-14.92	High Seas		Smts					

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
	21	Zheglov	87.14	9.67	High Seas	unclear bathymetry, elevation on Gakkel ridge	Smt					
	22	Auriga	40.52	-13.87	High Seas		Smt					
Category 5: Seamounts with insufficient or unclear information	1	Fernandes Lopes	42.47	-15.10	high seas		Smt					
	4	Martin Behaim	38.20	-27.73	Azores		Smts					
	5	Robert Perry	85.55	13.03	high seas	unclear bathymetry, elevation on Gakkel ridge	Smt	Accepted on HMRG 100-004 evidence.Isolated elevation on "Gakkel Ridge".				
	6	Sauerwein	37.10	-26.08	Azores		Smt					
	7	SHOM	40.00	-27.00	Azores	same as Gaillard?	Smts	A cluster rather than a " seamount chain "				
	8	Thoulet	37.42	-28.58	Azores		Smt	Relief : 1,500 m.				
Category 6: examples of unnamed seamounts identified from GEBCO/IBCAO bathymetry	1	unnamed1-	71.27	-5.88	Norway							
	2	unnamed2 -	71.34	-11.14	Norway	elevation on Jan Mayen Ridge						
	3	unnamed3 -	70.66	-11.95	Norway	elevation on Jan Mayen Ridge						
	4	unnamed4 -	37.36	-25.06	Azores							
Category 7:		North Atalante	45.04	-15.62	High Seas							

Categories	No	New list of seamounts in the OSPAR area					GEBCO Undersea features 2004/2005			OSPAR seamount database		WWF/Rogers 2001
		Seamounts > 1000 m elevation	Lat (dec)	Lon (dec)	Jurisdiction	Remarks	listed as	Remarks	GEBCO Undersea features 1985(?)	listed: Smt >1000 m elevation	listed: Smt <1000 m elevation	WWF reefs name
seamounts named on IFREMER chart		South Atalante	44.80	-16.00	High Seas	secondary peak on same ridge as north Atalante						
		Armoricain seamount	46.38	-12.58	High Seas							
Category 8: Seamounts immediately south of OSPAR boundary at 36°		Lion (Bank)	35.25	-15.58	Portugal		Bank	Shown as Seamount in ACUF Gazetteer and on INT Charts 11-12-14.				
		Ampere	35.00	-12.85	high seas/ Portugal		Smt					
		Coral Patch (Bank)	34.93	-11.92	Portugal	coord. acc. GEBCO, probably bathy not exact	Bankl					
		Dragon (Bank)	34.90	-16.50	Portugal		Bank					
		Unicorn (Bank)	34.75	-14.50	Portugal		Bank	Shown as Seamount in ACUF Gazetteer.				

Table 2.1.2. Further information on seamounts in the OSPAR area. 1. from GEBCO bathymetry (1998), and/or EarthRef and/or WWF/Rogers (2001) and/or other sources. 2. Pitcher et al. (submitted): shallow (within euphotic zone), intermediate (within range of scatterers), deep (below range of scatterers); large (>1500 m), small (<1500 m). 3. WWF/Rogers (2001) and other sources

Categories	No	New list of seamounts in the OSPAR area	Relief [1])		Classification [2])		Features [3])		
		Seamounts > 1000 m elevation	bottom depth	summit depth	1. shallow 2. intermediate 3. deep	1. large 2. small	shape	1 - Flat top 2 - peak 3 - caldera	1- basaltic rock 2 - limestone 3 - gravel 4 - sand
Category 1: summit inside euphotic zone	1	**Dom Joao de Castro (Bank)**	1500m	13m	1	2	round, isolated, volcanic cone	2 (3?)	kelp cover in down to ? m
	2	**Gettysburg**	> 5000m	20-28m	1	1			kelp, 1, 3,4, sandstone
	3	**Ormonde**	> 5000m	33-46 m	1	1			kelp, 1, 3, 4
Category 2: summit above daytime depth of deep scattering layer	1	**Vesteris**	> 3000m	130m	2	1	fairly round, isolated	2	recent origin, basaltic hydrothermalism
	2	**Josephine (Bank)**	> 2000m	170m	2	1	elongated	1	1-4 diverse substrates, sandstone
	3	**Rosemary (Bank)**	> 2000m	321m	2	2	round, isolated	1	?
	4	**De Guerne**	> 1500m	< 500m	2	2	insufficient info GEBCO, EarthRef - round		
	5	**Margarethe (Seamounts)**	> 2000m	< 500m	2	1	round	2	
	6	**Mary Celeste (Seamounts)**	> 1500m	< 500m	2	2			
	7	**Anton Dohrn**	2100m	521m	2	1	round, isolated, rather large	1	100 m thick sediment layer
	8	**Galicia (Bank)**	> 5000m	600m	2	1		1,2	1 - basaltic rock, 2- sand on flat plain
	9	**Prilyudko**	> 2000m	607m	2	2			

Categories	**No**	**New list of seamounts in the OSPAR area**	**Relief [1])**		**Classification [2])**		**Features [3])**		
		Seamounts > 1000 m elevation	**bottom depth**	**summit depth**	**1. shallow 2. intermediate 3. deep**	**1. large 2. small**	**shape**	**1 - Flat top 2 - peak 3 - caldera**	**1- basaltic rock 2 - limestone 3 - gravel 4 - sand**
	10	**Sedlo**	>2800m	667m. OASIS: min depth 725m	2	1	elongated	1	1, 3, 4
		L'Espérance (Seamounts)							
	11	**Erik**	> 3000m	777m	2	1	elliptical	1	similar Josephine?
		Horseshoe (Seamounts)							
	12	**Agostinho**	> 1500m	< 800m	2	2	isolated, round, SE Pico		
	13	**Borda**	2000m	< 800m	2	2	see Gaillard, but higher up, round		
	14	**Gaillard**	> 2000m	ca. 800m	2	2			
		Princesse Alice Bank							
Category 3: summit below daytime depth of deep scattering layer - a - summit depth less than 2000 m	1	**Antialtair**	> 2500m	< 1000m	3	1	elongated		
	2	**Hecate**	> 3000m	< 1000m	3	1	ridgelike feature		
	3	**Minia**	> 2500m	< 1000m	3	2	rounded		
	4	**Teresa**	> 4000m	< 1000m	3	1	elliptical	1	sandstone
	5	**Hebrides Terrace**	> 2000m	ca 1000m	3	2			
	6	**Heitor Alvares**	c2500m	1200m	3	2			
	7	**Evlanov**	> 4000m	1230m	3	1	acc. EarthRef: -round		
	8	**Chaucer (Seamounts)**	< 2500m	< 1500m	3	2	elongated		
	9	**Faraday**	> 3000m	< 1500m	3	1	elongated SE-NW		

Categories	No	New list of seamounts in the OSPAR area	Relief [1])		Classification [2])		Features [3])		
		Seamounts > 1000 m elevation	**bottom depth**	**summit depth**	**1. shallow 2. intermediate 3. deep**	**1. large 2. small**	**shape**	**1 - Flat top 2 - peak 3 - caldera**	**1- basaltic rock 2 - limestone 3 - gravel 4 - sand**
	10	**Ashton**	< 4500m	1500m	3	1	round, isolated		
	11	**Eriador**	< 2500m	ca 1700m	3	2	elongated		
	12	**Chaves**	> 2000m	1163m	3	2			
	13	**Eistla**	> 4000m	> 1500m	3	?			
	14	**Gjalp**			3	?			
	15	**Milne (Seamounts)**	> 4000m	> 1500m	3	1			
	16	**Altair**	> 3000m	> 1500m	3	1	round, isolated, rather large		
	17	**Atla**	>4000m	> 1500m	3	?			
	18	**Crumb Seamount**	> 3000m	< 2000m	3	2			
	19	**Porto (Hill)**	> 3000m	< 2000m	3	2	round, deep on 3 sides	1	
	20	**Hirondelle II**	> 4000m	ca. 2000m	3	1			sandstone
Category 4: summit below daytime depth of deep scattering layer - b - summit depth more than 2000 m	1	**Franklin**	>2500m	> 2000m	3	2	very small feature		
	2	**Gondor**	> 3000m	> 2000m	3	2	round, isolated, nearest sm Rohan and Eriador		
	3	**Marietta**	>2500m	> 2000m	3	2	very small feature		
	4	**Pyle**	> 3000m	> 2000m	3	2			
	5	**Rohan**	> 3000m	> 2000m	3	2	round, isolated		?
	6	**Vigo**	> 3000m	> 2000m	3	2			
	7	**Tore**	> 5000m	2200m	3	1	large, round, isolated with deep central basin	3	?

Categories	No	New list of seamounts in the OSPAR area	Relief [1])		Classification [2])		Features [3])		
		Seamounts > 1000 m elevation	**bottom depth**	**summit depth**	**1. shallow 2. intermediate 3. deep**	**1. large 2. small**	**shape**	**1 - Flat top 2 - peak 3 - caldera**	**1- basaltic rock 2 - limestone 3 - gravel 4 - sand**
	8	**Almeida Carvalho (Seamounts)**	> 4000m	> 2500m	3	1	rather small feature		
	9	**Biscay Seamount**	> 4000m	> 2500m	3	1	same as Charcot?		
	10	**Charcot (Seamounts)**	> 4000m	> 2500m	3	1	same as Biscay?		
	11	**Hugo de Lacerda**	> 4000m	> 2500m	3	1	elongated, very small "summit"		
	12	**Jovellanos**	> 4000m	> 2500m	3	2	elongated, more a hill than a seamount		
	13	**La Coruña**	> 4000m	> 2500m	3	2	round, rather flat?		
	14	**North Charcot Seamount**	> 4000m	> 2500m	3	1		1	?
	15	**South Charcot Seamount**	> 4000m	> 2500m	3	2	elongated	1	
	16	**Vasco da Gama (Seamounts)**	> 4000m	> 2500m	3	2	elongated	1	?
	17	**Vladimirov**	> 4000m	> 2500m	3	2			
	18	**Williams Seamount**	> 4000m	> 2500m	3	1	large structure with one broad peak	1	
	19	**Andromeda**	> 4000m	> 3000m	3	2			
	20	**Pedro Nunes (Seamounts)**	> 4000m	< 3500m	3	2	very small round feature		
	21	**Zheglov**	> 4000m	> 3500m	3	2			
	22	**Auriga**	>4000m	> 4000m ?	3	?	no bathy info		
Category 5: Seamounts with insufficient or unclear information	1	**Fernandes Lopes**	??	??					

Categories	No	New list of seamounts in the OSPAR area	Relief [1])		Classification [2])		Features [3])		
		Seamounts > 1000 m elevation	**bottom depth**	**summit depth**	**1. shallow 2. intermediate 3. deep**	**1. large 2. small**	**shape**	**1 - Flat top 2 - peak 3 - caldera**	**1- basaltic rock 2 - limestone 3 - gravel 4 - sand**
	4	**Martin Behaim**	?	?					
	5	**Robert Perry**			3	2			
	6	**Sauerwein**	?	?					
	7	**SHOM**							
	8	**Thoulet**	?	?					
Category 6: examples of unnamed seamounts identified from GEBCO/IBCAO bathymetry	1	***unnamed1-***	*> 2000m*	*< 500m*	*2*	*1*	*elongated*		
	2	***unnamed2 -***	*> 2000m*	*< 200m*	*2*	*2*	*broad base, small peak*		
	3	***unnamed3 -***	*> 1500m*	*< 200m*	*2*	*2*	*small peak*		
	4	***unnamed4 -***	*> 1500m*	*< 500m*	*2*	*2*	*round*		
Category 7: seamounts named on IFREMER chart		***North Atalante***	*> 4000m*	*< 2000m*	*3*	*1*			
		South Atalante	*> 4000m*	*< 2500m*	*3*	*2*			
		Armoricain seamount	*> 4000m*	*> 3000m*	*3*	*1*	*round, very large structure*		
Category 8: Seamounts outside OSPAR but close to the southern boundary of 36°		**Lion (Bank)**	> 3000m	< 1000m	2 ?	1			
		Ampere	> 3000m	60m	1	1	round		mixed substrate, lots of hard s.
		Coral Patch (Bank)	> 2500m	< 800m	2 ?	1	elliptical		
		Dragon (Bank)	> 3000m	< 1000m	3	1			
		Unicorn (Bank)	> 2000m	600m	2	1			

2.2 References

Epp, D. and Smoot, N. C. 1989. Distribution of seamounts in the North Atlantic. Nature, 337: 254–257.

Menard, H. W. 1964. Marine geology of the Pacific. McGraw-Hill, New York.

Murray, H. W. 1941. Submarine mountains in the Gulf of Alaska. Bulletin of the Geological Society of America, 52: 333–362.

Rogers, A. D. 1994. The biology of seamounts. Advances in Marine Biology, 30: 305–350.

3 Fishing activity on seamounts in the North East Atlantic

Term of Reference: on the basis of evidence to be sought from fisheries managers and other sources, review the distribution of fishing activity on seamounts.

3.1 Introduction

In 2005, the WGDEC was asked to provide direct and indirect evidence for the damage caused by fishing to seamounts in the OSPAR area (ICES 2005). At that stage, we had no access to satellite tracking (VMS data) for the area. We subsequently asked for such data from the North East Atlantic Fishery Commission (NEAFC) and national authorities. Data was provided by NEAFC and the UK and we have analysed information for the High Seas and the UK EEZ seamounts. If a comprehensive picture of fisheries activity on all seamounts is needed, then data from the Vessel Monitoring Scheme (VMS) from all relevant EEZs (or Fisheries zones) within the North Atlantic region is required.

3.2 Fishing on seamounts in the North East Atlantic High Seas

Satellite tracking data (VMS) were provided by NEAFC for the Atlantic high seas area of the OSPAR region covering January 2003 – March 2005, with some gaps (both geographical and temporal). Assuming the data are accurate, they provide an excellent means with which to get an overview of fleet activity, with strong clustering of positional data showing intense fishing activity in certain areas (Figs 3.2.1, 3.2.2, 3.2.3). Note that the VMS data presented here is unfiltered and shows all positional data (updated every 2 hours); a proportion of the data points refer to vessels that are in transit and not fishing. Research into standard methodologies for the interpretation of EU VMS data is being carried out at the University of Plymouth as part of the DC-UK programme (http://www.marlin.ac.uk/dc-uk/vms_offline.php) and at the UK CEFAS laboratory in Lowestoft.

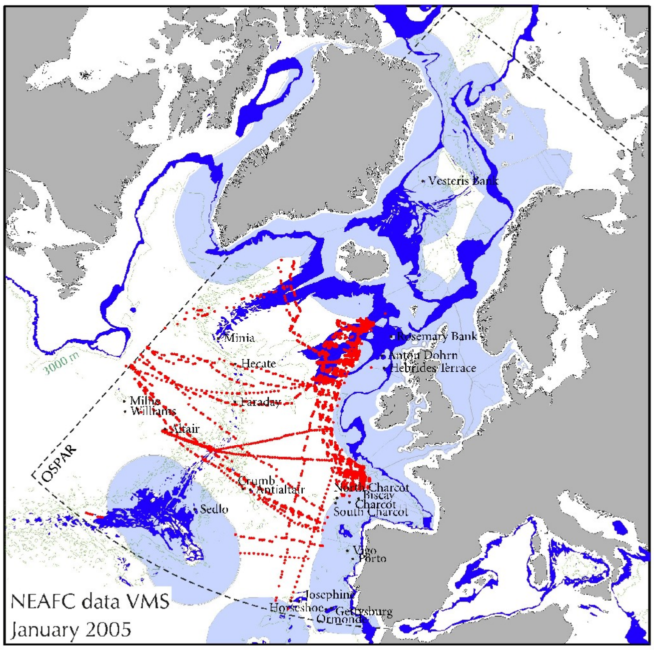

Figure 3.2.1 Locations of fishing vessels every two hours, as recorded by VMS, in the Atlantic High Seas section of the OSPAR area, January 2005 (data from NEAFC).

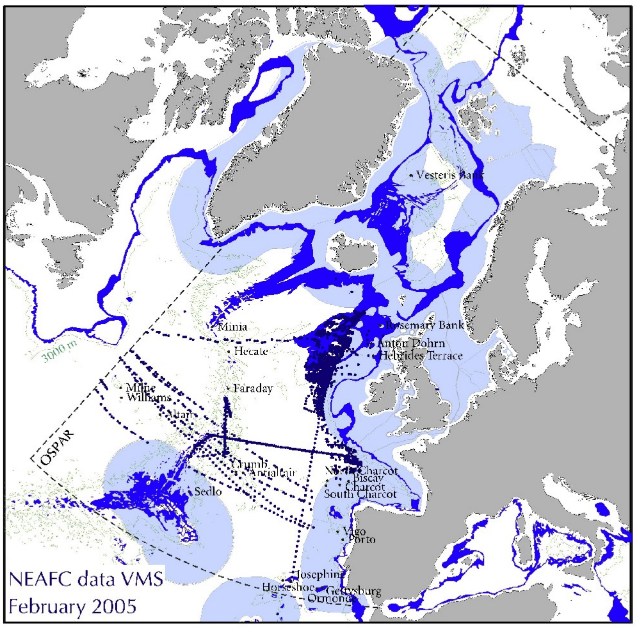

Figure 3.2.2 Locations of fishing vessels every two hours, as recorded by VMS, in the Atlantic High Seas section of the OSPAR area, February 2005 (data from NEAFC).

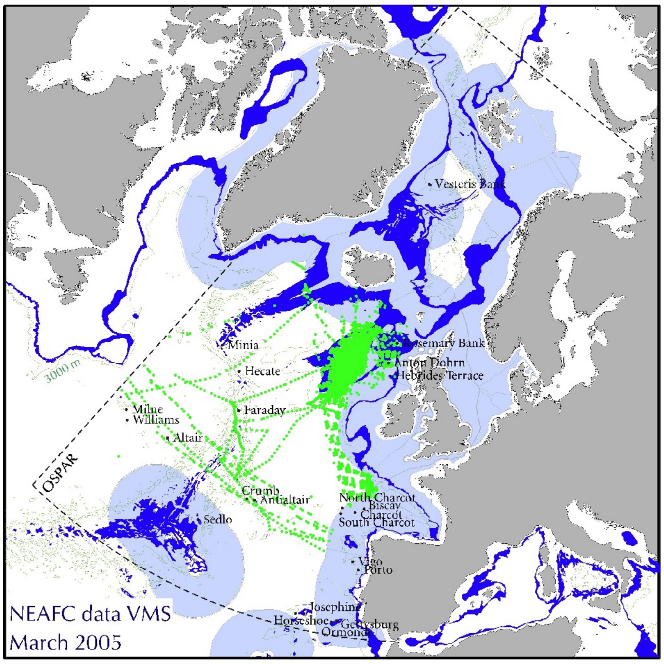

Figure 3.2.3 Locations of fishing vessels every two hours, as recorded by VMS, in the Atlantic High Seas section of the OSPAR area, March 2005 (data from NEAFC).

The data can also be used to examine individual seamounts. The working group examined and plotted data for those where NEAFC has taken management action to close the seamount. This reveals that fishing is not constant on seamounts, and in some cases that the regulation to close the seamount to fishing has not been obeyed.

3.2.1 Altair Seamount

The positions of VMS transmitters in 2003, 2004 and 2005 are shown in Figures 3.2.1.1, 3.2.1.2 and 3.2.1.3, covering the years 2003, 2004 and 2005 respectively. It is apparent that in the first two years, fishing vessels were essentially transiting the area, wheras after closure in 2005, fishing vessels targeted the south-east part of the seamount.

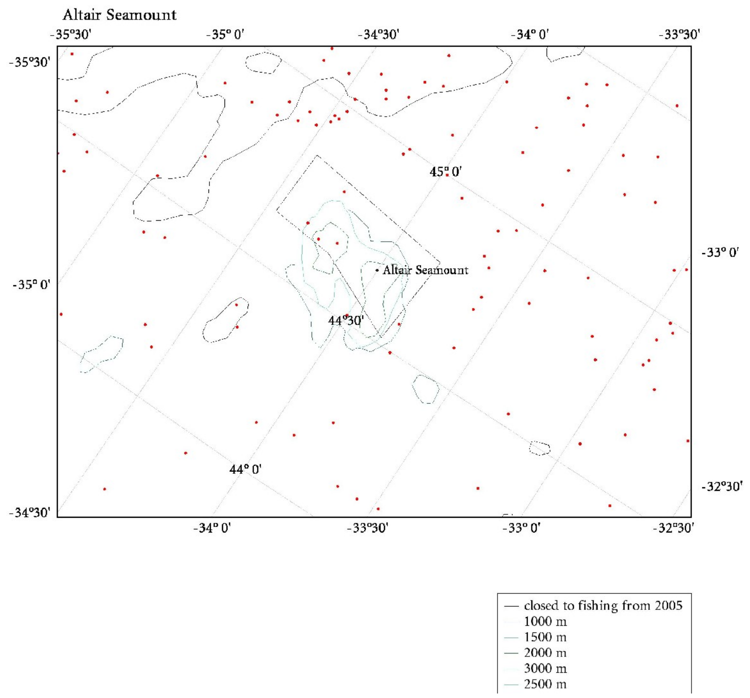

Figure 3.2.1.1 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Altair seamount, 2003 (data from NEAFC).

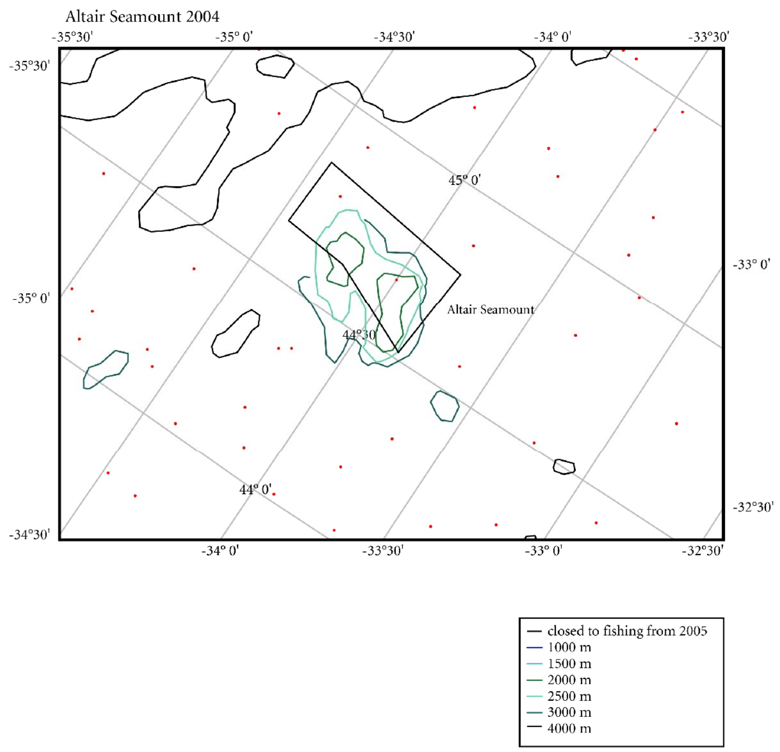

Figure 3.2.1.2 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Altair seamount, 2004 (data from NEAFC).

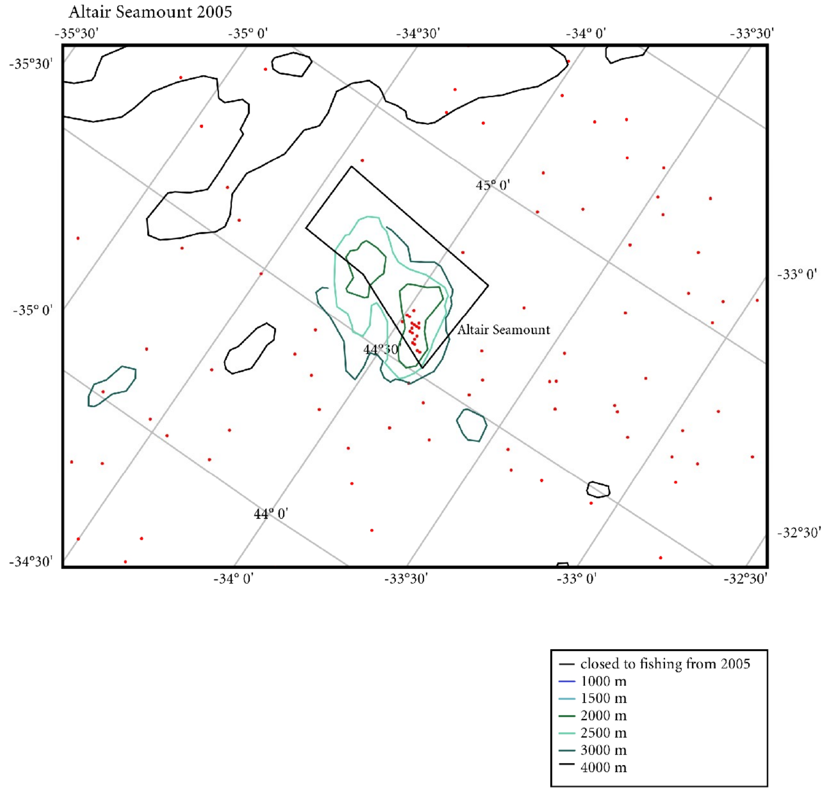

Figure 3.2.1.3 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Altair seamount, 2005 (data from NEAFC).

3.2.2 Antialtair Seamount

The Antialtair seamount did not appear to be fished in 2003, but was in 2004 and 2005 (again, the latter after closure by NEAFC) (Figures 3.2.2.1, 3.2.2.2, 3.2.2.3).

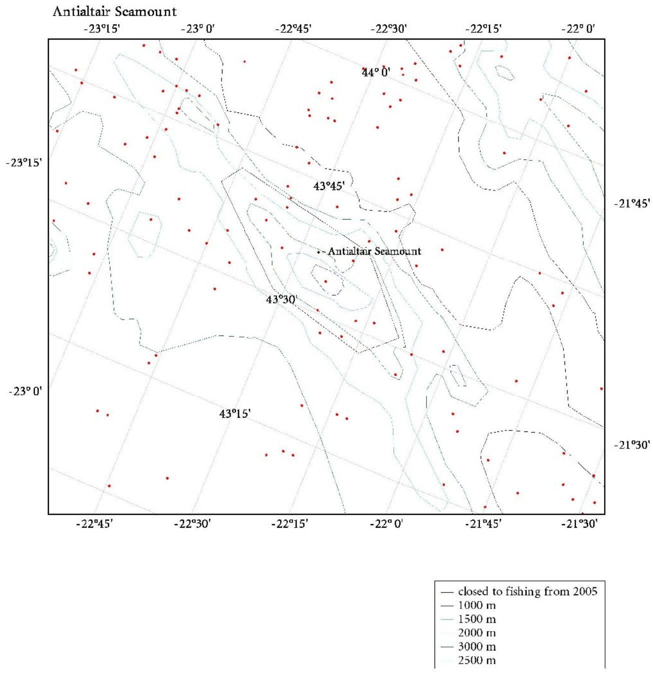

Figure 3.2.2.1 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Antialtair seamount, 2003 (data from NEAFC).

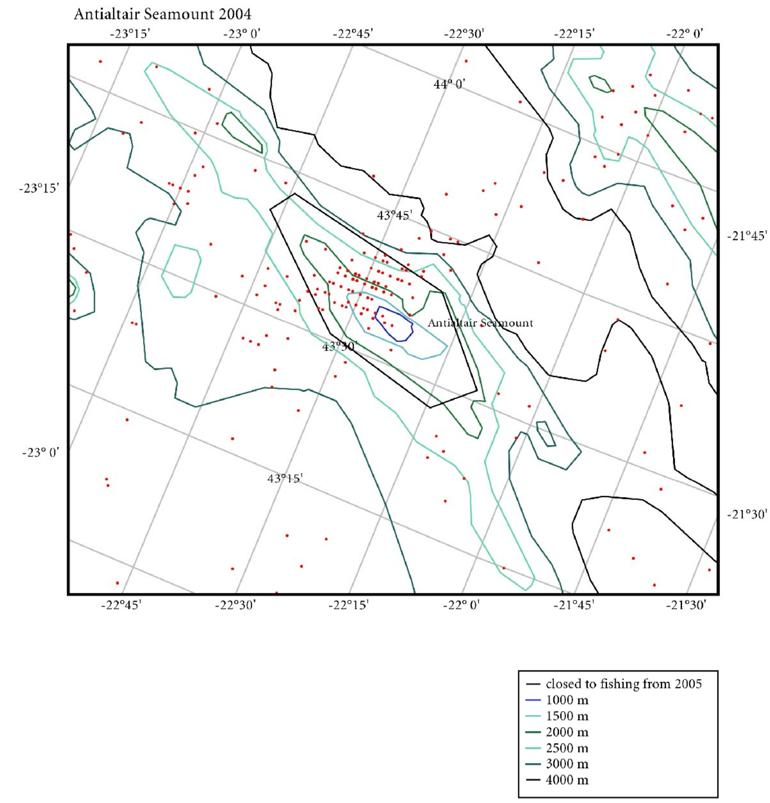

Figure 3.2.2.2 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Antialtair seamount, 2004 (data from NEAFC).

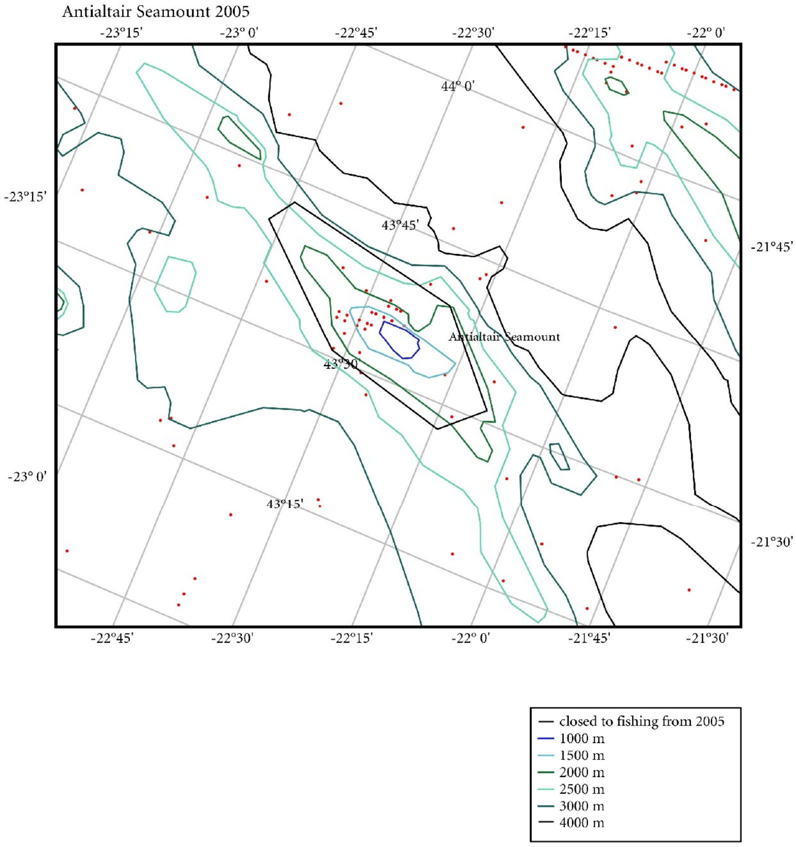

Figure 3.2.2.3 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Antialtair seamount, 2005 (data from NEAFC).

3.2.3 Faraday Seamount

Fishing occurred on the Faraday seamount in all years for which data were available, with perhaps a slight diminution in effort through these years (Figures 3.2.3.1, 3.2.3.2, 3.2.3.3).

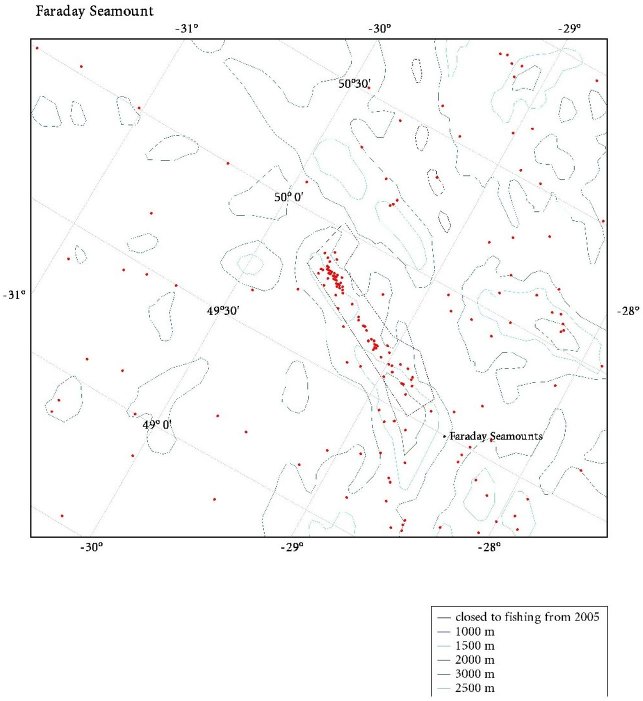

Figure 3.2.3.1 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Faraday seamount, 2003 (data from NEAFC).

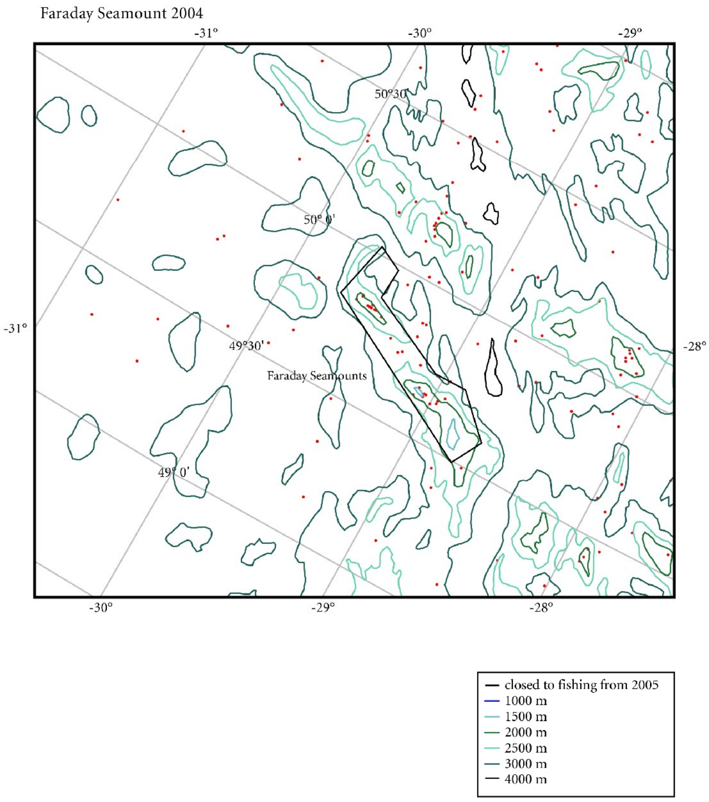

Figure 3.2.3.2 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Faraday seamount, 2004 (data from NEAFC).

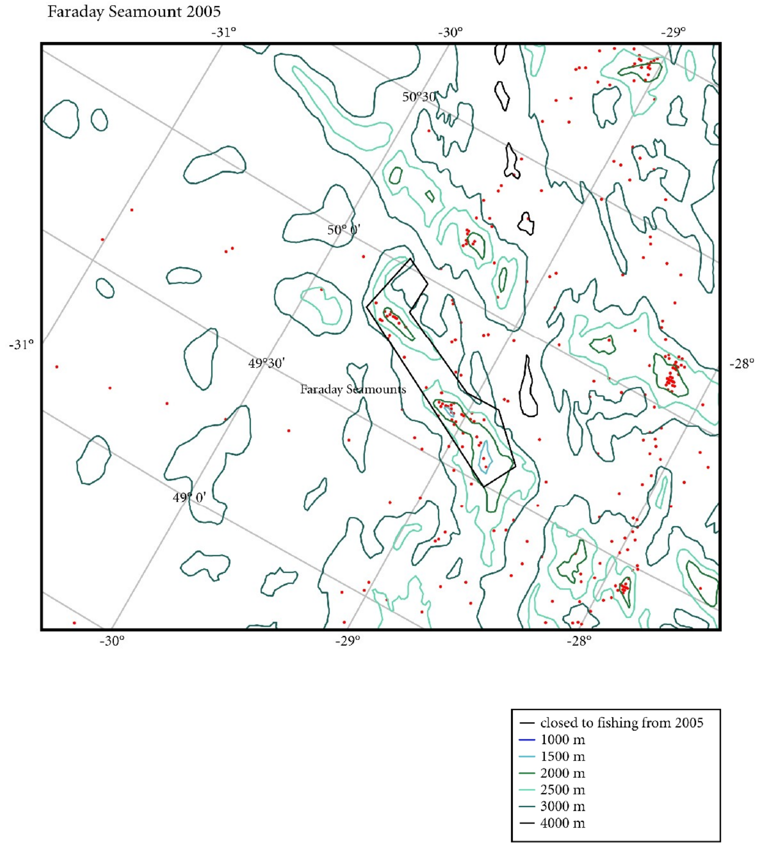

Figure 3.2.3.3 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Faraday seamount, 2005 (data from NEAFC).

3.2.4 Reykjanes Ridge

A section of the Reykjanes ridge was also close to fishing in 2005. It appears that this area has not been targeted by fishing vessels in any of the three years for which VMS information is available (Figures 3.2.4.1, 3.2.4.2, 3.2.4.3).

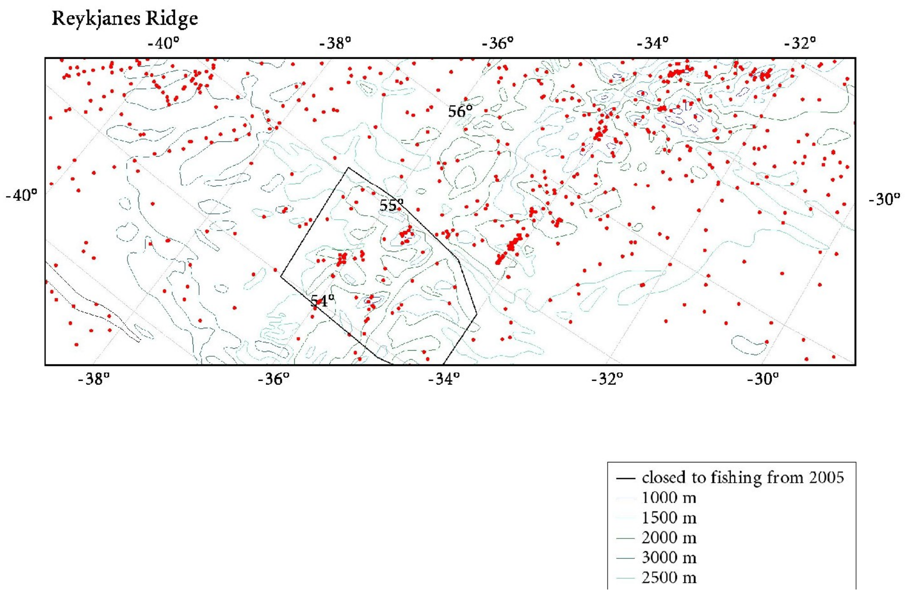

Figure 3.2.4.1 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Reykjanes Ridge, 2003 (data from NEAFC).

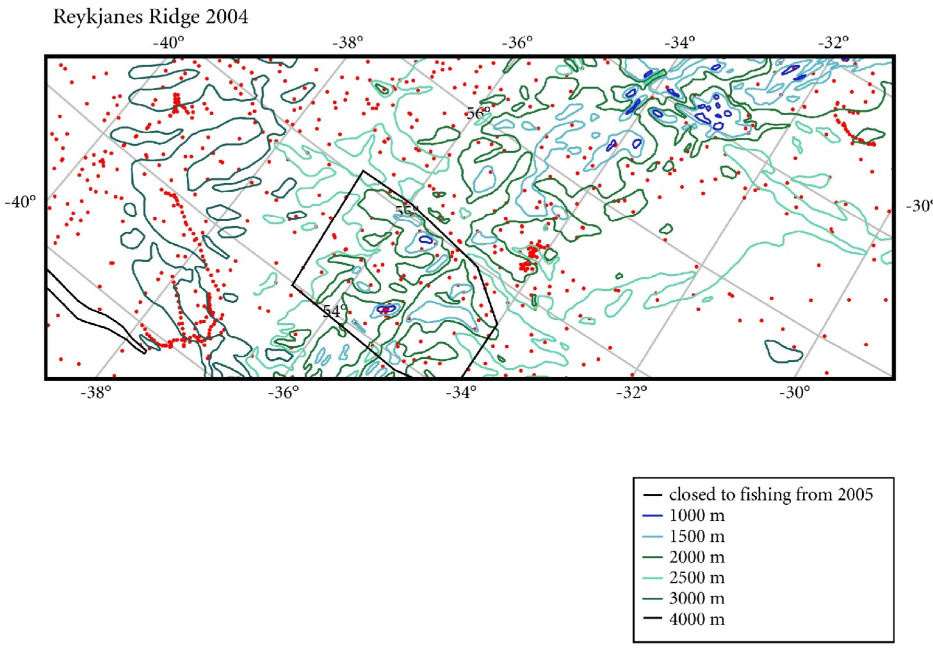

Figure 3.2.4.2 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Reykjanes Ridge, 2004 (data from NEAFC).

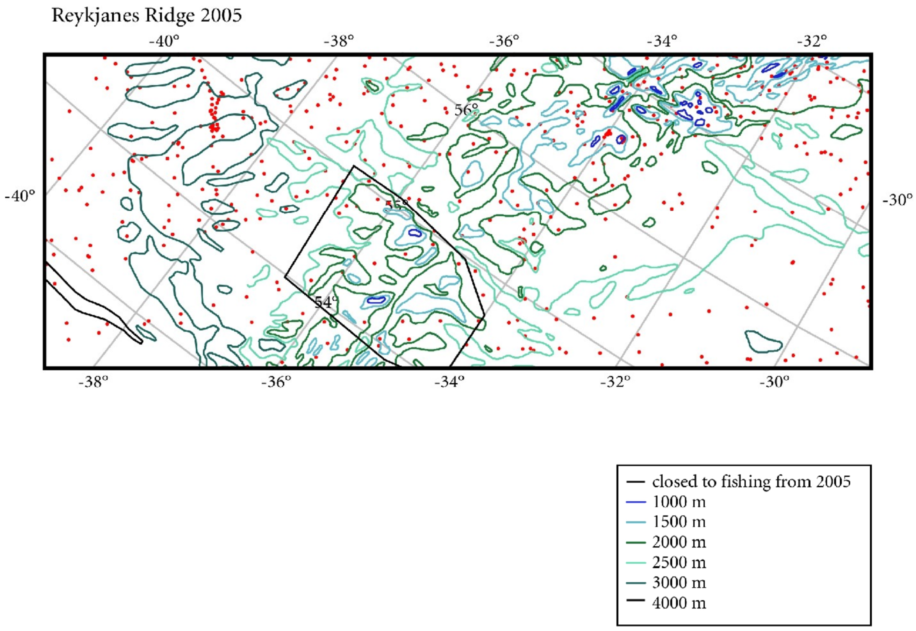

Figure 3.2.4.3 Locations of fishing vessels every two hours, as recorded by VMS, in the vicinity of the Reykjanes Ridge, 2005 (data from NEAFC).

This was obviously a preliminary look at data available to indicate fishing activity. The data have not been filtered to determine types of fishing vessel or nationality. It would be possible, given sufficient resources, to examine fishing activity on all NE Atlantic seamounts and determine which is least likely to have been affected by fishing pressure. It is known that NEAFC has focused on collecting information from the largest commercial fisheries (e.g. for herring, mackerel, blue whiting and oceanic redfish). It may be that data for deep sea vessels are not complete. Many of the mapped positions may therefore refer to pelagic fisheries.

3.3 Fishing on seamounts within the UK fisheries zone

The following three seamounts (as defined presently by OSPAR) occur within the UK continental shelf area;

1. Rosemary Bank is in the northern Rockall Trough and is conical in shape rising from c. 1830 m to a domed crest at c. 370 m (Stoker *et al*., 1993). It is mainly covered in sand with a mix of gravel, cobbles and boulders (Britsurvey, 1995) with steep, sediment-scoured rock along the SE flank (Dietrich and Jones, 1980).

2. Anton Dohrn is a flat-topped seamount (guyot) located in the central Rockall Trough ranging from 500 to >2000 m depth (Stoker *et al*., 1993). The summit plateau is covered in coarse biogenic sand diminishing in thickness towards the rim with a central knoll of exposed basalt (Graham *et al*., 2001). The steep sides consist of exposed basaltic rock to a depth of 1500 m (Jones *et al*., 1994).

3. Hebrides Terrace is elliptical/ elongate in shape with a relatively flat sedimentary summit at c. 1000 m, much deeper that the other two seamounts discussed. Graham *et al*. (2001) suggest that the flanks of the Hebrides Terrace consist of exposed bedrock.

These seamounts are located within ICES sub area VI where commercial catches include blue ling *Molva dyptergia*, black scabbardfish, roundnose grenadier, anglerfish *Lophius piscatorius*, megrim *Lepidorhombus whiffiagonis* and deep-water sharks. In 1991, a bottom trawl fishery was established for orange roughy with a first year peak in landings of 3500 t which has since declined to <200 t per annum (Basson *et al*., 2002). Orange roughy associate with seamounts and other steep topographical features such as the continental shelf-break (Basson *et al*., 2002). Over-flight data provided by the Scottish Executive Environment and Rural Affairs Department (SEERAD) from 1997-2004 identified vessels from eight nations (France, Norway, Ireland, Faeroes, Germany, France, Spain, UK) actively fishing on Rosemary, Anton Dorhn and Hebrides Terrace seamounts, using a variety of fishing gear, including bottom trawls, gill nets, covered pots, longlines, mid-water trawls, twin otter and multi trawls (Fig. 3.3.1). It is important to note that over-flight data were obtained less often for the UK seamounts than for the shelf-break region, so the lack of data points should not be interpreted as proportionately lower levels of fishing activity on seamounts. This is revealed by VMS data for January – March 2004 which shows the same strong clustering of positional data showing intense fishing activity in certain areas. The deep-water fisheries are concentrated along the shelf-break area although there is a clear clustering of high levels of fishing activity on Rosemary and Hebrides seamounts and to a lesser extent the Anton Dohrn seamount (Fig 3.3.2). Note that the VMS data presented here are unfiltered showing all positional data and so not all data point refer to active fishing.

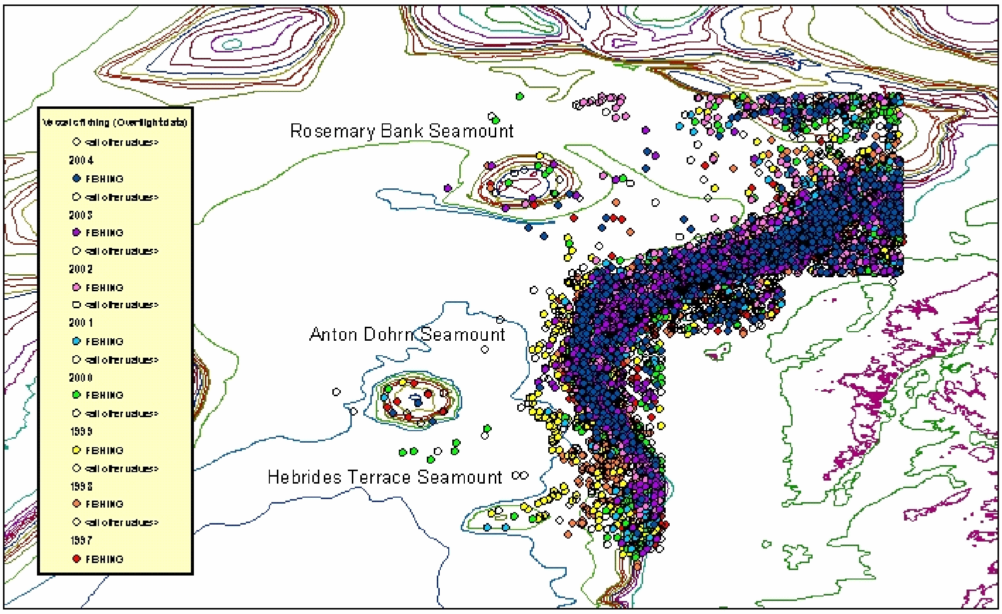

Figure 3.3.1. Location of fishing vessels off western Scotland as shown by sightings from aerial surveillance, 1997-2004. (Data from Scottish Executive Environment and Rural Affairs Department (SEERAD)). Note that these data are uncorrected for search effort.

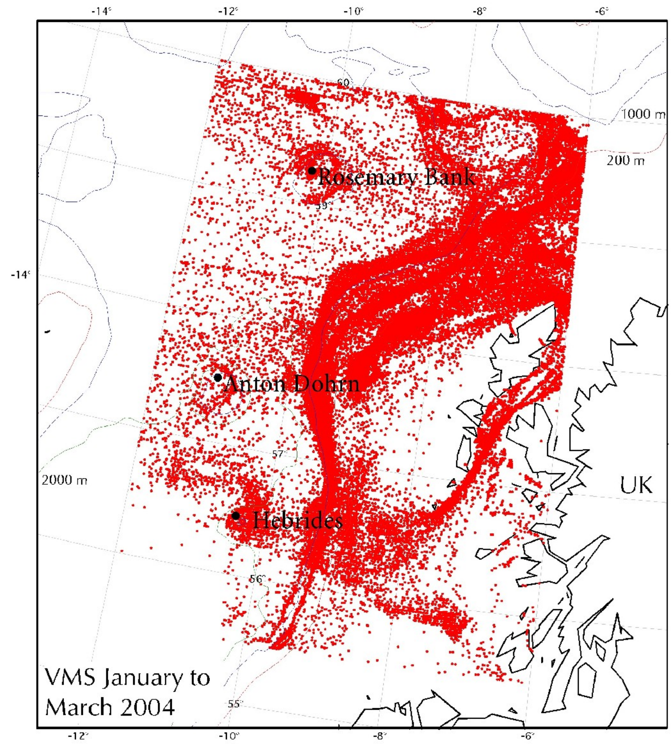

Figure 3.2.2. Data on location of fishing vessels west of Scotland, as shown by VMS data, January-March 2004 (data provided to JNCC by SEERAD).

In summary; bottom trawling occurs on all three UK seamounts. Landings for ICES area VI show there is a fishery for orange roughy which are known to aggregate around seamounts. Overflight data show use of bottom trawl gear on UK seamounts from 1997-2004 but it is highly likely that trawling occurred on UK seamounts since the development of the orange roughy fishery in 1991. VMS data show that the seamounts were a target of fishing activity in January-March 2004.

As orange roughy peak in abundance at around 1200m depth much of the trawling impact is likely to be on the steep sides of the seamounts as well as the summit. The exposed bedrock flanks of the seamounts provide the ideal substratum for the persistence of the sessile coral dominated communities described on other seamounts (Genin *et al*., 1986; Wilson and Kaufmann, 1987; Rogers 1994). This is supported by the presence of the cold water reef forming coral *Lophelia pertusa* reported from both the Anton Dohrn and Rosemary Bank Seamounts (BGS map, http://www.sams.ac.uk/sams/projects/benthic/ lophmap.htm).

There are currently very few data available describing the biological communities present on the UK seamounts and therefore no direct evidence of damage to the UK seamounts from fishing. However, bottom trawling is known to be highly damaging to seamount communities (Koslow *et al*., 2001) and is known to be occurring on the UK seamounts. Best available data suggest the UK seamounts harbour the sessile coral dominated communities described as present on other seamounts (Genin *et al*., 1986; Wilson and Kaufmann, 1987; Rogers 1994). It is highly likely therefore that the seamounts in ICES subarea VI have been impacted by the action of bottom trawling and remain under threat from this activity.

3.4 References

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4 Classification of deep-water habitats in the North Atlantic and frameworks for describing sensitivity to fishing activity

Term of Reference: review possible classifications of deep-water habitats in the North Atlantic and frameworks for describing sensitivity to fishing activities.

4.1 Summary

None of the classification schemes examined by the working group are immediately applicable in the deep-sea at all scales and for all purposes. All schemes at some point classify the habitat in terms of the geology of the physical habitat making all useful in terms of interpretation of the typical acoustic and imaging data derived from deep-sea survey. However, some explicitly include descriptive terms for other aspects of the physical habitat (biogeography, currents, seabed texture etc) while others focus on the biological community, implicitly taking the physical environment into consideration. What is required at a finer scale (and for the development of tools such as sensitivity frameworks) is a system of naming recurrent faunal assemblages observed in the deep-sea (ideally identified as distinct communities using multivariate analysis, and associated with known environmental conditions). Two schemes facilitate naming of assemblages: Allee *et al*. (2000) used ecotypes and the EUNIS scheme uses biotopes. Efforts should be made to interpret existing deep-sea biological data for use in developing the lower levels of classification systems such as EUNIS. Until such development occurs, the use of more descriptive systems such as Greene *et al*. (1999) and combinations of the available systems will allow a common 'language' to be used to gather data on deep-sea habitats and compare findings between studies. These data may be used in the future to identify and define recurrent biological communities.

The development of frameworks to describe sensitivity of habitat to fishing activities has been approached in two ways. Firstly through ranking the sensitivity of defined distinct habitat (biological and physical) units to various forms of disturbance, secondly through ranking the impact of various gear types on the seabed in general. The former approach requires the existence of a well developed habitat classification system, the latter does not explicitly. Neither approach taken in isolation is able to adequately describe the sensitivity of habitats to fishing activities. What is required is a combination of these approaches including terms to describe the frequency of disturbance necessary to cause various levels of damage. The development of a habitat classification system is therefore vital to the development of a framework to describe sensitivity of habitats to fishing, as is a fine-scale understanding of fishing effort and gear use.

4.2 Introduction

Marine habitat survey is expensive and time consuming, and this is especially true of deep-sea survey. As a result, and in comparison with shallow water marine habitats, much of our broad scale knowledge of deep-sea habitats comes from acoustic survey methods with little ground-truthing to support the biological interpretation of these data. Finer scale biological sampling of deep-sea communities has received attention worldwide, but interpretation is focused at the species level rather than the habitat or even community level. To date the terms used to interpret acoustic and community data and the scale at which they apply have not been consistent making comparison between existing studies of deep-sea habitats difficult. Thus there is a need for a consistent terminology with regard to deep-sea habitats; a habitat classification system.

Classification systems have an important role in management of the marine environment. They divide the marine environment into understandable distinct units that can be quantified and mapped for planning purposes and provide a framework for describing function and sensitivity of habitats. The uses of the habitat classification system are broad and can include spatial planning, predictive modelling of habitats, habitat management, use in monitoring and conservation strategies, reserve network design, scientific study and education. These varying uses all have different needs from a classification system.

The requirements of a classification system have been outlined by Allee *et al*. (2000) and Connor *et al*. (2004) and are broadly the following:

- be scientifically sound, adopting a logical structure in which the types are clearly defined on ecological grounds, avoiding overlap in their definition and duplication of types in different parts of the system, and ensuring that ecologically-similar types are placed near to each other and at an appropriate level (within a hierarchical classification)
- provide a common and easily understood language for the description of marine habitats
- be comprehensive, accounting for all the marine habitats within its geographic scope
- be practical in format and clear in its presentation
- focus on the natural community and its physical environment
- include sufficient detail to be of practical use for conservation managers and field surveyors allowing mapping of ecological units, but be sufficiently broad (through hierarchical structuring) to enable summary habitat information to be presented at national and international levels or its use by non-specialists
- be sufficiently flexible to enable modification resulting from the addition of new information, but stable enough to support ongoing uses. Changes should be clearly documented to enable reference back to previous versions (where possible, newly defined types need to be related back to types in earlier versions of the classification)
- Accommodate limited data and available technology
- Provide the basis for developing functional links between underlying mechanisms structuring the ecosystem and the described biological community

In the marine environment there are a number of classification systems being utilised by various groups in different geographical regions and for different purposes. Until recently these classifications have only been applied in coastal and shelf environments. The need to classify deep-sea habitats is a recent development brought about by the progressive movement of human activities e.g. fishing, oil and gas exploration etc, further and further offshore into deep water areas. With exploration and exploitation of the deep-sea environment comes the need for sustainable resource management strategies and the development of appropriate management tools.

4.2.1 Review of the classification schemes

Classification scheme	**Description**
EUNIS	A hierarchical key that allows the user to identify and classify a habitat into a pre-described type
Greene *et al*., 1999	A hierarchical common framework of language to describe deep-sea habitats
Day and Roff, 2000	Marine landscape approach based on geological physical and hydrographical factors
Allee *et al*., 2000	A semi-hierarchical common framework of language to describe marine habitats
Valentine *et al*., 2005	A common framework of language to describe deep-sea habitats
Auster *et al*., 2005	A hierarchical common framework of language to describe deep-sea seamount habitats

The group considered each of the above existing classification systems. The systems considered fell into two categories: Those where the fine scale units (biotopes) have been developed using existing large biological and physical datasets to describe consistent and coherent communities e.g. EUNIS. The biotopes are organised in a hierarchical fashion within larger scale units (habitats, habitat complexes) that can also be identified in terms of their biological and physical parameters. The second type of classification system uses a common language to consider and classify various environmental and in some cases biological parameters of areas of seabed (Greene *et al*., 1999; Day and Roff, 2000; Valentine *et al*., 2005; Auster *et al*., 2005). Some of these classification systems are organised in a hierarchical manner with regard to the scale of operation the parameter being considered (Greene *et al*., 1999; Day and Roff, 2000; Auster *et al*., 2005), others are not obviously hierarchical in their approach (Allee *et al*., 2000; Valentine *et al*., 2005).

EUNIS is reliant on existing data to describe biotopes to which new data can then be assigned. As a result of the limited data available at an appropriate scale and in a useful format in the deep-sea, the biotope level of the deep-sea section (A6) of the EUNIS classification is poorly developed. Therefore in its present state EUNIS is only useful for broad-scale habitat classification in the deep-sea environment (with the exception of very specific habitats such as Lophelia pertusa reefs). The EUNIS system also has a number of general problems with regard to inconsistency in the level at which habitats are described, for example, A2.31 – Polychaete/bivalve-dominated mid estuarine mud shores is looking at a “facies” level, where as A6.71 – “Seamounts, knolls and banks” is considering a megahabitat level. This is largely a result of the progressive evolution of the EUNIS system and the lack of available appropriate data at lower levels for the deep-sea environment.

The Greene *et al*., 1999 system, as with all subsequent systems in this review, falls into the second critera of classifications described above. It is largely hierarchical in its approach. It uses the concept of area as a major criterion for describing habitats, and it recognises four habitat sizes that include megahabitats (kilometres to 10s of kilometres), mesohabitats (10s of metres to a kilometre), macrohabitats (1 meter to 10 meters), and microhabitats (centimetres to a meter). The top level of this partly hierarchical classification is a system (marine benthic), followed by a subsystem (for mega- and mesohabitats), a class (for meso- and macrohabitats), two subclasses (for macro- and microhabitats), and modifiers that describe seabed characteristics and processes found in the various habitats.

The Day and Roff (2000) classification was produced to underpin the selection of Marine Protected Areas through the delineation of seascape features. The system is hierarchy founded on eight levels ranging from broadly different community types to lower levels where community types can be distinguished. Using GIS , each level of the hierarchy will merged with the others to produce seascape boundaries. At the lowest level (Level 8), seascape units are defined.

The Allee *et al*. (2000) classification was developed as a national marine and estuarine ecosystem classification system for the United States, broad enough in scope and fine enough in detail to be useful at a national scale. The system is a blend of global scale and regional systems. The hierarchical system consists of 13 levels moving from the broadest geographic scale down to most detailed level which uses a combination of physical and biological information to classify ‘ecological units’ (eco-units). These latter serve as a representation of the biological community or assemblage within a given habitat.

The Valentine *et al*., 2005 classification system is not obviously hierarchical in its approach. It is designed to be a template for a database that will allow the habitat characteristics of a site to be entered easily by selecting terms from lists. It provides a basis for organising and comparing habitat information and for recognizing regional habitat types. The classification is intended to be useful to scientists and to managers of fisheries and the environment. The classification recognises eight seabed themes (informal units) that form the backbone of the system. The themes are seabed topography, dynamics, texture, grain size, roughness, fauna and flora, habitat association and usage and habitat recovery from disturbance. Themes include one to many classes of habitat characteristics related to seabed features, fauna and flora, and processes. Below the classes, a sequence of subclasses, categories, and attributes addresses habitat characteristics with increasing detail. Code gives an overall geological descriptor, followed by the degree of physical structural complexity (with estimate of percent cover) followed by degree of biological structural complexity (with estimate of percent cover). The Valentine *et al*., 2005 system in addition to the geological and biological descriptors contained in the other classifications includes environmental dynamics, habitat usage and recovery criteria. The classification supports the definition of naturally disturbed or stable environments as well as areas of high or low productivity. It all responds to the need of managers to identify areas of particular sensitivity which are unlike to recovery quickly from perturbation.

The Auster *et al*., 2005 classification system used for seamount habitats follows a similar approach to that of Greene *et al*., 1999 in that is considers the landscape level or megahabitat, macro and mesohabitats and finally microhabitats and modifiers. As with the Valentine *et al*. (2005) classification it uses terms such as 'emergent structures' that may be useful in deep-sea habitat classification.

4.2.2 Applicability of each classification system for use in the deep-sea

We applied each classification (with the exception of Auster *et al*., 2005, which is specific to seamounts) to three habitat types found on a deep-sea carbonate mound taking as an example the Theresa mound in the Porcupine Seabight off western Ireland (Tables 4.2.2.1 – 4.2.2.5).

Table 4.2.2.1 Classification of habitats on the Theresa Mounds using: EUNIS

	Theresa Mound: coral reef	Theresa Mound: coral rubble	Theresa Mound: sandwaves
Level 1 – A	Marine Habitats	Marine Habitats	Marine Habitats
Level 2 – A6	Deep-Sea Bed	Deep-Sea Bed	Deep-Sea Bed
Level 3 – A6.6, A6.2, A6.3	Deep-Sea Bioherms	Deep-sea mixed substrata	Deep-sea sand
Level 4 – A6.61, A6.22, n/a	Communities of deep-sea corals	Deep-sea biogenic gravels (shell, coral debris)	No further detail
Level 5 – A6.611, n/a, n/a	Deep-sea [Lophelia pertusa] reefs	No further detail	No further detail

Table 4.2.2.2. Classification of habitats on the Theresa Mounds using Greene et al. (1999).

	Theresa Mound: coral reef	Theresa Mound: coral rubble	Theresa Mound:sandwaves
Megascale	Continental Slope (intermediate)	Continental Slope (intermediate)	Continental Slope (intermediate)
Mesoscale habitat	Mound, Build-up, crust (>3m in size)	Mound, Build-up, crust (>3m in size)	Mound, Build-up, crust (>3m in size)
Macroscale habitat	Reef (carbonate feature), Biogenic	Debris field, Biogenic	Sediment wave, Sand
Microscale habitat	Flat to sloping	Organic debris, Sloping (5-30%)	Sloping (5-30%)

Modifiers	Hummocky Contiguous Cover of encrusting organisms: Continuous (>70%) Patchy (20-70%) Little to known cover (<20%)	Regular Unconsolidated Poorly packed Pavement Cover of encrusting organisms: little to no cover Communities: coral/cerianthids	Irregular Unconsolidated Cover of encrusting organisms: little to no cover Communities: coral

Table 4.2.2.3 Classification of habitats on the Theresa Mounds using: Day and Roff (2000)

	Theresa Mound: coral reef	Theresa Mound: coral rubble	Theresa Mound:sandwaves
Level 1: Environmental type	Marine	Marine	Marine
Level 2: Geographic range	Atlantic Ocean Basin	Atlantic Ocean Basin	Atlantic Ocean Basin
Level 3: Temperature	Temperate	Temperate	Temperate
Level 4: Sea-ice cover	Absent	Absent	Absent
Level 5: Segregation of pelagic and benthic realms	Benthic	Benthic	Benthic
Level 6: Vertical segregation	Bathyal (200-2000m)	Bathyal (200-2000m)	Bathyal (200-2000m)
Level 7: Mixing and Wave Action	High slope >1°	High slope >1°	High slope >1°
Level 8: Benthic Substrate	Biogenic reef	Biogenic rubble	Sand

Table 4.2.2.4 Classification of habitats on the Theresa Mounds using: Allee et al. (2000)

	Theresa Mound: coral reef	Theresa Mound: coral rubble	Theresa Mound: sandwaves
Level 1: Life Zone	1a. Temperate northeast Atlantic	1a. Temperate northeast Atlantic	1a. Temperate northeast Atlantic
Level 2: Water/Land	2b. Water	2b. Water	2b. Water
Level 3: Marine/Freshwater	3a. Marine/estuarine	3a. Marine/estuarine	3a. Marine/estuarine
Level 4: Continental/non-continental	4a. Continental	4a. Continental	4a. Continental
Level 5: Bottom/ Water Column	5a. Bottom (benthic)	5a. Bottom (benthic)	5a. Bottom (benthic)
Level 6: Shelf/ Slope, and Abyssal	6b. Medium (200-1000m)	6b. Medium (200-1000m)	6b. Medium (200-1000m)
Level 7: Regional Wave/Wind Energy	7b Protected/Bounded, not applicable ??	7b Protected/Bounded, not applicable ??	7b Protected/Bounded, not applicable ??
Level 8: Hydrogeomorphic (hydroform) or earthform features	8a. Upper continental slope	8a. Upper continental slope	8a. Upper continental slope

Level 9: Hydrodynamic features	9c. Subtidal	9c. Subtidal	9c. Subtidal
Level 10: Photic/Aphotic	10b. Aphotic	10b. Aphotic	10b. Aphotic
Level 11: Geomorphic types or topography	Carbonate mound	Carbonate mound	Carbonate mound
Level 12: Substratum and Ecotype	Carbonate hard substrate, Biogenic reef	Carbonate hard substrate, Biogenic rubble	Sand, sand wave
Level 13: Local modifiers and eco-units	Strong current Eco-units: *Lophelia pertusa* *Madrepora oculata*	Strong current	

Table 4.2.2.5. Classification of habitats on the Theresa Mounds using: Valentine et al., 2005

	Theresa Mound: coral reef	Theresa Mound: coral rubble	Theresa Mound: sandwaves
Theme 1: Topographic Setting	Deep aphotic Shelf edge carbonate mound	Deep aphotic Shelf edge carbonate mound	Deep aphotic Shelf edge carbonate mound
Theme 2: Seabed dynamics and currents	Intermixed mobile and immobile substrates Deepsea tidal current Strong – diurnal	Intermixed mobile and immobile substrates Deepsea tidal current Strong – diurnal	Intermixed mobile and immobile substrates Deepsea tidal current Strong – diurnal
Theme 3: Seabed texture, hardness and layering in the upper 5-10 cm	Rock or other hard substrate	nil	nil
Theme 4: Seabed grain size analysis	Not available	Not available	Not available
Theme 5: Seabed roughness	C8: Biogenic structures Coral Reef, 20-100%	C6: Shell materials Coral debris	C5: Bedforms Sandwaves
Theme 6: Flora and fauna	nil	nil	nil
Theme 7: Habitat Association and Uses	Faunal habitat association Fishing Disturbed Static gears/deep towed gears	Faunal habitat association Fishing Disturbed Static gears/deep towed gears	Faunal habitat association Fishing Disturbed Static gears/deep towed gears
Theme 8: Habitat recovery from disturbance	Slow if ever Millennia	Medium	Fast

4.2.3 Assessment and recommendations

None of the schemes outlined above are immediately applicable in the deep-sea at all scales. Some operate at broad global scales (Day and Roff, 2000), others are more regional and fine scale (Greene *et al*., 1999; Valentine *et al*., 2005). There may be merit in combining some schemes, for example, using Day and Roff (2000) in conjunction with Greene *et al*. (1999) would allow the classification of global, geographic and landscape features with mega-scale to microscale habitat (Table 4.2.3.1).

All of the schemes reviewed, at some point, reach the intuitively identifiable units of coral reef, coral debris (rubble), and sand waves. Some then go on to look at small scale physical parameters in more detail (Greene *et al*., 1999; Allee *et al*., 2000), others introduce the biological component of the community at this stage (Allee *et al*., 2000; Valentine *et al*., 2004; EUNIS). The group felt that it is important to separate physical habitat from description of biotope or equivalent in the adoption of a working classification system. Greene *et al*. (1999) primarily describes the geology of the physical habitat and is organised to handle the typical acoustic and imaging data derived from deep-sea survey. What is then required is a system of naming of faunal assemblages observed in the deep-sea (ideally identified using multivariate analysis). Two schemes facilitate naming of assemblages: Allee *et al*. (2000) with her ecotypes and the EUNIS scheme with its biotopes. Formal nomenclature is best developed in the EUNIS classification which provides good examples of application from both terrestrial and shallow marine habitats.

While the Valentine *et al*. (2005) captures environmental dynamics, habitat use and impacts, we feel that this information may not always be available in the first instance and think that a habitat classification system should record only the habitat, and not anthropogenic modifiers. Additional parameters specific to habitat suitability modelling, assessment of human impacts and habitat sensitivity to, and recoverability following, impact can be recorded separately. We will deal with a framework for assessing human impact in Section 4.3.

Table 4.2.3.1 Classification of the Theresa Mounds using: Day and Roff (2000) and Greene et al. (1999)

EUNIS	Day and Roff (2000) and Greene et al (1999)	Theresa Mound: coral reef	Theresa Mound: coral rubble	Theresa Mound: sandwaves
LEVEL 1 A Marine Habitat	Level 1: Environmental Type	Marine	Marine	Marine
	Level 2: Geographic Range	Atlantic Ocean Basin	Atlantic Ocean Basin	Atlantic Ocean Basin
	Level 3: Temperature	Temperate	Temperate	Temperate
	Level 4: Sea-Ice Cover	Absent	Absent	Absent
	Level 5 Segregation of Pelagic and Benthic Realms	Benthic	Benthic	Benthic
Level 2 A6 Deep Sea Bed	Level 6 Vertical Segregation	Bathyal (200-2000m) Megascale: Continental Slope (intermediate)	Bathyal (200-2000m) Megascale: Continental Slope (intermediate)	Bathyal (200-2000m) Megascale: Continental Slope (intermediate)
Level 3 A6.6-Deep-sea bioherm	Mesoscale habitat	Mound, Build-up, crust (>3m in size)	Mound, Build-up, crust (>3m in size)	Mound, Build-up, crust (>3m in size)
Level 3 A6.2 Combination substrates A6.3 Deep-sea sand sediments	Macroscale habitat	Reef (carbonate feature), Biogenic	Debris field, Biogenic	Sediment wave, Sand
Level 4: A6.62-Deep-sea biogenic gravels (shell, coral debris)	Microscale habitat	Flat to sloping	Organic debris Sloping (5-30%)	Sloping (5-30%)
Level 4: A6.61-Communities of deep-sea	Modifiers	Hummocky Contiguous Cover of encrusting organisms:	Regular Unconsolidated Poorly packed	Irregular Unconsolidated Cover of encrusting organisms: little to

corals		Continuous (>70%) Patchy (20-70%) Little to known cover (<20%)	Pavement Cover of encrusting organisms: little to no cover Communities: coral/cerianthids	no cover Communities: coral
Level 5: A6.611-Deep-sea [Lophelia pertusa] reefs				

4.3 Frameworks for describing sensitivity to fishing activities

4.3.1 Introduction

Amongst other uses, an analysis of sensitivity of habitats to fishing activity forms part of a framework for necessary risk assessment when planning new fishing activities at sea, especially in unfished habitats.

NOAA Fisheries is developing an Environmental Impact Statement (EIS) that responds to a court directive and settlement agreement to complete new NEPA analyses for Amendment 11 to the Pacific Coast Groundfish FMP. A decision-making process for the EIS has been designed for policy to flow from assessment. The data analysis includes spatial and temporal analysis of the distribution of habitat types, distribution of fish species, habitat use by fish, sensitivities of habitat to perturbations, and the dynamics of fishing effort (Figure 4.3.1.1).

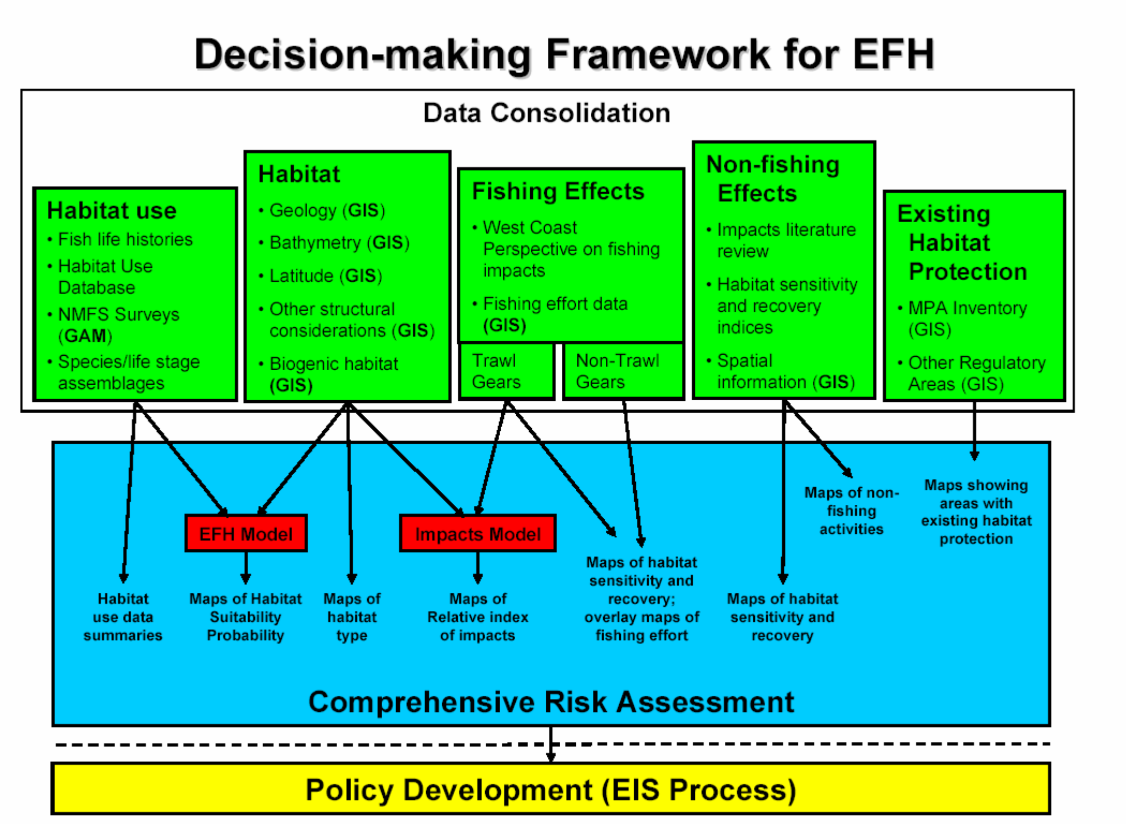


Figure 4.3.1.1 Decision-making framework for the assessment stage of the Pacific Coast Groundfish EFH EIS showing data inputs and separation of the assessment and policy components

This decision making framework usefully places habitat classification, habitat use, fishing effects and habitat sensitivity in the context of risk assessment and policy development. In the last section we addressed possible classification systems for use in the deep-sea. In this section we will example methods for determining habitat sensitivity to perturbation and likely powers of recoverability.

4.3.1.1 Habitat Sensitivity Framework

The description of biotope 'sensitivity' includes the evaluation of the likely damage from an activity and the potential for recovery after damage. Systems for assessing the sensitivity of coastal and shallow water biota to human activities has recently been reviewed (Tyler-Walters *et al*., 2001, Dalton *et al*. 2004). Here we discuss systems being developed in the UK, USA, Canada and Ireland.

4.2.1 The Marine Life Information Network (MarLin)

The Marine Life Information Network (MarLin) defines the sensitivity of a biotope as: intolerance of a habitat, community or species [biotope] to damage from an external factor (Tyler-Walters *et al*., 2001). Any part of the biotope becomes vulnerable to adverse effect(s) when an external factor is likely to happen and sensitivity must be assessed relative to change in a specific environmental factor.

MarLin includes in its framework for describing habitat sensitivity:

- Identification of key species within a habitat/biotope.
- Assessment of biotope sensitivity based on key species response to perturbation.
- Assessment of likely recoverability of the biotope following cessation of an activity.

4.3.1.2 Identification of species within habitat/biotope

Not all species within a community contribute to the sensitivity of a biotope to fishing activities. The loss of some species from a community may not adversely affect the viability, structure or function of the biotope. The species that indicate the sensitivity of a biotope are identified as species that significantly influence the ecological function and structure of a community, such that the loss of one or more of such species would result in changes in the population of associated species and their interactions. The MarLin framework uses criteria to identify species that indicate biotope sensitivity ('key' and 'important' species) based on the likely magnitude of the resultant change (Table 4.3.1.2.1).

Table 4.3.1.2.1. MarLin selection criteria for species used to indicate sensitivity. The criteria are used to decide which species best represent the sensitivity of a biotope or community as a whole (Tyler-Walters et al., 2001).

	Species used to indicate sensitivity
Rank	Criteria
Key structural	The species provides a distinct habitat that supports an associated community. Loss/degradation of this species population would result in loss/degradation of the associated community.
Key functional	The species maintains community structure and function through interactions with other members of that community (for example, predation, grazing, and competition). Loss/degradation of this species population would result in rapid, cascading changes in the community.
Important characterising	The species is/are characteristic of the biotope (dominant, highly faithful and frequent) and are important for the classification of that biotope. Loss/degradation of these species populations could result in

	loss of that biotope.
Important structural	The species positively interacts with the key or characteristic species and is important for their viability. Loss/degradation of these species would likely reduce the viability of the key or characteristic species. For example, these species may prey on parasites, epiphytes or disease organisms of the key or characteristic species.
Important functional	The species is/are the dominant source of organic matter or primary production within the ecosystem. Loss/ degradation of these species could result in changes in the community function and structure.
Important other	Additional species that do not fall under the above criteria but where present knowledge of the ecology of the community suggests they may affect the sensitivity of the community

4.3.1.3 Assessment of biotope sensitivity based on key species response to perturbation

In the MarLin framework the sensitivity assessments of key species is used to define the biotope sensitivity (Figure 4.3.1.3.1). In general it is assumed that if any of the key species were highly sensitive then the sensitivity of the biotope as a whole is likely to be high (Table 4.3.1.3.1). Similarly, if the 'important characterising' species were highly sensitive the overall sensitivity of the biotope was also high. The MarLin framework further assumed that the sensitivity of important species may increase the overall sensitivity of the biotope above that of the key species. For example, if the key species were judged to have an intermediate sensitivity but the important species were highly sensitive to the same factor, then the overall sensitivity of the biotope was reported as high (see examples given in Table 4.3.1.3.2).

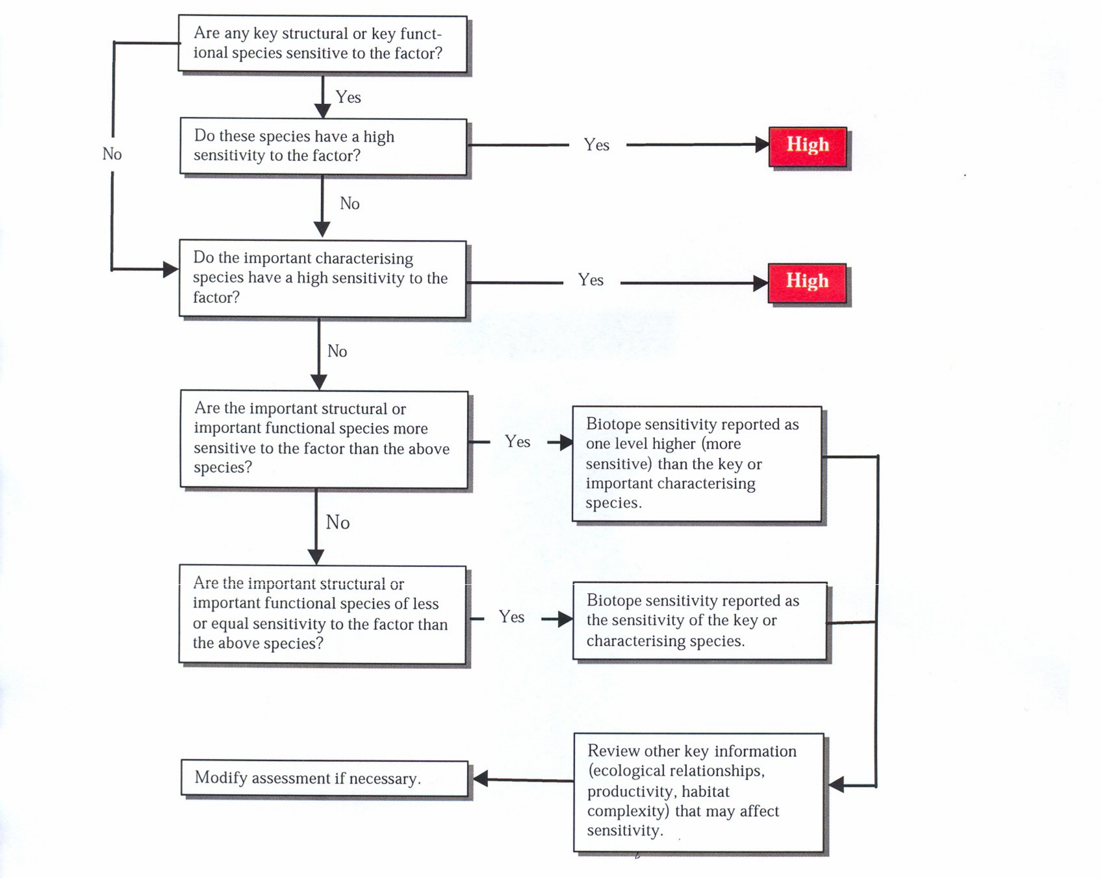


Figure 4.3.1.3.1 MarLin biotope sensitivity assessment decision tree (Tyler-Walters et al., 2001).

Table 4.3.1.3.1 Species sensitivity and recoverability assessment scales (ranks and criteria) (Tyler-Walters et al., 2001).

SPECIES SENSITIVITY The intolerance of a habitat, community or individual (or individual colony) of a species to damage, or death, from an external factor	
Rank	**Definition (from Hiscock et al., 1999)**
High	The species population is likely to be killed/destroyed by the factor under consideration
Medium	Some individuals of the species may be killed/destroyed by the factor under consideration and the viability of a species population may be reduced
Low	The species population is unlikely to be killed/destroyed by the factor under consideration. However, the viability of a species population may be reduced
Not sensitive	The factor does not have a detectable effect on survival or viability of a species or structure and functioning of a biotope
Not sensitive	Population of a species may increase in abundance or biomass as a result of the factor
Not sensitive	This rating applies to species where the factor is not relevant because they are protected from the factor (for instance, through a burrowing habit), or can move away from the factor

Table 4.3.1.3.2 Examples of MarLin biotope sensitivity assessment ranks derived from species sensitivity assessments. The values shown in the table are for demonstration only (Tyler-Walters et al., 2001).

Species used to indicate sensitivity					Biotope sensitivity
Key structural	Key functional	Important characterising	Important structural	Important functional	
High	High	Intermediate	Intermediate	Low	High
High	Intermediate	Intermediate	Low	Low	High
Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Intermediate	Low	High	Low	Low	High
Low	Low	Intermediate	Low	Low	Intermediate
Low	Intermediate	Low	High	Intermediate	High
Low	Low	Low	Intermediate	Low	Intermediate
Low	Low	Low	Low	Low	Low
Low	Low	N/A	N/A	N/A	Low
Not sensitive	Not sensitive	Intermediate	N/A	N/A	Intermediate
Not sensitive	Not sensitive	N/A	Intermediate	High	Low

4.3.1.4 The likely recoverability of the biotope following cessation of an activity

Partial or complete recovery of a habitat, community or species from adverse effect(s) (recoverability) may occur through e.g. re-growth and/or re-colonisation (Tyler-Walters *et al*., 2001). In the MarLin framework the recoverability of the biotope is assumed to depend on the recoverability of the key species and to be modified by the recoverability of the important species (Figure 4.3.1.4.1). The recoverability of any species is dependent upon the species ability to:

- regenerate damage by re-growth;
- re-colonize the habitat by immigration of adults, or
- re-colonize the habitat by larvae or juveniles (recruitment).

These criteria depend on the developmental biology, longevity, age at maturity and frequency of reproduction of the adults, together with the biology and sensitivity of the larvae and juvenile stages (Table 4.3.1.4.1). The recoverability to environmental factors that reduce viability of species populations is primarily dependent on the species ability to re-grow and regenerate. Opposed to long lived species (high sensitivity), short lived species with high growth rate and low age at maturity are considered to have low sensitivity to perturbation and their populations may recover rapidly from factors that have reduced the viability of populations. Therefore, the species capacity to recover from a low population level is dependent on its ability to recruit and re colonize the habitat (Table 4.3.1.4.2).

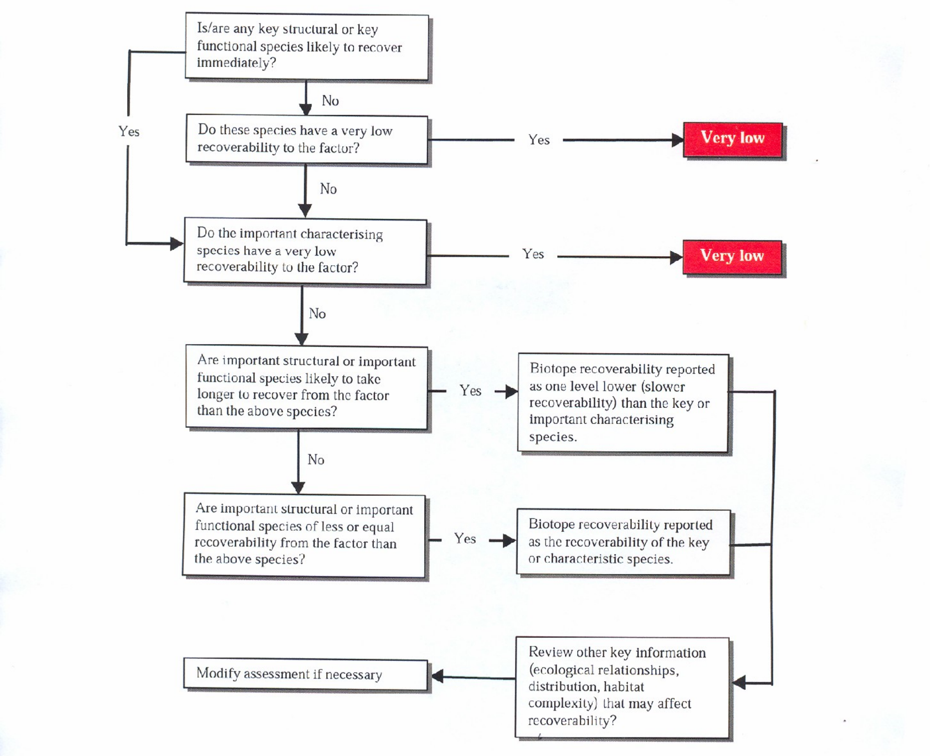


Figure 4.3.1.4.1. Biotope recoverability assessment rationale (Tyler-Walters et al., 2001).

Table 4.3.1.4.1 Biological characteristics that are considered in assessing recoverability at different levels of sensitivity (Tyler-Walters et al., 2001). The fundamental characteristics is the level of growth rate, age at maturity and life span. Developmental and larval biology is considered in order to differentiate between low sensitive and sensitive (intermediate, high) species. For sensitive species their distribution patterns are used to determine if they are intermediate or highly sensitive to perturbation.

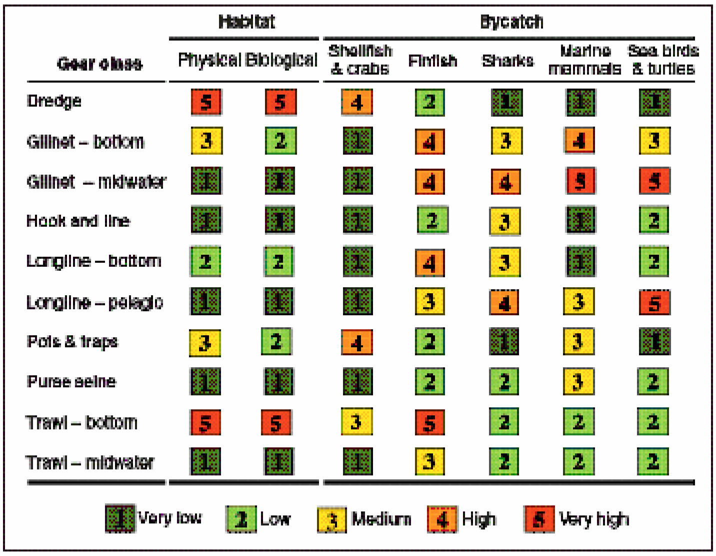
High sensitivity	**Intermediate sensitivity**	**Low sensitivity**
Abundance	Abundance	
Size at maturity	Size at maturity	
Growth rate	Growth rate	Growth rate
Mobility	Mobility	
Distribution		
Life span	Life span	Life span
Age at maturity	Age at maturity	Age at maturity
Generation time	Generation time	
Reproductive type	Reproductive type	
Reproductive frequency	Reproductive frequency	
Fecundity	Fecundity	
Larval settling time	Larval settling time	
Dispersal potential	Dispersal potential	

Table 4.3.1.4.2 Habitat sensitivity and recoverability assessment scales (ranks and criteria) (Tyler-Walters et al., 2001).

RECOVERABILITY	
The ability of a habitat, community or individual (or individual colony) of speciies to redress damage sustained as a result of an external factor Recoverability assumes that bthe impacting factor has stopped or been removed. The scale also refers only to the recoverability potential of a species, based on its reproductive biology etc	
Rank	**Definition**
None	Recovery is not possible.
Very low/ none	Partial recovery is only likely to occur after about 10 years and full recovery may take over 25 years or never occur.
Low	Only partial recovery is likely within 10 years and full recovery is likely to take up to 25 years.
Moderate	Only partial recovery is likely within 5 years and full recovery is likely to take up to 10 years
High	Full recovery will occur but will take many months (or more likely years) but should be complete within about five years.
Very high	Full recovery is likely within a few weeks or at most six months
Immediate	Recovery immediate or within a few days
Not relevant	If the sensitivity of a species is not relevant then recoverability cannot be assessed

4.3.2 Canadian and US frameworks

In Canada, Chuenpagdee *et al.* (2003) developed a ‘Damage schedule approach’ to assess collateral impacts of fishing methods on incidental bycatch and on habitats. This approach establishes a consistent ranking of the severity of fishing gear impacts using different fishing gears based on the response of fishers, scientists, and managers. A series of binary choices in a questionnaire format were given to the respondents who then had to rate the impact scenario that they considered most ecologically severe (Figs 4.3.2.1, 4.3.2.2).



Gear class	Habitat: Physical	Habitat: Biological	Bycatch: Shellfish & crabs	Bycatch: Finfish	Bycatch: Sharks	Bycatch: Marine mammals	Bycatch: Sea birds & turtles
Dredge	5	5	4	2	1	1	1
Gillnet – bottom	3	2	1	4	3	4	3
Gillnet – midwater	1	1	1	4	4	5	5
Hook and line	1	1	1	2	3	1	2
Longline – bottom	2	2	1	4	3	1	2
Longline – pelagic	1	1	1	3	4	3	5
Pots & traps	3	2	4	2	1	3	1
Purse seine	1	1	1	2	2	3	2
Trawl – bottom	5	5	3	5	2	2	2
Trawl – midwater	1	1	1	3	2	2	2

1 Very low, 2 Low, 3 Medium, 4 High, 5 Very high

Figure 4.3.2.1 Ratings of habitat and bycatch impacts for each gear class, as determined by participants of a workshop held in Seattle (Morgan and Chuenpagdee, 2003)

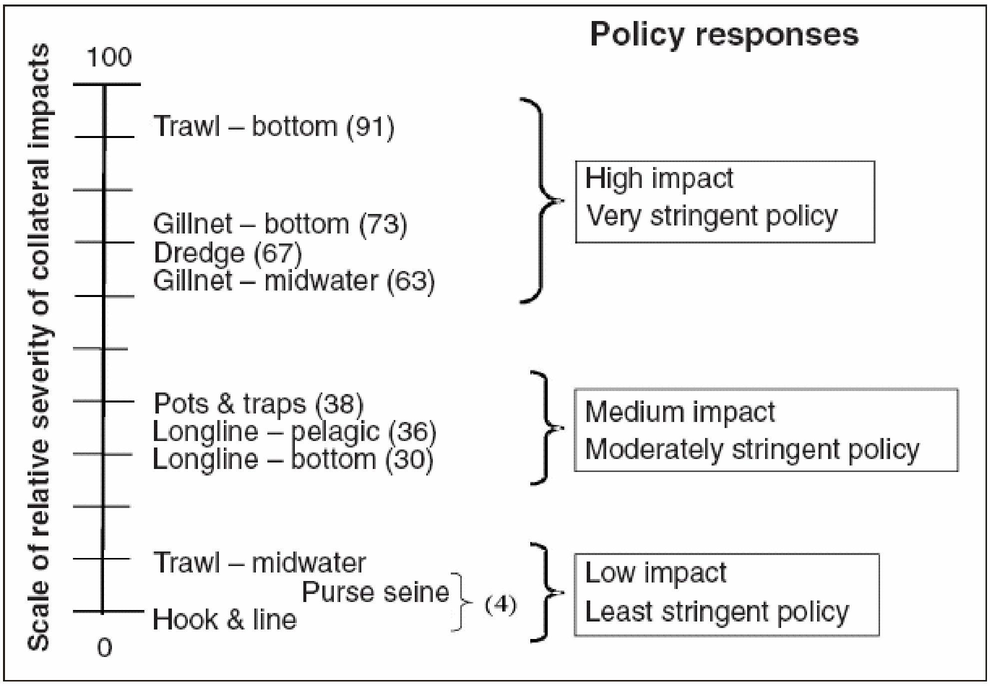


Figure 4.3.2.2 Scale of relative severity of collateral impacts of ten fishing gears and possible policy responses.

Advantages : original approach for the assessment of fishing gear impact and the resulting ranking of fishing gears, including opinions of various groups (fishers, scientists, and managers) on the severity of fishing gear impacts.

Disadvantages: The classification of habitats (biological/physical) and faunal groups is very general.

A further paper by the same group (Morgan *et al*. 2005) analyses differential ecological impacts of demersal fishing gears using an ecological footprint approach combining ground fishing catch by gear type with the ecological severity ranking of fishing gears (Morgan and Chuenpagdee, 2003). The paper reviewed by-catch and habitat impacts of ten fishing gears reported in over 170 documents and provided a ranking of the ecological impacts of these gears. Bottom trawling gear has far and away the region's largest ecological footprint. Other gears with smaller footprints include bottom longline, pot/trap and hook and line gear.

Advantages: takes into account both type of gear (and associated impact) and number of landings in a specific area.

Disadvantages: general impact on the seabed, not related to specific habitats, biotopes, or species.

In the US Pacific coast, the National Marine Fisheries Service (NMFS) has looked at habitat sensitivity as part of the development of the analytical framework to evaluate effects of alternative management actions on Pacific coast groundfish Essential Fish Habitat (EFH) (NMFS Northwest Fishery Science and Northwest Regional Office 2004).

4.3.2.1 Habitat sensitivity and recovery

In an effort to provide a quantitative measure of the degree of habitat modification resulting from a unit of fishing effort, two notional indices were developed: one describing the sensitivity levels of bottom habitats to gear impacts (the sensitivity index) and another describing recovery times from gear impacts (the recovery index). The form of each matrix is based on gear types used on the west coast, bottom habitat type designations used in the GIS mapping of habitat, and the available literature on gear impacts. The sensitivity scale used consists of four levels (0, 1, 2, and 3) representing relative sensitivity to gear impacts (Table 4.3.2.1.1). The descriptors for the sensitivities at each level are based on the actual impacts reported in the literature. The recovery scale is in units of time (years) with the values again taken from the literature.

Table 4.3.2.1.1 Descriptions of sensitivity levels and recovery time (years) for gear impact assessments (taken from Pacific States Marine Fisheries Commission 2004).

Sensitivity level	Sensitivity description
0	No detectable adverse impacts on seabed; i.e. no significant differences between impact and control areas in any metrics
1	Minor impacts such as shallow furrows on bottom; small differences between impact and control sites, <25% in most measured metrics.
2	Substantial changes such as deep furrows on bottom; differences between impact and control sites 25% - 50% in most metrics measured.
3	Major changes in bottom structure such as re-arranged boulders; large losses of many organisms with differences between impact and control sites >50% in most measured metrics.
Recovery time	**Recovery description**
0	No recovery time required because no detectable adverse impacts on seabed
n	n = time (years) required for return to pre-impact condition

While these indices provide a useful step in the quantification of fishing gear effects on habitat, they have some limitations at this stage. The sensitivity index provides a relative measure of the changes to the physical (and not biological) habitat caused by the interactions with various fishing gears. However it is not explicit that the changes described in the index results from a single contact with the gear, nor what happens with subsequent contacts. Relationships between fishing effort and habitat change (impact) is likely to be complex and almost certainly non-linear. The power of recovery is similarly difficult to quantify. At this stage, however, they have no empirical data from which they can develop such relationships. A first attempt is made, however, in the development of an Impacts Model which combines habitat classification and the impact specific gears with fishing effort data. This model has a number of limitations resulting from incomplete effort data (only data from trawl fishing is used) and poor spatial resolution of effort data (data is provided in 10 minute blocks of latitude and longitude). As a result of these limitations the Scientific and Statistical Committee (SSC), in a review of the EFH analytical framework did not recommend use of the current EFH fishing impacts model for risk assessment or to produce maps of intensity of habitat use (Dalton *et al*. 2004). However, the SSC did approve the use of the fishing impacts model for a variety of purposes, including:

- Evaluation of the future impacts of closures, changes in fishing efforts, and modifications to gear characteristics in an absolute sense.
- Evaluation of these impacts in a relative sense
- Evaluation of which areas are most impacted.

Advantages of fishing impact models: join different sources of data, from habitat (including sensitivity and recovery) and fishing (including different gears, intensity of fishing). Models are more flexible and adapted to the complex and non linear.

Limitations: the problem of spatial inconsistency between fishing impact and habitat has been pointed out for the fishing impact model of the NMFS. The data set has to be sufficient as well as spatial resolution.

In Alaska, a mathematical fishing impact model to evaluate the effects of fishing on benthic habitats was developed by the Alaska Fisheries Science Center (Alaska Fisheries Science Center 2003). The model is based on equations that incorporate the basic factors determining impacts of fishing on habitats: a) fishing intensity, (absolute effort in area swept per year divided by area size), b) sensitivity of habitat to fishing effort and c) habitat recovery rate.

Results for a region can be presented in a single value as a mean impact, frequency distribution of impacts for each block, and the geographic distribution of the impacts.

Advantages: Potentially more robust quantification of impact.

Disadvantages: The vulnerability may be difficult to determine. Certain features of the gear may make the gear more damaging to one type of organism than to another type. The process is data intensive

4.3.3 Irish Approach - Sensmap

An approach developed by MacDonald *et al*. (1996) for deriving a sensitivity index for benthic species to physical disturbance caused by fishing activities has been adapted here to include chemical contaminant input and other environmental disturbances. The sensitivity of a species is appraised by an assessment of both its initial intolerance to a perturbation and ability to recover. The sensitivity of larger areas of marine benthic life is assessed at the biotope, biotope complex or lifeform level.

The method developed by MacDonald *et al*. (1996) assesses the sensitivity of benthic species to physical disturbance caused by fishing methods. The components of sensitivity identified are:

- physical fragility (F) of a species that comes into contact with the disturbing force
- the intensity of that force (I), and
- the ability of the species to recover to its former population or physical status once original conditions return (R)

Species sensitivity to impact is described by the following equation where the importance of species recovery is weighted (e):

$S = (F \times I)\, eR$

The model developed by MacDonald *et al*. (1996) is based on the assumption that, for any particular species, with increasing physical disturbance (I), there is a corresponding linear increase in sensitivity (S). This is because both physical fragility (F) and recovery (R) are constants for a given species. Whilst the assumption of linearity between sensitivity and intensity generally follows for physical disturbance, such a linear progression does not exist for many chemical and other environmental factors.

The sensitivity of species that respond both linearly and non-linearly to different factors is assessed here by defining species intolerance (I) for a range of factor intensities. The modifications applied in this study to the method outlined by MacDonald *et al*. (1996) are described by the following equation:

$S = I \times R2$

S = sensitivity of a species to a factor, I = intolerance of a species to a factor at a particular intensity, and R = species recovery.

An overall assessment of species sensitivity is made by determining both species intolerance

(I) to a factor intensity and species recovery (R). Sensitivity assessments are made in relation to the factor(s) associated with activities.

Values for species intolerance (I) are assigned to each species through consideration of each activity in terms of the effect of that activity e.g. smothering. The average intolerance of a species in an area of impact is used to represent species intolerance (I). Where available, empirical data are used to evaluate the different proportions of a population being affected to different degrees. The 'degree of effect' is measured using 100 to represent mortality, 0 to represent no effect, and between 1 and 99 to represent increasingly significant levels of sublethal effects. For example, where an activity has led to the following: 10% of the population are dead (degree of effect is 100), 40% of the population are sublethally affected (degree of effect is 50) and the remaining 50% of the population are not affected (degree of effect is 0) the average intolerance is calculated via the following equation:

$$\frac{(10 \text{ x } 100) + (40 \text{ x } 50) + (50 \text{ x } 0)}{100} = 30$$

The ability of a species to recover (R) is estimated by considering the components of each category, i.e. Recruitment, Recolonisation and Regeneration. Estimation of species recovery involves the following steps: A score ranging between 1-100 is assigned for each of Recruitment, Recolonisation and Regeneration, where, for example, 1 represents maximum regeneration ability and 100 represents no regeneration ability. In reality, it is difficult to select an exact point on this scale and it is more useful to select a probable range e.g. regeneration is between 10-30. In so doing, the 'best estimate' i.e. 20 or 'worst case' i.e. 30 can be used. Estimating a score for each of the recovery categories requires an overall subjective judgement of the relevant component attributes. For example, the importance of a low recruitment success over-rides an otherwise high fecundity. The appropriate weighting is then applied to each recovery category score (Recruitment, Recolonisation and Regeneration are weighted respectively at 8:1:1) these are summed, and then normalised to give an overall recovery score between 1–100, where 1 represents excellent species recovery and 100 represents no species recovery.

Species sensitivity to multiple factors i.e. an activity, may also be addressed. To achieve this, the sum of the intolerance scores for the multiple factors is used for species intolerance (I) with species recovery (R)

Species sensitivity to multiple factors = [ˆIspecies to factors] x R2

S = sensitivity of a species to multiple factors, I = sum of intolerances to multiple factors and R = species recovery.

The above process is appropriate for simultaneous factors only and not cumulative factors. The latter needs to be considered as separate events. When assessing the intolerance of a species to multiple factors, an additive effect is assumed. Where significant synergistic or antagonistic relationships between certain factors is understood, overall intolerance scores are assigned for species for such combinations of factors. Where the sum of species intolerance to multiple factors exceeds the maximum score of 100 (indicating that the species intolerance has increased beyond the point at which it is believed the entire population of that species would die), a maximum score of 100 is imposed.

The Sensmap framework also allows for assessing sensitivity of habitats (biotopes). A hierarchical classification of units is needed and in this case the Marine Habitat Classifiaction for the UK and Ireland (Connor *et al*., 1997) is used. The classification units can be spatially represented and are therefore suitable for mapping the physical and biological characteristics of benthic areas. For sensitivity assessments, biotopes and sub-biotopes (now within this document referred to only as 'biotopes') are chosen as the primary unit for use in the sensitivity assessment of areas of benthos. These units can then be used as the 'building blocks' for the derivation of the sensitivity of all other, larger, biological units described above. Although they do not always represent a functional ecological unit, they are a commonly understood unit above species level.

The choice of species on which to base biotope sensitivity is made on their value in determining the sensitivity of the biotope as a whole. Species within a biotope fall into several categories including sensitive, rare, scarce, keystone and characteristic. Keystone species appear the primary choice for assessing biotope sensitivity. Unfortunately, in the case of some biotopes, for example, sediment biotopes, there is less inter-species dependence and therefore no identifiable keystone species. However, amongst the characteristic species in a biotope, there are those which constitute high biomass, and are immediately conspicuous and probably contribute to the ecological functioning of the community. These characteristic species are of importance because their loss or degradation may result in gradual change or degradation of the biotope and affect how recognisable the biotope is in comparison to the original biotope definition. On this basis, the most appropriate species to base biotope sensitivity are: those that underpin the community, i.e. keystone species; and those that best describe the biotope, i.e. important characteristic species.

It is suggested that for each biotope, three species are chosen with which to derive sensitivity. These three species will be a combination of keystone and important characteristic species, with keystone species selected first by preference. In order to recognise the greater contribution that keystone species sensitivity makes to the overall biotope sensitivity, the contribution made by keystone species in any calculation of biotope sensitivity is weighted by a factor of two.

4.3.3.1 Comments

The Sensmap framework for assessing sensitivity shares some similarities with the MarLin approach in that it considers activities in terms of their effect (rather than the activity as a whole) and considers both intolerance and recoverability of the species. The values assigned to intolerance are, in general, based on 'expert judgement' (although where data are available may be calculated as depicted), as are the values assigned to recovery. This again is similar to MarLin but is unlike the USA framework where the values are based on empirical data. The Sensmap framework is flexible in that is allows the user to look at the species level, biotope level or at broader scales, and its strength that again it shares with MarLin is the integration of the framework with a well developed classification scheme. The vision for the Sensmap approach was to develop a database based on the framework outlined, which would allow the broadest cover of factors and species in terms of sensitivity assessments. This is essentially what has been done with MarLin and thus in their present forms MarLin is the more usable of the two systems.

4.3.4 Sensitivity to bottom fishing activities using Lophelia reefs as an example

4.3.4.1 MarLin framework

Lophelia pertusa is vulnerable to demersal fishing gears such as trawls, gillnets and long lines. The following physical factors are believed to express the sensitivity of *Lophelia* reefs for fishing:

- substratum loss,
- increase in suspended sediments,
- abrasion and physical disturbance,
- displacement.

Sensitivity and recoverability assessment of Lophelia reefs for different physical factors has been carried out and can be found on the MarLin website.

The definitions of physical factors by MarLin:

Substratum loss: All of substratum occupied by the species or biotope under consideration is removed. A single event is assumed for sensitivity assessment. Once the activity or event has stopped (or between regular events) suitable substratum remains or is deposited. Species or community recovery assumes that the substratum within the habitat preferences of the original species or community is present.

Increase in suspended sediments: An arbitrary short term, acute change in background suspended sediment concentration e.g., a change of 100 mg/l for 1 month. The resultant light attenuation effects are addressed under turbidity, and the effects of rapid settling out of suspended sediment are addressed under smothering.

Abrasion and physical disturbance: mechanical interference, crushing, physical blows against, or rubbing and erosion of the organism or habitat of interest.

Displacement: Removal of the organism from the substratum and displacement from its original position onto a suitable substratum.

The working group used results of an assessment by MarLin for the factors that apply to physical impacts of fishing activities on Lophelia reefs. MarLin ranked the sensitivity, recoverability (very low – very high) and species richness of Lophelia reefs, WGDEC has considered these according to the three types of fishing gear.

Fishing gear	Physical Factors	Recoverability	Sensitivity	Species richness	Evidence/ Confidence
Bottom trawl	Substratum Loss	Very low	Very high	Major Decline	High
	Increase in suspended sediment	Very high	Very low	No change	Low
	Abrasion & physical disturbance	Very low	Very high	Major Decline	High
	Displacement	Very low	High	Decline	Low
Bottom gillnet	Substratum Loss	Very low	Very high	Major Decline	High
	Increase in suspended sediment	Very high	Very low	No change	Low
	Abrasion & physical disturbance	Very low	Very high	Major Decline	High
	Displacement	Very low	High	Decline	Low
Long line	Substratum Loss	Very low	Very high	Major Decline	High
	Increase in suspended sediment	Very high	Very low	No change	Low
	Abrasion & physical disturbance	Very low	Very high	Major Decline	High
	Displacement	Very low	High	Decline	Low

The results show that Lophelia reefs are rated the same way for all the bottom tending fishing gears. The MarLin framework focuses on assessing how physical factors effect key species of a habitat. Any of the given physical factors used in the working example have the same effects on Lophelia reefs independent of what fishing gear is used. For example, in all cases a removal of substratum does have the same consequences for Lophelia whether it is caused by bottom trawling, bottom gillnet or long lining. However, the intensity of a single impact differs between gears, where bottom trawling is ranked highest. Also, the frequency of impact plays an important role in how severely Lophelia reefs are impacted by different fisheries. Frequent impacts by bottom gillnetting may eventually lead to the same level of impact as a single impact from a bottom trawl. Frameworks for describing sensitivity to deep-sea fishing activities need to include criteria for ranking intensity of a single impact and the frequency of impact.

4.3.5 Discussion

A topic that was not considered by either the Marlin or the Sensmap frameworks is the issue of frequency of disturbance of the bottom by fishing gear. There was no consideration of these data in the formulation of the sensitivity and recovery values in the impact tables. Two major reviews have developed conceptual models incorporating fishing intensity in their assessment of gear impacts. Auster and Langton (1999) related "level of fishing effort" to changes in habitat characteristics, particularly habitat complexity. The National Research Council 2002 related "frequency of fishing disturbance" and "frequency of natural disturbance" to their overall effect on benthic communities in different kinds of substrates. These kinds of analyses recognize the fact that fishing intensity is an important consideration regardless of how gear impacts are assessed.

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5 Describing fish communities on seamounts

Term of Reference: examine possible ways of describing fish communities on seamounts.

5.1 Introduction

In 1981, the U.S. Board of Geographic Names defined a seamount as an underwater elevation rising 1,000 m or more from the sea floor. Since that definition, more thorough descriptions have been added, including that a seamount is also volcanic in nature and the landscape is usually conical in shape. These physical attributes are extremely important in that the seamount tends to give rise to upwelling and eddies, with fish aggregating downstream of such physical phenomenon. The effect of a seamount on oceanic flow is extremely complex and variable and depends upon a variety of variables.

5.2 Sampling

There are several sampling methods used to describe fauna found on and around seamounts and the methods selected are dependent upon the depth, shape, and seabed condition of the study area. Bottom trawling, traps and pots and long-lining have been used to sample fish, (Hughes, 1981, Menezes *et al*. in prep.). Increasingly, deep-sea still photography and video from a variety of underwater platforms including ROVs and submersibles are more commonly used in these types of investigations.

There are strengths and weaknesses in any sampling method and the method chosen can greatly bias the results. Some limitations include (a) attraction or avoidance of lights on the underwater vehicles and submersibles; (b) small cryptic species are often overlooked, especially if hiding among the coldwater corals or other structures; (c) nocturnally active or inactive, although this may be of less concern below the photic zone; and (d) burrowing species that may be in the substrate. These limitations should be clearly noted and discussed when developing a species list.

5.3 Describing fish communities

Comparing a list of species (abundance and distribution) with many geological (e.g. bottom types), chemical (e.g., temperature, calcium concentration) and biological (e.g., feeding guilds) variables can be reported in a number of ways, from the relatively simple descriptive (presence/absence, abundance, diversity) to the more complex inferential (the principal forces that explain these patterns) using multivariate statistical methods at appropriate scales (e.g., across depths within and between seamount features). Ecologists and resource managers are generally interested in understanding patterns in the distribution and abundance of organisms and identifying ecological or environmental factors that help to explain these patterns. Correlation analysis (strength of association between two variables), principal component analysis (factors that account for major patterns seen) and multiple regressions (relationship among a number of different variables) are used to evaluate how one variable (e.g., fish) relates to another (e.g., depth) or a series of variables (e.g., depth, temperature, presence/absence of coral).

The structure of any fish community (distribution, abundance, functional relationships of the species present in a defined area) is the product of many abiotic and biotic processes. Ebeling and Hixon (1991) described the abundance and diversity of many Hawaiian reef fishes as being primarily associated with coral diversity and bottom relief and only secondarily with such factors as water movement, light, and bottom type. Kukuev (2002) showed that there was little differentiation in the deepwater fishes (> 500 m) of the Corner Rise complex, mid-

Atlantic Ridge and east Atlantic seamounts. However, the shallow water ichthyofauna (from those peaks with depths < 300 m) east of the mid-Atlantic Ridge showed affinities for the east Atlantic shelf fauna. At local scales species composition differed for fishes associated with basalt and fine grain sediment habitats from the New England Seamount chain (Auster *et al.*, in prep.). Temperate fish show varying degrees of bathymetric movements related in changes in environmental conditions (Ebeling and Hixon, 1981). These seasonal changes can coincide with water temperature, water movement, and the presence/absence of prey.

Fish communities associated with seamount landscapes can be described based on several attributes. The first and perhaps simplest is geographic; are species individuals more abundant based on latitude (north-south)? Another simple description is based upon position on the seamount, or depth in the water column. Alton (1986) described the group of animals collected on Alaska seamounts as epipelagic (within 30m of the surface), mesopelagic (30-150m) or bathypelagic (150m downward to the seamount summit). This designation does not mean that the species do not move between these zones. Underwater observations on the New England and Corner Rise Seamounts have demonstrated that some "classically pelagic" species interact with seafloor communities by foraging along the seafloor-water interface. These individuals are likely foraging for zooplankton trapped by down-welling near the seafloor or using seafloor structures for flow refuges to reduce physiological requirements for operating in high flow regimes while maintaining access to prey through accelerated flows.

The position in the water column in relation to the seamount can have significant consequences for both fishermen and resource managers. Some species aggregate 10s to 100s of metres above or away from seamounts surfaces in order to gain some advantage in fitness from the large scale effects of impinging currents on the location and delivery rates of prey but also on the cascading effects of such altered flows on patterns of primary and secondary productivity. This type of simple classification can be used by management to partition target species (or size classes for those that exhibit gradients in size based on distance above or away from seamount features) associated with seamounts into those that would be exploited using demersal versus midwater trawls or longlines.

With different shapes and heights, occurring either individually or in groups, seamounts likely have a significant effect on water movements and thermohaline fronts. Roden (1986) found that seamounts in the Gulf of Alaska produced intense flow patterns, eddies, upwelling, downwelling, and changes in temperature and salinity. The effect of seamounts on oceanic flow is very complex and depending upon the parameters chosen, a variety of flow patterns and speeds, including eddies, can be seen. However, these flow patterns most certainly have an effect on the habitat and granularity of the sediment present in a particular area.

Fishes select habitat for a variety of reasons, including food resources, spawning and nesting sites, and as refuge from predation and current flow. The strength of this association is extremely important in determining conservation measures. Are species actively selecting coldwater coral areas on seamounts, for example, to fulfil some of these functions or will any three-dimensional vertical structure do? Research in this area is lacking and would help in a variety of management questions.

Fish communities can also be described based on the distribution of the trophic status of component species. A deepwater fish community can capture energy either by consuming organic matter and plankton that is swept over the seamount by currents or as a carnivorous fish that consumes primarily fish prey. Most fish species are opportunistic and flexible in their feeding habits (Juanes *et al.*, 2002) and deepwater fish may also consume benthic invertebrates and species attached to habitat such as octocorals and hard corals. By using changes in feeding guilds, one can monitor changes in the functional diversity of seamount fish communities over time or between communities (i.e., seamounts) subject to exploitation and those that are not (e.g., Diamond, 1975; Feeley, 2003). Such approaches have been used to discern such patterns in shallow coral reef fish communities (Auster *et al*., 2005; Semmens and Auster, 2004).

Fish associated with seamounts are members of a complex ecological community. They interact with fish and invertebrate species as well as the physical structure around them. Their preferences (if any) can lead to describing what types of environments they are likely to thrive in. Fish communities can be described based upon geography (latitude), bathymetry (depth preference), environmental factors (water temperature, water quality, and current velocity), habitat association, dietary requirements (planktivore or carnivore), feeding behaviour (functional predatory response).

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6 New information on the distribution and status of cold-water corals in the North Atlantic

Term of Reference: report on new information on the distribution and status of cold water corals in the North Atlantic and recommend ways by which information on the occurrence of these species might be made more easily available and kept up to date.

6.1 Introduction

This term of reference continues the work of the forerunner group to the Working Group on Deep Water Ecology, the Study Group on Cold-water Corals (SGCOR). This section does not repeat the information in the three reports of the Study Group (ICES 2002, 2003, 2004) or of WGDEC in 2005 (ICES 2005).

There is no single publication providing a full detailed picture of the distribution of cold-water corals in the North Atlantic. As new areas of cold-water coral habitats have been discovered quite regularly the last years, the message perceived by the general public has lead to a misconception that nothing has been known about the distribution of cold-water corals. However, reviews covering the North Atlantic have previously been provided by Madsen (1944); Wilson (1979); Zibrowius (1980); Frederiksen *et al*. (1992); Tendal (1992); Rogers (1999); Cairns and Chapman (2001). Much of this historic information has not been presented in previous reports (ICES 2002, 2003, 2004, 2005).

6.2 Distribution

6.2.1 Canada (and adjacent international waters)

Wareham and Edinger (2005) mapped the distributions of deep-water corals in the Newfoundland, Labrador and southwest Baffin Island regions using incidental by-catch samples from Department of Fisheries and Oceans Multispecies Stock Assessment Surveys, Northern Shrimp Stock Assessment Survey, and by-catch samples and records from the Canadian Fisheries Observer Program (Figure 6.2.1.1). Twenty-eight coral were recorded; four alcyonaceans, two antipatharians, eight gorgonians, three scleractinians (Figure 6.2.1.2), and 11 pennatulaceans. Corals were distributed along the edge of the continental shelf (> 300 m), and were most common in submarine canyons or saddles where the continental shelf is incised. Only alcyonaceans were found on shelf (< 170 m). The deepest samples (1433 m) were collected on the edge of the southwest Grand Banks (43°13’N, 51°50W) which included *Acanella arbuscula*, *Flabellum* spp., and 4 species of seapens. Large, structurally robust corals included the gorgonians *Paramuricea* spp., *Paragorgia arborea*, *Primnoa resedaeformis*, *Keratoisis ornata*, and *Acanthogorgia armata*, and two antipatharian corals *Bathypathes arctica*, and an unknown antipatharian.

Gorgonian distributions were highly clustered, with most occurring with small gorgonian, soft corals, or other coral species. In Labrador two coral hotspots were identified southwest Baffin Island-Cape Chidley, and southern Labrador. Off Newfoundland three hotspots were identified Funk Island Bank-NE Newfoundland Shelf, Flemish Cap, and SW Grand Banks. The Flemish Cap was composed exclusively of soft corals, sea pens, and cup corals. Most of the ‘hotspots’ identified were consistent with earlier information from survey samples and from fishermen, with the majority from the latter (Gass and Willison 2005). The coral hotspots identified in this study, due to conclude in October 2006, are not currently protected from benthic fishing activities.

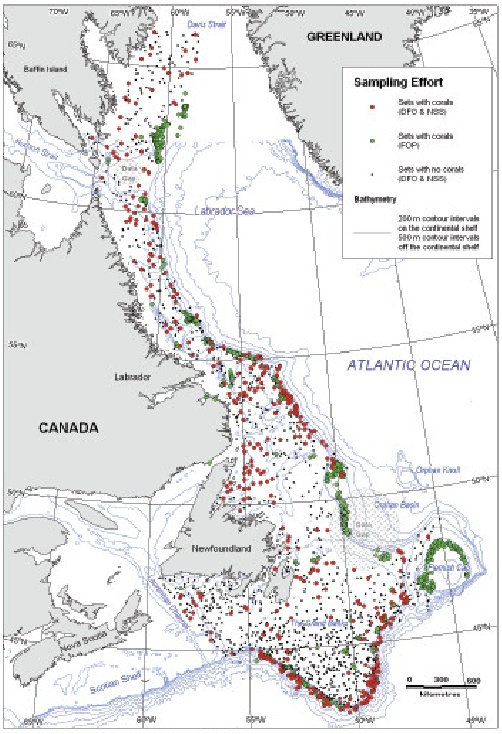


Figure 6.2.1.1. Sampling effort used in mapping the distribution of deep-water corals in the Newfoundland, Labrador and southwest Baffin Island regions using incidental by-catch samples from Department of Fisheries and Oceans Multispecies Stock Assessment Surveys, Northern Shrimp Stock Assessment Survey, and by-catch samples and records from the Canadian Fisheries Observer Program

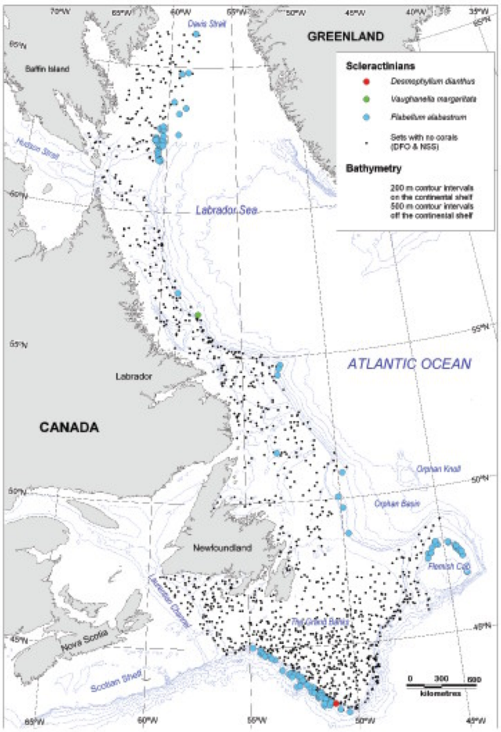


Figure 6.2.1.2. The distribution of scleractinian corals in the Newfoundland, Labrador and southwest Baffin Island regions from the sampling indicated in Figure 6.2.1.1.

6.2.2 United States

A peer-reviewed report will be produced in the near future by NOAA entitled ‘The state of deep coral communities of the United States.’ This will collect and synthesise the current state of knowledge of deep-coral ecosystems in U.S. waters. The report is in two parts, the first summarising information on major deep coral taxa found in U.S. waters, discussing key threats to these fragile ecosystems and summarising distributions. The second part contains a series of regional chapters that provide information on geological and oceanographic settings, inventories of known, structure forming, deep corals, spatial distribution of deep coral habitats, associated ecological communities, threat assessments, conservation and management measures currently in place, information gaps and priorities for further work.

6.2.3 Iceland

In 2004, the Marine Research Institute (MRI) in Iceland started a research programme aimed at assessing species diversity and the status of coral areas off Iceland, particularly in relation to potential damage caused by fishing activities. A second survey was scheduled for summer 2005 that had to be cancelled due to technical problems.

The Icelandic legislation on fisheries management (Act no. 79/1997: Lög um veiðar í fiskveiðlandhelgi Íslands) is aimed at minimising detrimental impacts of fishing on commercial fish stocks. The legislation enables the Minister of Fisheries to close areas to use by specific fishing gears, either temporarily or for longer periods, based on recommendations from the MRI. A number of areas have been closed to fishing activities using this legislation, including closures for bottom trawling (e.g. in 2004, ban for bottom trawling off the coasts of Iceland applied to a total area of 15.700 km^2).

In 2005 the fisheries management act (Act no. 79/1997) was revised with the objective of being able to protect other parts of the marine ecosystem than commercial fish stocks. The revised act now facilitates protection of vulnerable marine habitats, including habitat forming species such as *Lophelia pertusa*.

MRI recommended that the Icelandic minister of fisheries close four coral areas for all fishing activities that affect the seabed, based on the findings from the ROV survey carried out in 2004 by the MRI. These recommendations have been reviewed and approved by the fisheries sector. In addition to the four coral areas, the fisheries sector proposed a closure of an additional coral area, which has not yet been surveyed with a ROV by the MRI. These five areas closures for coral off Iceland, with a total surface area of 80 km^2, will be in operation from 1 January 2006. No fishing activities are allowed within the boundary of the closed areas, except fisheries targeting pelagic fish. Three areas are located on the shelf (Skafárdjúp-deep and Hornafjarðardjúp-deep) and two on the shelf slope (Reynisdjúp-deep and Hornafjarðardjúp-deep) off the southeast coast of Iceland (Figure 6.2.3.1).

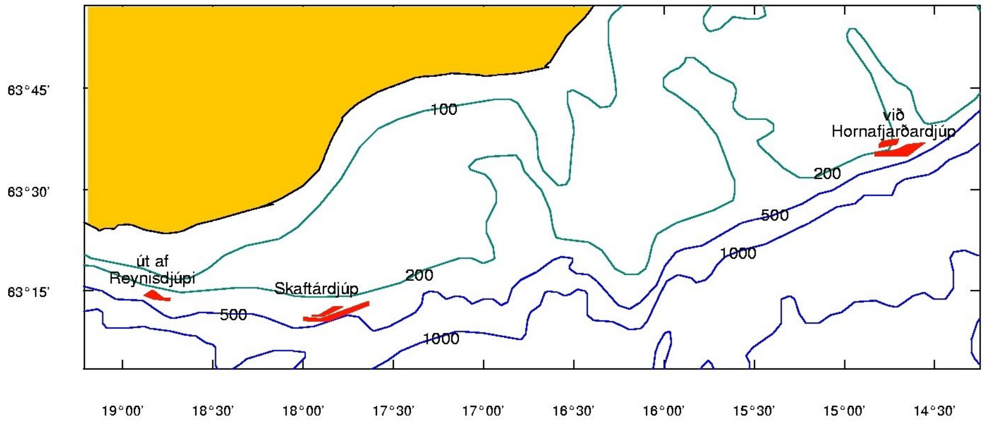


Figure 6.2.3.1. Coral areas, totalling 80km², off SE Iceland that are closed for all bottom tending fishing activities from 1st January 2006.

6.2.4 Norway

Thirty-six *Lophelia* reefs off Northern Norway were studied during a cruise in June 2005 (Figure 6.2.4.1) (Fosså 2005). These reefs were previously known only as topographic highs on detailed bathymetric maps or as information from fishers. The reef in the Sotbakken area is the furthest north so far confirmed in the world. Morphology of reefs in three survey areas (Sotbakken, Lopphavet and Trænahola) was studied by visual inspection using both a drift camera and an ROV. In total 35 h and 17 min of videotape was recorded. No reefs were observed in the Snøvit and the Egga Nord study areas. Data for description of the reef environment was gathered from bottom located current meter, ADCP, CTD, and direct observation. The reefs in the Sotbakken and Lopphavet study areas had an almost circular outline and a high cover of living coral. .In the Trænahola area, reefs were elongated and aligned with the main current direction, with a live part on the up-current side ("reef head"). Dead coral fragments were sampled along the "reef tail" from the "reef head" to the down-current end at one selected reef. Thirty-two samples for studies of the associated fauna were collected with a video-assisted van Veen grab and the ROV.

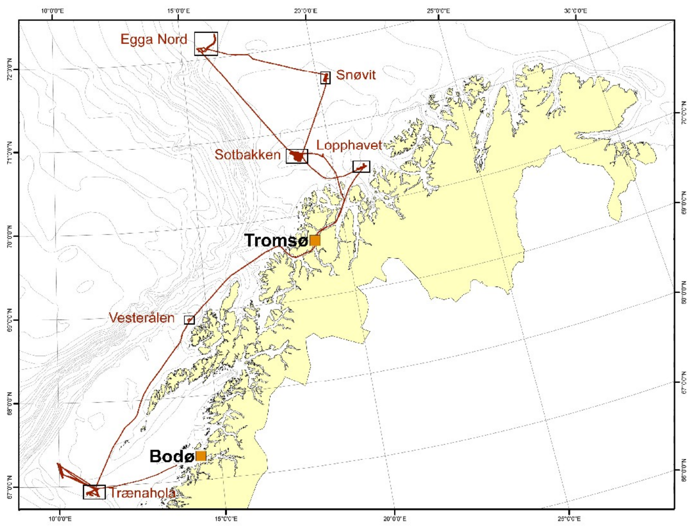


Figure 6.2.4.1 The survey track for G.O Sars (cruise 2005108) off northern Norway showing the Location of Sotbakken, Lopphavet, and Trænahola study areas where Lophelia reefs were studied in June 2005 (Fosså, 2005).

The German vessel RV Poseidon surveyed deep-water coral reefs off northern Norway during July 2005. Five areas off Norway's northwest coast and in the Stjernsund at depths between

430 and 230 metres were the main targets during this expedition. Fourteen dives in the manned submersible Jago allowed the scientists to observe and sample the seafloor, capture spectacular video footage and take high-resolution images. Jago also sampled corals, epifauna and sediments. Some unusual cigar-shaped reef structures in the Traenadjupet Slide area were studied in detail, but work in the Røst Reef area was interrupted by very rough sea conditions. Multibeam mapping of the Stjernsund area revealed a sill structure rising about 100m above the seafloor, with the topography of the sill surface suggesting the presence of extended coral patches. Several dives with Jago mapped out the large extension of *Lophelia pertusa* in the Stjernsund. Dense populations of the gorgonian corals *Paragorgia arborea* and *Primnoa resedaeformis* were observed alongside *Lophelia pertusa*. Large numbers of commercially interesting fish (saithe *Pollachius virens* and Atlantic cod *Gadus morhua*) were present, but there was very little evidence of fisheries impact; only few lost longlines were documented during Jago dives.

6.2.5 Portugal

Presently about 150 species of coral occur in the Azores region. Considerable information on the distribution of cold-water corals is being obtained through cooperation with the Azores fishery fleet. Historical distributional information on coral occurrences are being compiled from published information and from Natural History museum catalogues. Deep-sea corals seem to be common throughout the region, mostly on the steep volcanic underwater slopes of the islands and offshore subsea volcanoes.

Relatively common reef-building species include *Madrepora oculata*, *Lophelia pertusa*, *Solenosmilia variabilis* and *Dendrophyllia cornigera*. Lace coral hydroids (i.e. Stylasteridae) are also quite common and are important bio-builders.

The most sampled gorgonians include large *Callogorgia verticillata*, Dentomuricea spp., *Acanthogorgia hirsuta* and *A. armata*, *Viminella flagellum*. These species probably form deep sea forest of considerable densities. Other conspicuous gorgonian species such as *Paragorgia johnsoni* are also important elements.

Antipatharian fauna is apparently dominated by the *Antipathella wollastoni* in the littoral of the islands and shallow seamounts below ca. 20 m. The black coral *Leiopathes glaberrima* can reach up to 2m high and it forms dense forests between 200 and 600 m.

Several coral associations can be recognised. These associations can include species of the same group (e.g. *Madrepora oculata* with *Lophelia pertusa*) mixed with gorgonians (e.g. *Paramuricea* spp), stony hydroids, etc. The composition of those associations is probably depth related.

The Azores EEZ (as that of Madeira and Canaries) is protected by EU regulations and legislation from bottom trawls and deep-water gill nets.

Deep-sea corals seem to be common throughout the region, namely in the steep volcanic biotopes of the insular slopes and offshore seamounts.

6.2.6 Rockall Bank

A UK fisheries survey on Rockall Bank in 2005 made 23 hauls (Table 6.2.6.1). Eight of these hauls had *Lophelia pertusa* as a bycatch. Three of these eight hauls held only what appeared to be dead coral. Four of the bycatches of live coral were to the immediate west of the closure area advised by ICES in 2005 on south Rockall, with a further such haul made to the north east of the Logachev mounds.

Table 6.2.6.1 Locations of trawl tracks made on Rockall during UK fishery research survey in autumn 2005 (E. Jones, pers. comm.)

Shooting position		Hauling position		Coral
Lat min	Lon min	Lat min	Lon min	Dead or alive
55° 31’	14° 13’	56° 26’	14° 19’	None
55° 46’	15° 00’	55° 44’	15° 01’	Dead
56° 08’	15° 40’	56° 13’	15° 37’	Live and dead
56° 18’	16° 09’	56° 13’	16° 16’	Live and dead
56° 16’	16° 32’	56° 16’	16° 43’	Live and dead
56° 21’	16° 31’	56° 22’	16° 28’	Live and dead
56° 21’	16° 08’	56° 23’	16° 06’	Live and dead
56° 58’	15° 37’	56° 53’	15° 46’	None
56° 44’	15° 23’	56° 51’	15° 14’	None
56° 59’	15° 07’	57° 56’	15° 04’	None
56° 55’	15° 04’	56° 49’	15° 05’	None
56° 44’	14° 49’	56° 43’	14° 38’	None
57° 11’	14° 57’	57° 12’	14° 25’	None
57° 31’	14° 51’	57° 25’	14° 53’	None
58° 11’	15° 00’	58° 11’	15° 12’	None
58° 18’	15° 09’	58° 17’	15° 22’	None
58° 17’	14° 53’	58° 19’	14° 37’	None
58° 26’	14° 00’	58° 22’	14° 01’	Dead
57° 44’	13° 20’	57° 51’	13° 26’	None
57° 51’	13° 28’	57° 55’	13° 37’	None
58° 03’	13° 25’	58° 05’	13° 31’	Dead
58° 07’	13° 33’	58° 11’	13° 41’	None
58° 11’	13° 41’	58° 14’	13° 44’	None

A survey conducted by the UK’s Department of Trade and Industry covered parts of north and east Rockall Bank in August 2005. A total of 849 minutes of video and just under 400 photographs were taken. These data are still being processed and early results have confirmed the presence of *Lophelia* reefs.

6.2.7 Hatton Bank

A survey conducted by the UK’s Department of Trade and Industry covered parts of Hatton Bank in August/September 2005. A total of 693 minutes of video and 650 photographs were taken. These data are still being processed and early results have confirmed the presence of Lophelia reefs.

A multidisciplinary survey conducted by the Spanish Institute of Oceanography (IEO) covered the North western slope of Hatton Bank (ICES VIb1 and XII) during October 2005. Close to 14000 km2 was surveyed with acoustic methods. In addition 15 bottom trawl hauls were carried out. The 2005 Hatton survey was very difficult due to poor weather. IEO are processing the data collected in the survey (multibeam data, TOPAS data, and biological samples). A second survey will take place in 2006 in order to complete the sampling.

6.2.8 Other high seas

Mortensen *et al*. 2005 reported on the results of a MAR-ECO cruise on the mid Atlantic Ridge. Three areas on the ridge were examined using ROVs, bottom trawls and long lines. The areas were centred approximately on 43°N 29°W, 51° 30’N 30° W and 53°N 35°W. Thirty taxa of corals (including 6 taxa of seapens) were observed, with *Lophelia pertusa* and *Solenosmilia variabilis* as the main structure corals. These species were difficult to separate on video, but it seems likely that *Solenosmilia* was most common in the deeper parts of the study areas. All *Lophelia/Solenosmilia* colonies were relatively small with a maximum diameter of less than 0.5m. *Lophelia/Solenosmilia* was most common on the video in the north and central sites, but rare on video in the south. The video-observations indicated that the diversity of corals is higher in the southern than the middle and northern study areas. Bycatch of corals was recorded in bottom trawl and on longline from all areas, but most species were caught in the southern area.

6.3 Future collation and storage of information on cold-water corals

6.3.1 Uses of information on cold-water corals

There are a number of potential uses of information on the distribution of cold-water corals. This working group, and its predecessor study group, have been asked to provide information on the location of cold water coral reefs so that ICES might provide information to managers (European Commission, North-East Atlantic Fisheries Commission) on areas suitable for closure to protect the reefs from fishing activities. OSPAR has also requested advice on coral distribution.

An easily available, reliable and comprehensive information source would enable these questions to be more easily answered and in addition would help in the planning of other activities, such as cable laying, research and offshore minerals extraction, all of which have the potential to adversely affect corals. Although an easily available database on cold-water corals would not necessarily have a direct educational purpose, it could certainly act as an educational resource.

6.3.2 Existing databases/initiatives

There are a number of existing databases that have collected together information on cold-water corals. In many cases these records relate to the reef-forming structural corals – mostly Lophelia pertusa.

6.3.2.1 Deep Sea UK project

A module of this project, run by the University of Plymouth, is working to maintain and update the database developed initially by Rogers (1999). This database holds records of all Gorgonians, Antipatharians, Styasterids and Zooanthids for the North East Atlantic (as far south as the Cape Verde islands). Fields in the database are:

1. Record ID
2. Entered by
3. Species name
4. Ocean/Region (set to NE Atlantic at present)
5. Topographical classification (oceanic island, continental shelf, etc.)
6. Seamount name (if relevant)
7. Biogeographic region
8. Reference source
9. Latitude (original version in reference)
10. Longitude (original version in reference)
11. Latitude (converted to degrees/decimal degrees)
12. Longitude (converted to degrees/decimal degrees)
13. Minimum depth (if dredged)
14. Maximum depth (if dredged)
15. Mean/actual depth
16. State of specimen (live/dead)
17. Date of collection
18. Expedition (if relevant)

19. Site No (if relevant)
20. Notes

6.3.2.2 WWF Northeast Atlantic and Mediterranean offshore reefs inventory

This database describes known reefs beyond 12 nm from the coast in the north-east Atlantic and the Mediterranean (WWF, 2001). This database therefore includes more than just coral reefs, and does not include corals where the existence of a reef is uncertain. The database holds much text and illustrative information (Figures 6.3.2.2.1, 6.3.2.2.2, 6.3.2.2.3).

ID	**#3**
Name	**Vesteris Seamount**
Position	Centres on 73.5°N, 9.10°W (Haase & Devey, 1994)
Jurisdiction	**Greenland**
Site Area	Approximately 2,000km^2
Classification	Reef (seamount)
Extent of Habitat	100%
Description	Vesteris Seamount has an elliptical, elongate shape trending roughly SW - NE. It rises from the Greenland Basin at a depth of 3,000m to within 130 m of the surface (Haase & Devey, 1994). Overall the seamount occupies about 500km^2 making it comparable in size to some of the large Pacific Seamounts. Essentially Vesteris is a large volcano with a number of satellite cones around it. The northern flank is very rough whilst the southern flank shows smoother topography. The maximum inclination of the slopes of this submarine volcano is about 26o. There are no significant sediments on the seamount itself (Hempel et al., 1991). The seamount is fairly recent in origin and there are signs of recent hydrothermalism on the seamount (Henrich et al., 1993). Vesteris Seamount is unusual in terms of its isolated position in the middle of the Greenland Basin but it is reported to have a rich fauna (Hempel et al., 1991). This fauna includes build-ups of sponges and bryozoans in an area characterised by seasonal ice-edge plankton blooms (Henrich et al., 1995). The general area around Jan Mayen is an important site for marine mammals (e.g. Folkow et al., 1996; Larsen et al., 1996; Martinez & Pastene, 1999) and if Jan Mayen, like other seamounts, has large associated populations of invertebrates and fish the area maybe important for these animals. The seamount lies in the Jan Mayen EEZ.
Representation	An excellent example of an isolated seamount. I provisionally place it in Category A.
Cons. status	Unknown. The seamount lies in the Jan Mayen EEZ. It is likely to be ice covered for much of the year.
Gobal importance	The extremely unusual situation of this seamount, lying by itself in the middle of the Greenland Basin, makes the site unique in the area and without doubt a Category A site on a global scale.
Associated species	Sponges, Bryozoans
Category	A
Figures	Vesteris 3/Vesteris 3 bathym. chart2
	Vesteris 3/Vesteris 3 bathymetry
	Vesteris 3/Vesteris 3 seismic profile

Figure 6.3.2.2.1 Example of contents of WWF north-east Atlantic reefs inventory (WWF, 2001)

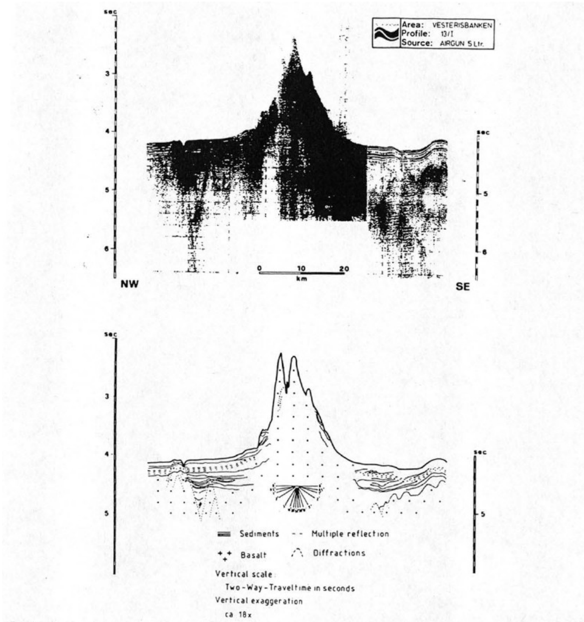
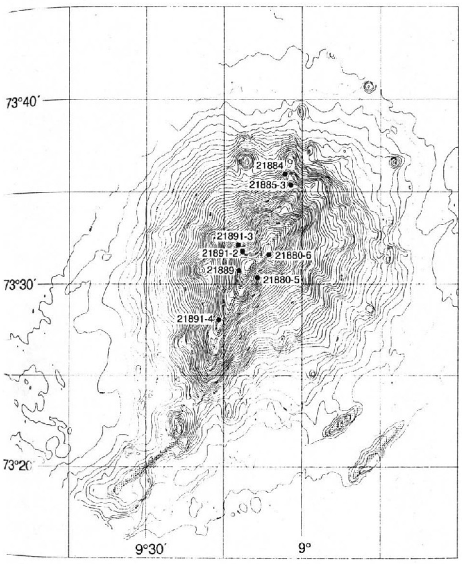


Fig. 5. Seismic reflection profile across Vesterisbanken. The pelagic sediment blanket of the basin floor is disturbed by young volcanic intrusions. For location of profile see Fig. 3.

Figure 6.3.2.2.2 Example of figure within WWF north-east Atlantic reefs inventory (WWF, 2001)



G. 2. B[illegible]ymetric map of Vesteris Seamount after Henrich *et al.* (1993) with sampling locations (contour interval 50 m). The outlines of the volcanic rift zones are shown stippled.

Figure 6.3.2.2.3 Example of figure within WWF north-east Atlantic reefs inventory (WWF, 2001)

6.3.2.3 MARBEF/ EurOBIS

The MARBEF website provides a portal (http://www.marbef.org/data/ermssearch.php) that can search a number of databases for records of specific biota and then provides a link through to EurOBIS that plots these records. Records plotted in this way can be interrogated interactively to find its details (Table 6.3.2.3.1).

Table 6.3.2.3.1. Fields within the MARBEF database, not all are completed for each record.

Computed	Institution Code	Collection Code	Catalogue Number
Record URL	Scientific Name	Basis of Record	Source
Citation	Kingdom	Phylum	Class
Order	Family	Genus	Subgenus
Species	Subspecies	Scientific Author	Identified by
Year identified	Month identified	Day identified	Type status
Collector number	Field number	Collector	Year collected
Start year collected	End year collected	Month collected	Start month collected
End month collected	Day collected	Start day collected	End day collected
Julian day	Start Julian day	End Julian day	Time of day
Start time of day	End time of day	Time zone	Continent / Ocean
Country	State / Province	County	Locality
Longitude	Start Longitude	End Longitude	Latitude
Start Latitude	End Latitude	Coordinate Precision	Start /End coordinate precision
Bounding box	Minimum elevation	Maximum elevation	Minimum depth
Maximum depth	Depth range	Temperature	Sex
Life stage	Preparation type	Individual count	Observed individual count
Observed weight	Previous catalogue number	Relationship type	Related catalogue item
Notes	GML feature		

6.3.2.4 OSPAR database

Lophelia pertusa reefs have been listed by OSPAR on their list of threatened and declining habitats. Each OSPAR Contracting Party has agreed to compile the relevant data for its own marine waters and submit these to the lead country (UK) for collation into composite maps on the distribution of each habitat type across the whole OSPAR area. The work has been coordinated by UK's Joint Nature Conservation Committee (JNCC).

A web-mapping application has been developed to disseminate the data collated through the OSPAR mapping programme, derived from the UK's National Biodiversity Network web-mapping facility (www.searchnbn.net). This has been further developed to enable OSPAR habitat types to be mapped, to map data beyond the UK national grid area and to enable mapping using latitude/longitude co-ordinates (Figure 6.3.2.4.1).

Access to the source data on which the maps are based is possible through the 'query records' facility. These supporting data are provided by OSPAR Contracting Parties to ensure there is an appropriate level of quality assurance in the maps made available here. The supporting data are also intended to indicate whether each record is a confirmed (certain) record for the habitat or whether it is 'uncertain', possibly due to lack of supporting species data. In particular, many of the *Lophelia pertusa* reef records are marked as uncertain records as they relate to the known occurrence of the *Lophelia pertusa* species but there is as yet insufficient information to confirm the presence of *Lophelia* reef habitat. Efforts are underway to improve this situation.

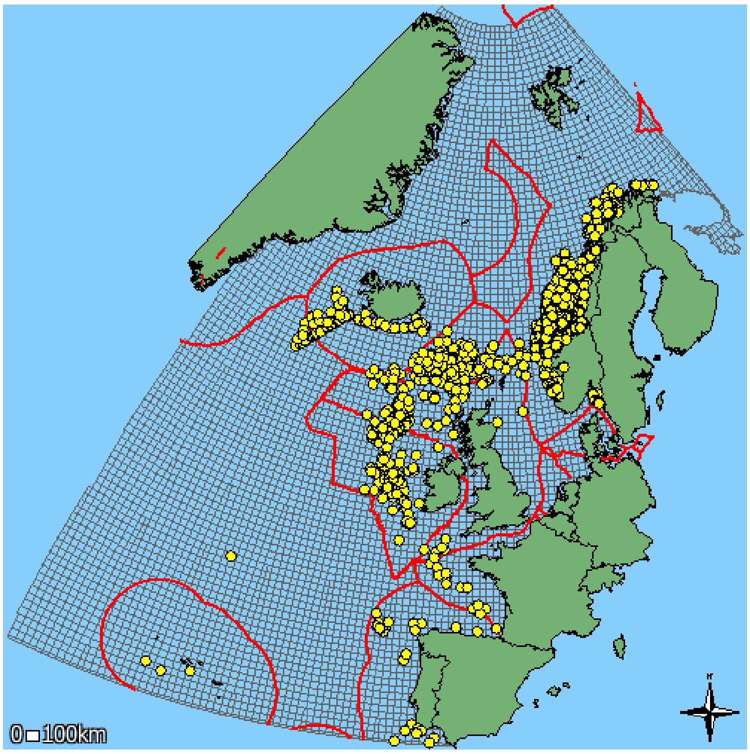


Figure 6.3.2.4.1 Locations of records of Lophelia pertusa (reef) in the OSPAR database.

6.3.2.5 US CoRIS (Coral information system)

NOAA has established a coral information system, hosting information collected by NOAA or by NOAA sponsored projects. This system has a database with a web-based mapping output with dot distribution maps (http://www.coris.noaa.gov/metadata/map-search/viewer.htm). At present the majority of information hosted is on warm-water reefs, but there are plans to develop cold-water (deep) coral database. This will be based on existing data, such as those assembled by Watling and Auster (2005) for Alcyonacea, and co-operative developments with other researchers (Scanlon *et al*., 2005).

6.3.2.6 UNEP/UNEP- WCMC

The United Nations Environment Programme (UNEP) in association with the World Conservation Monitoring Centre (UNEP-WCMC) have initiated a project to establish a global cold-water coral reef database and internet-based GIS system, providing a central entry point and easy access to geo-referenced data and information on cold-water coral reefs from around the world. The primary objectives of the project are conservation and management related.

The project started from the understanding that most data and information on cold-water coral ecosystems are held by individual scientists, national authorities and industry sectors operating on or near the seafloor (e.g. fisheries, oil & gas, pipeline laying, cable placement). The fragmented and disjointed nature of cold-water coral reef records makes access and use difficult, and carries the risk that vital data might be lost over time.

For tropical warm-water coral reefs, a number of comprehensive databases and GIS facilities are in place, e.g. Reefbase (http://www.reefbase.org/) and UNEP-WCMC IMapS tool (http://imaps.unep-wcmc.org/imaps_index.htm). However, there is no equivalent for cold-water coral reefs.

The UNEP-WCMC IMapS tool provides web access to the Centre's comprehensive, geo-referenced environmental information and conservation data bases (presently including World

Heritage sites), and distribution of warm-water coral reefs, seagrasses and mangroves at the global level, and regional information for *e.g*. the Caribbean and Mediterranean. IMapS enables users to create their own, customised maps over the internet to meet their individual requirements, incorporating information and background data on environmental sensitivities such as protected areas, breeding areas and vulnerable species. As the system is GIS-based, it is possible to add a range of other features to any maps produced.

At present the data set of reef-building corals used to create the maps in Freiwald *et al*. (2004), consisting of 1269 records of *Lophelia pertusa*, 189 records for *Madrepora oculata*, 49 records for *M. carolina*, 3 records for *M. kauaiensis*, 99 records for *Solenosmilia variabilis* are available for inclusion in the system. Agreement has also been made to include the OSPAR dataset (see Section 6.3.2.4) and the data sets on deep-water corals collected by Alex Rogers and Jason Hall-Spencer (see Section 6.3.2.1).

A standard format and guidance for data submission from other experts and sources will be established in the light of the experience gained in developing the system and entering the early data. At early stages of the development of the system, data received will be entered by UNEP-WCMC. At a later stage, it is hoped to develop facilities to allow remote data entry via the internet.

The validation of data and information will be carried out in two steps: (i) 'junk' entries will be deleted by the system administrator; (ii) other entries will be examined by a small group of international experts. The composition, terms of reference and working procedures of this group will be developed during the project.

It is also planned to attach information in the GIS to each cold-water coral reef location. At present this is in a somewhat simple format (showing very brief physical details of the location) but could easily be expanded to include *e.g*. text files, pictures, video clips, internet links etc. A future development may be to use predictive modelling to map and display potential, but not yet proven, areas of cold-water coral reefs.

6.3.3 Discussion

Each of the various cold-water coral reef databases and GIS initiatives has been established to fulfil certain objectives, purposes and need(s). In the case of national initiatives, it seems likely that these were compiled to provide the relevant government agencies with information which helps them to more effectively manage, regulate and control the human activities in their national and EEZ waters, especially those which have an impact, or might pose a threat, to cold-water coral reef ecosystems and biodiversity. In addition, these national data bases and GISs are an essential tool for implementing the various national and international commitments. This is also the case for the OSPAR initiative, where Contracting Parties work collectively on these matters. This is important for transboundary issues, and for work on the high seas.

The UNEP/UNEP-WCMC global database and GIS was initiated with the primary intention of providing easy access to basic geo-referenced data on cold-water coral reefs from around the world, including data from the scientific community which are normally not or less accessible. Main objective was to present this information in a way that is easily accessible and understandable for policy and decision makers. The database and GIS can also be used as a tool to raise the awareness and responsibility for the conservation and sustainable management of cold-water coral reefs within this target group, especially in developing countries and states without a good conservation infrastructure. The global cold-water coral reef database and GIS may be able to provide information for initiatives in the High Seas.

Of the various initiatives outlined above, that of UNEP/UNEP-WCMC appears to best meet the needs of both management and science. In both cases, perhaps the weakest area of the output of the project is the relative lack of supporting data lying behind each record. This though could be developed and is likely only to be inhibited by lack of resources. UNEP/UNEP-WCMC has indicated that they do not have the in-house ability to support such a system, so perhaps may be able to connect their databases to others that support this information. The ability to check this supporting information can be important when conservation actions need to be fully checked and justified.

In many cases, records of the occurrence of reef-building corals have not been explicitly linked with the presence of a reef. In management (and conservation) terms, the presence of the reef appears to be the most important feature. This may not however be a great hindrance as, with few exceptions, when the technology has been available to check for reef presence (of *Lophelia*) when a live specimen has been obtained, such reefs are usually found. It may be that the predictive modelling project planned for later implementation in the WCMC-UNEP proposal, if based on the presence of reef (not just species), would enable records of species only to be rated by likelihood of coming from a reef.

The Working Group recommends that ICES should endorse the UNEP/UNEP-WCMC initiative as a suitable central repository and GIS system for cold water corals. ICES should negotiate to join the user group of this initiative; ICES might then work within this user group more available. ICES Member Countries might also be encouraged to support this initiative also, in some cases by redirecting national initiatives or spending. Member countries could also include conditions in the contracts of all publicly-funded science to contribute records of cold-water corals to the UNEP/UNEP-WCMC database.

One current shortcoming of the UNEP/UNEP-WCMC initiative is that it supports only information on cold-water corals; it may well be that further species groups or habitats need to be included in a central database and mapped in due course. Any initiatives for cold-water corals should keep possible future requirements in mind as they are developed.

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7 Further information and food for thought

7.1 CENSEAM

A new project, Census of Marine Life on Seamounts (Censeam), started in 2005 under the Census of Marine Life programme (http://www.coml.org/descrip/censeam.htm). The first phase (Planning and Expansion) has been funded and is under way. The project is planned to run until 2010 and the main goal is: "What roles do seamounts play in the biogeography, biodiversity, productivity, and evolution of marine organisms and what is their effect on and contribution to the global oceanic ecosystem?"

Specific research themes and questions of the project will be:

1 - What factors drive seamount community structure, diversity, endemism, both at the scale of whole seamounts and individual habitats within seamounts?

a) What factors might affect community composition and structure (e.g. depth, elevation, age of seamount, geological origin, substrate type, oceanographic conditions, isolation etc.)

b) Can such information be useful to predict communities on unsampled seamounts?

c) What part of the ocean's biodiversity is held by seamounts?

d) Are they globally significant centres of speciation?

e) What are the key driving factors?

2 What key processes operate to cause differences between seamounts and between seamount and non-seamount regions?

a) To what degree are seamount communities genetically isolated, and limited by dispersal and recruitment?

b) How much do seamounts affect the wider ecosystem (e.g. population source, food web connectivity, physical influence on currents, eddies)?

c) What functional properties support the high biomass often associated with seamounts?

3 What are the impacts of exploitation (fisheries, mining) on seamount community structure and function?

a): How many seamounts globally are fished and already impacted environments?

b) What is the dependence of various fisheries on seamounts?

c) What is the impact of human activities on the seamount communities?

d) How can these activities be managed sustainably, to allow both exploitation and conservation?

CenSeam will also provide the framework to:

a) Coordinate and expand seamount research (standardise methods and data reporting, produce a comprehensive protocols book with recommendations, facilitate community networking, provide mini-grants to expand the scope of funded expeditions);

b) Foster new field expeditions.

8 Proposed Terms of Reference for next Meeting

The Working Group on Deep-water Ecology [WGDEC] (Chair: Mark Tasker, UK) will meet in (Plymouth, UK) from vv to vv vvvvv 2007 to:

a) Examine information on cold-water corals on Eastern Rockall and Hatton Bank to determine suitable areas to close to protect cold-water corals (*see if we can get EU and/or NEAFC to ask these questions*);

b) Compile a map of areas where biological research/survey has occurred in the deep water area (>200m) of the North Atlantic;

c) Review information on the distribution of areas holding large structural sponges in the North Atlantic;

d) Compile information on occurrence of soft-coral communities, specifically Gorgonians and Antipatharians in the North Atlantic;

WGDEC will report by nn 2007 for the attention of ACE and the Living Resources Committee.

Supporting Information

Priority:	High. This is the only group in ICES providing information on deep water ecology that is proving to be an expanding area of interest to fisheries managers and to OSPAR.
Scientific Justification:	These recommendations address areas of difficulty encountered by the group in 2005. Information on fisheries over seamounts needs to be sought from others.
Relation to Strategic Plan:	Action plan 1.2.
Resource Requirements:	None
Participants:	Approximately 10–15. Expertise on cold-water corals and on deep-water fishing is required. The Chairs of WGDEC and WGDEEP (Paul Marchal, France) will consult and coordinate their activities.
Secretariat Facilities:	None
Financial:	None
Linkages to Advisory Committees:	ACE, ACFM
Linkages to other Committees or Groups:	LRC, MHC, WGECO, WGMHM, WGDEEP
Linkages to other organisations:	EC, OSPAR, NEAFC

Annex 1: Attendees list

WORKING GROUP ON DEEP WATER ECOLOGY

Doubletree Hotel, Miami

4 – 7 December 2005

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