The Implementation of UN Resolution 61/105 in the Management of Deep-Sea Fisheries on the High Seas

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Photographs:


Mediterranean roughy (Hoplostethus atlanticus), over coral garden habitat mainly comprising Acanthogorgia spp., Faial Island, Azores, North Atlantic, 350m depth. © A.D. Rogers and Rebikoff Foundation.
SUMMARY

For the past eight years, the issue of protecting biodiversity in the deep-sea in areas beyond national jurisdiction – the high seas – has been extensively debated by the United Nations General Assembly and in other international fora. The UN General Assembly adopted a series of resolutions, including a resolution in 2004 (resolution 59/25) which called on high seas fishing nations and regional fisheries management organizations (RFMOs) to take urgent action to protect vulnerable marine ecosystems from destructive fishing practices, including bottom trawl fishing, in areas beyond national jurisdiction (UNGA 2004).

A report from the UN Secretary General in 2006 on progress in the implementation of the 2004 resolution concluded that little action had been taken to protect deep-sea ecosystems on the high seas from the adverse impacts of bottom fisheries in spite of the fact that “deep-sea habitats in these areas are extremely vulnerable and require protection” (UNSG 2006).1

As a result of the report and a review by the UN General Assembly of the effectiveness of the measures called for in resolution 59/25, the UN General Assembly called for a series of specific actions to be taken by States and RFMOs in UN GA resolution 61/105, adopted by consensus in December 2006 (UNGA 2006). Resolution 61/105 committed nations which authorize their vessels to engage in bottom fisheries on the high seas to take a series of actions, outlined in paragraph 83 of the resolution (see Annex I), summarized as follows:

- Conduct impact assessments of individual high seas bottom fisheries to ensure that “significant” adverse impacts on vulnerable marine ecosystems (VMEs) would be prevented or else prohibit bottom fishing (not authorize bottom fishing to proceed);
- Close areas of the high seas to bottom fishing where VMEs are known or likely to occur unless bottom fisheries can be managed in these areas to prevent significant adverse impacts on VMEs;
- Ensure the long-term sustainability of deep-sea fish stocks;
- Require bottom fishing vessels to move out of an area of the high seas where ‘unexpected’ encounters with VMEs occur.

Subsequent to the adoption of the resolution, a set of International Guidelines for the Management of Deep-Sea Fisheries in the High Seas were negotiated under the auspices of the UN FAO to, inter alia, further define and agree to criteria for the conduct of impact assessments of high seas bottom fisheries; the identification of VMEs; and assessing whether deep-sea fisheries would have “significant adverse impacts” on VMEs. The International Guidelines for the Management of Deep-Sea Fisheries in the High Seas were adopted in August 2008. Key elements of the Guidelines are contained in Annex II (FAO 2009a).

In the North Atlantic, vessels from the European Union (Estonia, France, Latvia, Lithuania, Portugal and Spain), the Faeroes Islands, Iceland, Norway and the Russian Federation are involved in the high seas bottom fisheries. Collectively, the EU fleet is responsible for approximately 80% of the reported catch in the Northwest Atlantic and 95% of the catch in the Northeast Atlantic. Virtually all EU vessels engaged in high seas bottom fishing in the North Atlantic are bottom trawl vessels.

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1 Paragraph 204: “Some States have undertaken, or are in the process of undertaking extensive efforts to protect some fishery habitat areas within their national jurisdiction, in particular through the establishment of protected areas. However, this is not the case on the high seas, though deep-sea habitats in these areas are extremely vulnerable and require protection.”
The European Union announced a series of policy initiatives both during the 2006 UN General Assembly negotiations and in 2007 in relation to the implementation of the resolution 61/105. These include a commitment to “expeditiously” implement the resolution, conduct environmental impact assessments of high seas bottom fisheries as a prerequisite to allowing fishing to take place, apply the reverse burden of proof to the management of bottom fisheries on the high seas, and to take unilateral action to comply with the resolution where RFMOs, of which the European Community is a member, fail to do so (EC 2006, 2007, EU 2006).

In relation to the four key actions called for in the 2006 UN General Assembly resolution, the report assesses the measures and regulations adopted by the North-East Atlantic Fisheries Commission (NEAFC) and the Northwest Atlantic Fisheries Organization (NAFO) both prior to and in response to the 2006 UN GA resolution. The key findings of the report include the following:

1. Impact assessments of individual bottom fishing activities:

None of the nations whose vessels engage in bottom fishing activities in the high seas areas managed by NEAFC and NAFO, including EU Member States, have conducted impact assessments of their bottom fishing activities, despite the fact that these are required for all deep-sea bottom fisheries for low-productivity species in the high seas.

2. Close areas of the high seas to bottom fishing where VMEs are known or likely to occur:

NEAFC has closed substantial areas of the high seas to bottom fishing due the presence, or likely occurrence, of cold-water coral reefs. However, NEAFC has not closed all areas for which there is strong evidence of the presence of coral reefs, specifically areas outside of the current closed areas on the Hatton and Rockall Banks. Additionally, NEAFC has not closed any areas to fishing because of the presence of other types of VMEs such as sponges and coral garden habitats (although some of these VMES are likely to be found within current closed areas).

NAFO has agreed to prohibit high seas bottom fishing in 12 areas along the slope of the Grand Bank in international waters where “significant” concentrations of some coral species and sponges are known or likely to occur. In addition NAFO has closed most seamount areas at fishable depths to bottom fishing, at least temporarily. However, it is clear from the work of the NAFO Science Council that sponges, corals and other vulnerable seabed species occur in many areas in the Northwest Atlantic, albeit in lesser concentrations, that remain open to bottom fishing. An assessment of the biological and ecological function of these lesser concentrations should be conducted as well as an assessment of degraded CVME areas to determine whether additional areas should be closed to ensure the maintenance or regeneration of VMEs in areas where bottom fishing is allowed to occur.

3. Ensure the long-term sustainability of deep-sea fish stocks:

In the NEAFC area there has been extensive misreporting, under-reporting or non-reporting of catch, particularly of by-catch species, in the fisheries for deep-sea species. Altogether some 70 or more deep-sea species are caught in the deep-sea fisheries in the NEAFC area. For most of these species, insufficient information on the biology, life history, fishing mortality, and/or the geographical range of stocks of these species makes it currently difficult or impossible to ensure the long-term sustainability of these fish stocks. Although NEAFC has established regulations to freeze and reduce to 350% the fishing effort for deep-sea species since 2004, the reported catch of these species has increased by over 350%. Most of these fisheries can effectively be characterized as unregulated. The management of most of the deep-sea fisheries in the NEAFC area has consistently failed to follow the advice of the International Council for the Exploration of the Seas. Many of these species exhibit life-history characteristics that mean they are low productivity species and/or they are threatened or
endangered as a result of fishing impacts on their populations. NEAFC have therefore failed to adopt fishery management plans for deep-sea fisheries in high seas areas, and to establish biological reference points aimed at ensuring the long term sustainability of fisheries for low productivity species, consistent with the FAO Guidelines, Paragraphs 75 and 76. Furthermore, they cannot ensure the conservation of target and non-target fish species in the Regulatory Area and have failed to protect marine biodiversity in the deep-sea in accordance with Paragraphs 12, 21 and 22 of the FAO Guidelines.

In the NAFO area, a more systematic effort has been undertaken to manage a number of the target fisheries for deep-sea fish stocks. Nonetheless, the deep-water fisheries of the NAFO Regulatory Area have a record of severe overfishing and many stocks are at a fraction of historic abundance and biomass and are in recovery from, or remain in, a depleted state. The catch of a number of other deep-sea species in the NAFO region is essentially unregulated – no management measures are in place. The Fisheries Commission has consistently set catches above the levels proposed by the NAFO Scientific Committee for low-productivity deep-water species, in some cases to levels almost double the recommended quotas. NAFO have therefore also failed to adopt fishery management plans for deep-sea fisheries in high seas areas, and to establish biological reference points aimed at ensuring the long term sustainability of fisheries for low productivity species, consistent with the FAO Guidelines, Paragraphs 75 and 76. They also cannot ensure the conservation of target and non-target fish species in the Regulatory Area and have failed to protect marine biodiversity in the deep-sea in accordance with Paragraphs 12, 21 and 22 of the FAO Guidelines.

4. Move out of an area where ‘unexpected’ encounters with VMEs occur:

The threshold levels set by NEAFC and NAFO for VME encounters apply only to sponges and corals even though other VME habitats have been identified within the Regulatory Areas of both RFMOs. The levels are an order of magnitude or more too high and would not result in any by-catch levels actually triggering a move in most areas of the North Atlantic with a very few exceptions. Using the same threshold levels for active and passive fishing gears has no logical basis. Using the same threshold levels for different types of corals is inappropriate (e.g. smaller octocorals, antipatharians and stylasterids). The 2nm move on rule is impractical as it is impossible to identify where a VME encounter occurs along a tow using commercial bottom trawl gear (commercial trawl tows are up to 20nm long). The move-on rule differentiates between fished and non-fished areas for both NAFO and NEAFC in a manner that is inconsistent with Paragraph 23 of the FAO Guidelines, which requires that deep-sea fisheries should be rigorously managed throughout all the stages of their development, including experimental, exploratory and established phases.
RECOMMENDATIONS

The following are a set of recommendations for improving the implementation of UN GA resolution 61/105 by NAFO, NEAFC and other RFMOs. In particular, these recommendations are directed to the Annual Meeting of NEAFC, which will meet 9-13 November, the European Community, and the UN General Assembly Sustainable Fisheries Resolution negotiations, which will take place 16-23 November 2009 to review and decide on further actions necessary by States and RFMOs to effectively implement resolution 61/105.

1. At a minimum, States whose vessels engage in bottom fisheries on the high seas should be required to perform impact assessments consistent with the criteria agreed in the UN FAO Guidelines (paragraphs 47, 42, 17-20) as a precondition to further authorizing bottom fishing in areas which have been historically fished or those where exploratory fishing activities are proposed;

2. Where impact assessments cannot make a clear determination that bottom fishing will not produce significant adverse impacts (SAIs) on VMEs, then fishing should be prohibited, in particular in respect of bottom trawl fisheries;

3. All areas where VMEs are known or likely to occur should be closed to bottom fishing unless or until an assessments has determined that fishing in these areas would not result in significant adverse impacts to VMEs;

4. Identifications of VMEs should not be limited to sponge and corals only but include the full range on benthic habitat forming species vulnerable to bottom fishing as identified by scientists in RFMO Regulatory Areas;

5. States should implement measures sufficient to protect VMEs even where an RFMO fails to adopt sufficient measures, e.g. if the decision-making structure of an RFMO has allowed one or more countries to block the adoption of measures necessary to effectively implement resolution 61/105, the other Parties should nonetheless establish measures to regulate their high seas fleets to ensure the full and effective implementation of the UN GA resolution;

6. Where bottom fishing on the high seas currently occurs, at a minimum States and RFMOs should establish closures of representative areas where VMEs are likely to have previously occurred to allow for recovery or regeneration of degraded areas;

7. Any evidence of catches of VME indicator species at levels indicated by scientists to represent a likely encounter with a VME should trigger an immediate (and at least temporary) closure of the area until an assessment of the area has been conducted and a determination has been made as to whether fishing can be resumed in the area without adverse impact to VMEs;

8. High seas fisheries targeting, or taking as bycatch, low productivity species where the long term sustainability of the species cannot be ensured should be phased out.
**Introduction**

In 2008, UN FAO published a report that estimated the total global catch in high seas bottom fisheries in 2006 was some 250,000 tonnes, representing 0.3% of the marine capture fisheries worldwide. The value of the high seas bottom catch in 2006 was estimated at approximately $450 million US dollars or €360 million. Of this amount, approximately 105,000 tonnes were caught in the North Atlantic (Bensch et al. 2008).

An estimated 285 vessels flagged to 27 countries engaged in high seas bottom fisheries in 2006, though many of the vessels were only involved in bottom fishing on the high seas on a part-time basis. Of this number, 80% were flagged to only ten States: Spain, Republic of Korea, New Zealand, Russian Federation, Australia, Japan, France, Portugal, Belize and Estonia. Over one-third were flagged to European Union (EU) countries and the EU fleet took half or more of the high seas bottom catch. The majority of the vessels engage in high seas bottom trawling. The conclusions of the UN FAO report were similar to the findings of a study published by IUCN in 2004 (Gianni 2004).

Vessels from the European Union (Estonia, France, Latvia, Lithuania, Portugal and Spain), the Faeroes Islands, Iceland, Norway and the Russian Federation are involved in the high seas bottom fisheries in the North Atlantic. Collectively, the EU fleet is responsible for approximately 80% of the catch in high seas bottom fisheries in the Northwest Atlantic and 95% of the catch in the Northeast Atlantic. Virtually all EU vessels engaged in high seas bottom fishing in the North Atlantic are bottom trawl vessels.

Deep-sea bottom fisheries have been demonstrated to have significant impacts on deep-sea communities formed by emergent epifaunal animals such as corals and sponges. These have included studies in fished versus unfished areas using seafloor observations with towed cameras, submersibles or remotely operated vehicles, acoustic imaging of the seafloor, sampling of seabed communities and by documenting by-catch of benthic invertebrates in deep-water fishing gear (Koslow & Gowllett-Holmes, 1998; Rogers, 1999; Roberts et al., 2000, 2009; Koslow et al., 2001; Hall-Spencer et al., 2002; Fossà et al., 2002; Anderson & Clark, 2003; Clark & O’Driscoll, 2003; Freiwald et al., 2004; Ardron, 2005; Gass & Willison, 2005; Mortensen et al., 2005; Shester & Ayers, 2005; Stone, 2006; Clark & Koslow, 2007; Edinger et al., 2007a; Clark & Rowden, 2009). Bottom fishing damages or destroys long-lived epifaunal animals such as corals on the seabed, reducing the three dimensional complexity of the bottom and leading to decreased species diversity and faunal biomass (Koslow et al., 2001; Reed et al., 2005; Stone, 2006; Clark & Rowden, 2009).

It is important to note that such effects do not only arise from bottom trawling but all bottom-contact fishing methods including benthic long lines, gillnets and pots (e.g. Stone, 2006; Edinger et al., 2007a; FAO, 2008), although the intensity of impact differs between gears and is influenced by fishing practices (WGDEC, 2006; FAO, 2008). Nonetheless, bottom trawling is likely to have the most serious adverse impacts on vulnerable deep-sea benthic species given the size and weight of bottom trawl gear, the scale of the seabed area impacted by bottom trawl tows, and the fact that bottom trawling is the dominant method of bottom fishing for deep-sea species on the high seas (Gianni 2004; Freiwald et al., 2004; Davies et al., 2007; ICES 2008; Grehan et al., 2009). These vulnerable marine ecosystems (VMEs) may also be susceptible to the direct and indirect effects of increased sediment load in the water overlying the seabed that may smother live colonies or bury hard substrata required for settlement of larvae. Removal of target fish species and the dumping of by-catch or offal from fish processing can also have effects on ecosystems in general, potentially including coral and sponge communities and other VMEs, and individual species, especially if they influence food webs within such habitats (Clark & Koslow, 2007; DeVries et al., 2007). For example,
offal from hoki fisheries off New Zealand have been shown to alter oxygen concentrations at 800 m depth and change the composition of the benthic community (Clark & Koslow, 2007). Removal of Antarctic toothfish (*Dissostichus mawsoni*) from the Ross Sea by deep-sea fishing are thought to be responsible for local – regional declines in the abundance of predators such as killer whales (DeVries et al., 2007).

Observations of significant adverse impacts of fishing on deep-water coral communities have been reported from the northeastern Atlantic (Hall–Spencer et al., 2002; Fosså et al., 2002; Wheeler et al., 2005) and northwestern Atlantic (Mortensen et al., 2005; Edinger et al., 2007a), the northeastern Pacific (Stone, 2006; Krieger, 1998, 2001; Stone et al., 2005), and southwestern Pacific (Koslow & Gowlett-Holmes, 1998; Koslow et al., 2001; Clark & O’Driscoll, 2003; Rowden et al., 2004; Clark & Rowden, 2009). Knowledge of the recovery of deep-sea ecosystems from the mechanical impacts of bottom fishing have been poorly studied. However, it is likely that such ecosystems will only recover very slowly, if at all, as habitat-forming corals have slow growth rates, especially some Antipatharia and Octocorallia (Roark et al. 2006, 2009) and the coral habitat itself may have taken thousands of years to develop (Hall–Spencer et al., 2002). In some areas impacted by trawling there have been observations of the occurrence on the seabed of stylasterid corals, potentially indicating that these are capable of either surviving trawling impacts or that they are able to colonise areas of rock relatively quickly after disturbance (Clark & Rowden, 2009). However, in many cases no recovery of seabed ecosystems have been observed even years after fishing impacts (Waller et al., 2007).

The United Nations General Assembly (UNGA) adopted Resolution 61/105, in December 2006, to address international concerns regarding the adverse impacts of deep-sea fisheries on cold-water corals, sponges, seamounts and other types of vulnerable benthic ecosystems and species, including species of fish, found in the deep-sea (UNGA 2006). The resolution called on States and regional fisheries management organizations (RFMOs) to regulate high seas bottom fisheries through conducting impact assessments to determine whether significant adverse impacts to VMES would occur. Furthermore, they required that areas of the high seas to where VMES were known or likely to occur, should be closed to fishing unless such fisheries could be managed to prevent significant adverse impacts. High-seas fisheries should also be managed to ensure the long-term sustainability of deep-sea fish stocks targeted or otherwise impacted, for example, caught as ‘by-catch’. Since then a number of States and RFMOs, including those involved in high seas bottom fisheries in the North Atlantic, Northwest Pacific, South Pacific and Southern Ocean have adopted framework agreements to implement the UNGA resolution.

Subsequent to the adoption of the UNGA resolution, the UN Food and Agriculture Organization (FAO) hosted a series of consultations and negotiations to draft a set of guidelines for the implementation of the UNGA resolution. The FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas, adopted by member countries of the UN FAO in 2008, elaborate science-based criteria to identify VMES, conduct impact assessments of bottom fisheries on the high seas, and determine whether ‘significant adverse impacts’ to such ecosystems would occur (FAO, 2009a).

In November 2009, the UN General Assembly will again take up the issue of the management of bottom fisheries on the high seas and conduct further negotiations on measures that must be taken to protect deep-sea ecosystems in international waters. The present report, the initial phase of a more comprehensive report to be released in early 2010, will review the regulations adopted by two RFMOs responsible for the management of deep-sea fisheries on the high seas in the North Atlantic – the Northwest Atlantic Fisheries Organization (NAFO) and the North-East Atlantic Fisheries Commission (NEAFC).

These RFMOs were chosen for the initial phase of the report for the following reasons:
• The high seas bottom fisheries in the North Atlantic are the largest in the world as measured by volume of catch and the number of vessels involved.
• Most of the major high seas fishing nations whose vessels are involved in deep-water fisheries are members of one or both of the two RFMOs in the North Atlantic.
• Finally, the high seas bottom fishing fleet flagged to Member States of the European Union is, collectively, the largest in the world and the majority of the fishing conducted by this fleet takes place in the North Atlantic Ocean.

The report reviews the regulations adopted by these RFMOs, including as they relate to the management of EU fisheries, as ‘case studies’ of the implementation of the UNGA resolution and the UN FAO Guidelines. The report concludes with a set of recommendations relevant to the UNGA negotiations on further actions needed by both these and other relevant RFMOs to ensure the effective management of bottom fisheries on the high seas to protect deep-sea ecosystems and ensure the long-term sustainability of deep-sea fish stocks and species.
North East Atlantic Ocean

The North East Atlantic Ocean (Fig. 1) is important in terms of fisheries production, with catches of 9.1 million tonnes of fish recorded for 2006 (FAO, 2009b). The North East Atlantic Fisheries (NEAFC) Commission is the competent regional fisheries management organization in this area.

![Figure 1. The NEAFC Regulatory Area showing the ICES Sub-Divisions used as reporting areas for the purposes of fisheries statistics and management (NEAFC, 2009).](image)

The four main fisheries under its regulation are spring-spawning herring (*Clupea harengus*), mackerel (*Scomber scombrus*), blue whiting (*Micromesistius poutassou*) and pelagic redfish (*Sebastes mentella*). Of these, blue whiting and pelagic redfish are found in deep water, with the former being classed as mesopelagic, occurring at depths between 30-400m, and the latter as benthic or bathypelagic, occurring at depths between 300 and >1440m (Whitehead et al. 1986; http://www.fishbase.org). These fisheries make up a catch of some 4 million tonnes (31% total catches in the area), worth in the region of $681 million per annum in the convention area (Arbuckle et al., 2008). These fisheries are pelagic and NEAFC state that they are relatively clean (i.e. catches are close to 100% target species) and do not impact on the seabed. This, however, has been
questioned in a recent review of management by NEAFC which called for verification of low-levels of by-catch through scientific studies so that a full understanding of the ecosystem-level impacts of these fisheries could be attained (Arbuckle et al., 2008). In addition, there are fisheries for a variety of demersal species, including cod, haddock, hake and others that take place both within EU waters and outside of national jurisdiction. Whilst these are high productivity fish species, they are fished using bottom-contact fishing gear and so have the potential to impact on vulnerable marine ecosystems associated with the seabed. In particular the haddock fishery on the Rockall Bank has been identified as having the potential to impact populations of by-catch fish species as well as benthic communities (Arbuckle et al., 2008). Finally, there are a variety of deep-sea species of fish that are exploited in the region using a variety of different types of gear including bottom trawls, longlines, gillnets and pots.

**Management of fisheries for deep-sea species of low productivity**

**Pelagic redfish (Sebastes mentella)**

Whether or not pelagic redfish fall within the remit of the FAO Guidelines has not been addressed by NEAFC or other parties probably because it is assumed this is not a low productivity species. However, *S. mentella* exhibits several features that would suggest that it may not be able to sustain the levels of exploitation possible for high productivity species. These features include ooviviparity (live bearing), and that it has a high longevity (ageing studies have indicated that adults were generally 65 years old, but ages up to 75 years were found; Campana et al., 1990). In 2001, ICES ranked *S. mentella* highly on a scale of vulnerability for deep-sea species, lying below roundnose grenadier and orange roughy (the former species having a similar vulnerability score to *S. mentella*, orange roughy having a considerably higher vulnerability score; ICES, 2001; see also WGEAFM, 2008a). ICES have advised that this species is vulnerable to overfishing in the NEAFC Regulatory Area and the stock size at the present time appears low compared to the early 1990s although clear trends have not been apparent since 1999 (Arbuckle et al., 2008).

Pelagic redfish are fished in two regions of the NEAFC Regulatory Area, the Irminger Sea between east Greenland and Iceland and in the Norwegian Sea. These fisheries occur within EEZs and on the high seas. There has been substantial disagreement on whether the pelagic redfish forms a single or multiple stocks in the Irminger Sea region, with objections to NEAFC’s management proposals arising mainly from Iceland and Russia (Arbuckle et al., 2008). This has meant that no management objectives or harvest controls (biological reference points) have been set for the species in this region (Arbuckle et al., 2006; NEAFC, 2009). NEAFC have set overall total allowable catches (TACs) for pelagic redfish but they have been exceeded because of IUU fishing and as a result of objections from coastal states (Arbuckle et al., 2008). Indeed, since 2002, this has meant that specific advice from ICES on TACs for pelagic redfish have not been agreed and so catches have been beyond recommended limits (NEAFC, 2009). The independent review of NEAFC concluded that there was an urgent requirement to resolve outstanding issues regarding stock structure consistent with the precautionary principal so that management for the species, regarded as vulnerable, could progress in a sustainable manner (Arbuckle et al., 2008). In addition, this report indicated significant problems with catch data for pelagic redfish, with catches not always being reported, as well as inconsistencies in acoustic survey data for the species which has meant that estimates of stock size have been uncertain (Arbuckle et al., 2008).

For the Norwegian Sea, pelagic redfish was taken as by-catch in the pelagic fishery for blue whiting and herring, in waters beyond national jurisdiction, for some years (the Banana Hole). In 2004-2006 this became a targeted fishery without management and catches reached 40,000t taken by 40 vessels by 2007 (NEAFC, 2009). In national waters the fishing was strictly regulated as the stock was regarded to be at low levels. In 2007 a TAC of 15,500t was established and fishing banned until the
end of August. Note that this was despite consistent advice from ICES that no fishery should be directed towards this species in the region and that by-catch should be limited (NEAFC, 2009).

**Directed deep-water bottom fisheries**

**Ling (**Molva molva**)**

Ling are mainly targeted by long line fisheries within exclusive economic zones (EEZs) but some catches are from high seas areas, such as the western Rockall Bank. Catch per unit effort (CPUE) data indicate a decline in catches from the 1970s to 2000 in ICES Area II (includes the Banana Hole). There has been limited provision of data from some of the major fisheries for this species in the NEAFC region. At present, length and age data are inadequate for reliable age-based assessments of this species (WGDEEP, 2009).

**Blue ling (**Molva dypterygia**)**

Fisheries for this species initially started around Iceland, targeting spawning aggregations, but these were depleted relatively quickly. The species is now taken mainly as by-catch in redfish and other fisheries but this is mostly within the Icelandic EEZ. Some catches are from the high seas portion of the Irminger Sea, Rockall and Hatton Banks. In northern areas fishing has been mainly by trawl fisheries, although the species is now also targeted by long lines. Landings from high seas areas have been very variable and little information is available on these (e.g. Spanish landings in 2003). ICES have advised that there should be no directed fisheries towards blue ling because the species is vulnerable to overfishing especially when spawning aggregations are targeted (WGDEEP, 2009). They also advise that where spawning aggregations are present they should be closed to fishing. Currently, in Icelandic waters, spawning areas are closed to fishing but there is no TAC for blue ling and the increased effort from long line fishing targeted at this species is against ICES advice (WGDEEP, 2009). Further spawning areas have also been identified in northern regions off the Norwegian continental slope (Storegga), on the Reykjaness Ridge on the edge of the Icelandic EEZ (ICES, 2007a; Fig 2).

![Figure 2. Blue ling: Spawning areas in the Icelandic EEZ (WGDEEP, 2009).](image)

Blue ling has been an important by-catch for mixed deep-water trawl fisheries on the Hatton Bank. In other high seas areas, such as in the Norwegian Sea and north of the Azores, it is taken in small quantities. In the Hatton Bank region CPUEs have been variable but a dramatic reduction in catches occurred between 2002 and 2006. No catches were reported from this region in 2007 and 2008. The main states involved in this fishery were Spain and France. Recently, results from the EU POORFISH project together with other information enabled ICES to advise NEAFC and the EC on the likely presence of spawning aggregations of blue ling in the Hatton and Rockall Bank areas. These studies have indicated spawning grounds for this species on the continental slope off western Scotland and around the Hatton, Rockall and Rosemary Banks (ICES, 2007a; Fig. 3). In EU waters these spawning
grounds have been protected from fishing during the spawning period by specific fisheries measures. As yet NEAFC has not agreed to specific measures based on this advice, despite the information having been available since 2007/2008. However the measures that extended the closures to bottom trawling on Hatton Bank in 2007 and 2008 include at least part of the putative spawning area for blue ling (NEAFC, 2006, 2007; these are to be reviewed in December 2009). It should be noted that the presence of a spawning ground is viewed as a feature that identifies a geographic area as a vulnerable marine ecosystem (FAO, 2009a Para 42 (i)).

![Map of spawning areas in ICES areas XII, Vlb, Vlb and V (ICES, 2007a).](image)

Fishing on spawning aggregations may result in underestimation of stock trends and so these analyses require cautious interpretation (Arbuckle et al., 2008). Ageing is also difficult in this species making stock analysis problematic (WGDEEP, 2009).

**Tusk (Brosme brosme)**

It is likely that tusk form several distinct stocks in the NE Atlantic region (WGDEEP, 2009). For some regions, where there is a directed fishery, there is management in place (e.g. Icelandic EEZ). However, in others there is no species-specific management (e.g. ICES areas I and II including the high seas areas of Banana Hole and Barents Sea). On the mid-Atlantic Ridge tusk has been taken as a by-catch from gillnet and longline fisheries. There does not seem to be any specific management of the species in this region of the high seas although there are no clear trends in available catch data. The same is true for Rockall where tusk is also a by-catch species landed mainly by Norwegian vessels. Length and age data are inadequate for aged-based analyses (WGDEEP, 2009).

**Greater silver smelt (Argentina silus)**

Silver smelt were taken as a by-catch and generally discarded up to 1996. Since 1997 a directed bottom trawl fishery has existed for this species although it is also taken as by-catch in the redfish fisheries in the region. ICES have advised that silver smelt is a low-productivity species and that it can only sustain low levels of exploitation. Catches have been very variable for this species along the continental slope west of the British Isles and Ireland, in the Norwegian Sea and around the Faroes and Iceland. In some cases there is evidence of over exploitation but in others no significant evidence of declines although catches seem to reflect market demand for the species. Stock structure in this species has not been resolved and there is an urgent requirement for genetic studies to identify
biologically relevant management units. The great silver smelt is often caught as by-catch in other fisheries and data on this is limited. Some confusion exists with identification of smelts in the region. No recent stock assessment.

Orange roughy (*Hoplostethus atlanticus*)

Orange roughy are recognised as a low productivity species that aggregate at seamounts to spawn. Throughout the northeastern Atlantic this species has been targeted by fishing vessels when aggregations have been located and in almost all cases depletion of stocks has occurred (WGDEEP, 2009). ICES recommend that no fisheries be directed at this species as a result of its vulnerability. There are no stock assessments for orange roughy but stock status is based on CPUEs which fluctuate strongly probably as a result of fisheries being targeted at spawning aggregations. It is likely that management should be directed at the level of individual aggregations around specific topographic features but spatial fisheries statistics are not available to enable such management.

Roundnose grenadier (*Coryphaenoides rupestris*)

This species is subject to a directed trawl fishery to the west of the British Isles including around the Rockall and Hatton Banks and has been fished in the Skagerrak and on the northern Mid-Atlantic Ridge. In the western part of the NE Atlantic it is suspected that landings in international waters are unreported especially in areas to the west of the Hatton Bank where Spanish vessels have been operating. This is a concern as catches in this area have been high. In almost all these areas there have been indications of declining stocks with fairly catastrophic drops in catches in some cases (WGDEEP, 2009). Virtual population analysis of stocks, to the west of the U.K., and around the Faroes, indicate a significant decline in roundnose grenadier (WGDEEP, 2009). Statistics from the area to the west of the Hatton Bank were not included in this because of their unreliability. It is also reported that numbers of large fish are declining (Arbuckle et al., 2008).

Fisheries on the mid-Atlantic ridge for roundnose grenadier commenced in the 1970s and were targeted at seamounts using both pelagic and bottom trawls. The fishery has since declined with the fall of the Soviet Union, although sporadic fishing by various nations has taken place since then. Roundnose grenadier are also taken as by-catch in orange roughy and blue ling fisheries in this area. In general, information is sketchy about current exploitation of this species on the mid-Atlantic Ridge. ICES identify this as a low productivity species and have recommended restricted fishing and that no further fisheries are developed until it is shown that they are sustainable. There are age-based stocks assessments for this species for some areas.

Black scabbardfish (*Aphanopus carbo*)

In the northern parts of the NE Atlantic this species has been targeted along the continental slope and off the Rockall and Hatton Banks by bottom trawl fisheries. Further south, in areas such as the Azores, it is targeted by long line fisheries. In most areas, in the northern part of the NE Atlantic, stocks have shown significant declines in CPUE (to ~20% of original CPUE estimates; WGDEEP, 2009). ICES have recommended that catches be restricted to 50% of the level prior to the fishery expansion in 1992-1993 and that no further fisheries be developed unless they can be proved as sustainable. It is suspected that this species undergoes significant ontogenetic migrations over considerable distances but further information is required on the reproductive and population biology of the species before this can be confirmed.

Goldeneye perch (*Beryx splendens* and *Beryx decadactylus*)

These species are generally taken as by-catch in the NE Atlantic region, particularly along the mid-
Atlantic Ridge, on the high seas to the north of the Azores EEZ. General trends are for a decline in catches of the species. No assessments are available but there is concern about sequential depletion of stocks and under-reporting of catches from high seas areas (WGDEEP, 2009). ICES have identified these species as being highly vulnerable to trawl fisheries as a result of their aggregating behaviour around seamounts, the result of which may be that they are only capable of sustaining low levels of exploitation. There are insufficient data for assessment of the state of populations. The stock structure of this species is poorly understood and aspects of reproductive biology poorly known.

Black spot sea bream (*Pagellus bogaraveo*)

The species has been fished on the continental slope off the United Kingdom, France, Portugal and Spain, as well as the Azores. Stocks along the northern European continental shelf collapsed in the 1980s following overfishing over at least 10 years when the fishery was unregulated. Fisheries continue in other areas. It is speculated that the life history of this species (protandrous hermaphrodite) make it vulnerable to overfishing as all large fish are female. There is evidence of population differentiation between the European continental slope / shelf and the Mid-Atlantic Ridge (Stockley et al., 2005).

Greater forkbeard (*Phycis biennis*)

This species is mainly taken as by-catch in bottom trawl and longline fisheries throughout the NE Atlantic region, along the European continental slope, offshore banks and oceanic islands. Trends in catches are unclear and vary markedly from area to area. In general data on catches of this species are not reliable as it is a by-catch species and not always recorded and is also confused in landing statistics with other species (morids).

Sharks

Sharks are low productivity species as a result of conservative life histories with low fecundity, slow rates of growth and a long time to maturity (ICES WGEF, 2007; Gibson et al., 2008). In the NE Atlantic region, sharks are captured along the European continental shelf, including the Rockall and Hatton Banks, and on the mid-Atlantic ridge. They have been targeted directly by gillnet and long line fisheries, make up an important component of mixed deep-water species fisheries (Hareide et al., 2004), and are taken as by-catch, especially in hake and monkfish fisheries but also others.

Siki sharks (*Centroscymnus coelolepis, Centrophorus squamosus*)

These sharks are widely distributed in the NE Atlantic but many aspects of their biology are poorly understood. Fisheries directed towards these sharks commenced in the late 1980s and in the last decade CPUEs have declined substantially indicating that stocks are depleted (ICES WGEF, 2007). In 2006 ICES recommended that no fisheries should be targeted at these species unless sufficient information was available to determine sustainable levels of exploitation and that efforts to limit by-catch of these species should also be taken. At present TACs are set for “deep-water sharks” including: Portuguese dogfish (*Centroscymnus coelolepis*), leafscale gulper shark (*Centrophorus squamosus*), birdbeak dogfish (*Deania calceus*), kitefin shark (*Dalatis licha*), greater lanternshark (*Etmopterus princeps*), velvet belly (*Etmopterus spinax*), black dogfish (*Centroscyllum fabricii*), gulper shark (*Centrophorus granulosus*), blackmouth dogfish (*Galeus melastomus*), mouse catshark (*Galeus murinus*), Iceland catshark (*Apristurus* spp.), *Deania hystricosum* and *Deania profundorum*. For the majority of these species, fisheries are essentially unregulated, and reporting on catches, by-catches and discards are unreliable. This is exacerbated by confusion in identification of shark species or placing many species into a single category of “deep-water sharks”. It should be noted that some of these species are listed on the IUCN Red List in various risk categories: Near Threatened – *Centroscymnus coelolepis* (Endangered in the NE Atlantic); Vulnerable - *Centrophorus granulosus*
(Critically Endangered in the NE Atlantic); *Centrophorus squamosus* (Endangered in the NE Atlantic).

In European waters, gillnets have now been banned from deeper than 200m in international waters and those around the Azores, Madeira and Canary Islands and deeper than 600m elsewhere. This has displaced gillnetting to other regions of the world’s oceans.

Other species
A variety of other fish species are fished in the NE Atlantic, including on high seas areas, such as the Hatton Bank. These include: roughhead grenadier (*Macrourus berglax*), common Mora (*Mora moro*) and other Moridae, rabbit fish (*Chimaera monstrosa* and *Hydrolagus* spp), Baird’s smoothhead (*Alepocephalus Bairdii*) and Risso’s smoothhead (*A. rostratus*), wreckfish (*Polyprion americanus*), bluemouth (*Helicolenus dactylopterus*), silver scabbard fish (*Lepidopus caudatus*), deep-water cardinal fish (*Epigonus telescopus*) and deep-water red crab (*Chaceon affinis*). Some of these species appear to be showing marked declines in catch possibly as a result of overexploitation. However, since there is no management in place for these species on the high seas and data on catches is likely to be unreliable, as well as the fact that many will be discarded, then realistic assessments of population status and trends are not feasible under present the management regime. It is notable that catches of *Alepocephalus Bairdii*, in particular, have increased markedly in recent years (NEAFC Catch Statistics).

NEAFC have made several requests to ICES with respect to improving information on the spatial and temporal patterns of deep-sea fishing in their area of competence. ICES reported (WGDDEEP, 2009), that the VMS and reported catch data provided by NEAFC was insufficient for these purposes. This was because of the low frequency of VMS reports on vessel positions (once every 2 hours), and because fishing operations were not generally logged to tally with VMS data. There was also strong suspicion that there were significant amounts of missing data or misreporting of catches. In addition, 70% of vessels reporting demersal catches only reported catches of a single species. This is highly unlikely given that many of these deep-sea fisheries are multispecies fisheries and so the conclusion must be that only the target species or most abundant species in catches are reported, and that data on total catches are incomplete or misreported. For similar reasons ICES were unable to help NEAFC classify deep-sea fishing activities into management categories (e.g. targeted fishery, by-catch fishery etc.; WGDDEEP, 2009).

The review of management of fisheries by NEAFC (Arbuckle et al., 2008) identified that deep-sea fisheries in the area were not subject to long-term management objectives and therefore long term management plans were not in place. Some unilateral and multilateral agreements had been initiated for some species / fisheries. It was also concluded that the status of many of the deep-sea species targeted in the NEAFC regulatory area was unknown. Their concerns were summed up:

“The Panel nonetheless considers the situation for deep-sea species to be inadequate, in particular as regards knowledge of the species, nature of the fisheries, status of the resources and management planning. This is a critical issue that NEAFC needs to address as a priority and every effort should be made to develop the necessary fisheries database to begin this process.” (Arbuckle et al., 2008).

In 2004, the North-East Atlantic Fisheries Commission (NEAFC) established a cap on fishing effort (no more than the highest level in previous years) for deep-sea species in the NEAFC Regulatory Area—the first ever measure to regulate fisheries for deep-sea species on the high seas of the Northeast Atlantic. In 2006, NEAFC Contracting Parties agreed to further reduce fishing effort by 35% in fisheries for deep-sea species (Bjornadal, 2009). In spite of this regulation however, the reported catch of deep-sea species in high seas bottom fisheries in the NEAFC area has risen from approximately 25,000 tonnes in 2004 to over 90,000 tonnes in 2007 (Table 1). European Union fleets are responsible for 95% of the catch of deep-sea species on the high seas in the NEAFC area.
Whilst these catches include species that are high or medium productivity, catches of species around which there is considerable concern, including blue ling, sharks and argentines have increased dramatically (catches of orange roughy declined). Information on whether these catches are from high seas areas or not is difficult to ascertain but it is certain that there has been a dramatic increase in catches of deep-sea species over the last 5 years in the NEAFC Regulatory Area.

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Table 1. High seas catches of deep-sea species in the NEAFC Regulatory Area 2004-2007 (tonnes). Data extracted from NEAFC catch statistics.

Conclusions

- Exploitation of deep-sea species within the NEAFC regulatory area has led to depletion of stocks of several species. In some cases, these species are now classed as endangered or critically endangered as a result of targeted fishing and/or by-catch (deep-water sharks).
- For the majority of deep-sea fish species, targeted, taken as by-catch, or both, there are no fishery-independent data for analyses of stock status or trends. Reliance on fisheries (CPUE) data is extremely difficult for deep-sea species in this region because:
  - For aggregating species, such data are of limited value.
  - There is strong evidence of misreporting of catches in the NEAFC regulatory area
  - There are few data on by-catch / discards for many of the deep-sea fisheries in the NEAFC regulatory area
- As a result of the above, the fisheries for many deep-sea species in the NEAFC regulatory area, including low productivity species, may be regarded as effectively un-regulated. Indeed, for many deep-sea species any form of management is impossible in view of the complete lack of reliable data on catches.
- NEAFC has adopted measures to reduce effort on deep-sea species but this has not taken place and instead catches increased significantly from 2004 – 2007 (increase of 356%).
- Catches for deep-sea species have exceeded or been in contravention of ICES recommendations for several species.
- NEAFC have banned the use of gillnets below 200m depth on the high seas in their regulatory area, this is a positive development, especially with regards to the protection of deep-sea shark species.
- No specific spatial protection measures have been undertaken for protection of deep-sea fish species, although the extension of protected areas on the Hatton Bank have coincidentally protected part of a suspected spawning area for blue ling.
- Particularly problematic in terms of data and management are multispecies deep-water trawl fisheries along the Mid-Atlantic Ridge and to the west of the Hatton Bank.
Protection of benthic marine ecosystems

To determine whether existing deep-sea fisheries in the NEAFC area have impacted, or have the potential to impact, benthic ecosystems requires the overlaying of geo-referenced fisheries data onto maps of the known occurrence of Vulnerable Marine Ecosystems. In the case of the NE Atlantic, the following vulnerable marine ecosystems are known to occur in the region beyond areas of national jurisdiction (WGDEC, 2009):

Cold-water coral reefs

Other coral associated benthic habitats (octocoral meadows or forests, dense stands of Antipatharia or Stylasterida)

Dense stands of sea pens

Sponge –associated habitats

Areas of dense occurrence of xenophyophores

Dense stands of cerianthid sea anemones

Serpulid reefs (*Filograna*)

Deep-water oyster beds (Wisshak et al., 2009)

These systems are especially associated with areas of elevated or steep topography, the occurrence of strong bottom currents, especially those generated by small-scale oceanographic phenomena such as internal waves, a high concentration of food and the occurrence of hard substrata (Rogers et al., In press).

**Cold-water coral reefs**

Cold-water coral reefs have been studied more thoroughly in the NE Atlantic than anywhere else in the world. In this region, reefs are mainly formed by the framework-building coral *Lophelia pertusa*, with contributions from other species, mainly *Madrepora oculata*, but also *Solenosmilia variabilis*, *Desmophyllum dianthus* and *Dendrophyllia cornigera* (Rogers, 1999; Roberts et al., 2009). For *Lophelia pertusa*, the NE Atlantic is the most important area known in terms of the number of observations of the species, especially as a component of deep-water coral reefs. The coral occurs on the shelf-break and upper continental slope of Norway, and continental Europe, including offshore banks such as the Faroes, Rosemary, Lousy, Hatton and Rockall Banks. Elsewhere, the coral occurs along the Mid-Atlantic Ridge and on the continental slope of West Africa, in the Mediterranean, along the continental slope in the NW Atlantic, in the southern Atlantic, Indian and North Pacific Oceans (Rogers, 1999; Davies et al., 2007; Fig. 4).
The main areas in the NEAFC Regulatory Area known to host *Lophelia pertusa* are the high seas portions of the Rockall Bank, the Hatton Bank and the Mid-Atlantic Ridge. Cold Water coral reefs have been known from the Rockall and Hatton Banks for many years (see Rogers, 1999).

**Rockall Bank**

Following evidence largely gathered by ICES WGDEC a number of areas were closed on the Rockall Bank including Northwest Rockall, The Logachev Mounds and West Rockall Mounds (Fig. 5). In addition to this, an area known as the Haddock Box remained closed to trawling to protect haddock stocks on the Rockall Bank (WGDEC, 2007). The EU closed the portions of these areas lying within the EEZs of member states.

Subsequently, further observations indicated the presence of *Lophelia pertusa* reefs on the southwestern Rockall Bank on the Empress of Britain Bank (Fig. 6). In addition, significant areas of *Lophelia pertusa* reefs were also detected on the northeastern part of the Rockall Bank and just outside of the NW Rockall Bank protected area (Fig. 7). ICES subsequently recommended that all these areas be closed to bottom fishing. The adjustments to the NW Rockall protected area and the adoption of the Empress of Britain protected area were accepted by NEAFC and will be in place until December 2009, whilst the eastern proposed area is under consideration (NEAFC, 2007).
Hatton Bank

In 2007 NEAFC also closed a portion of the Hatton Bank because of evidence of the presence of *Lophelia pertusa* reefs presented by ICES (WGDEC, 2005), following a proposal to close a portion of the bank from Norway. In 2008, this was extended following evidence gathered by U.K. and Spanish researchers indicating areas of *Lophelia pertusa* reef to the south of the 2007 closure (WGDEC, 2007; NEAFC, 2007; Fig. 8). Subsequently evidence of further occurrences of cold-water coral reefs have been found in three areas to the west of the existing closure, all associated with rock outcrops forming ridges or more irregular topographic features lying between 700 - >1,700m deep (Fig. 9). Coral mounds are present in this area and live Scleractinia (*Lophelia pertusa, Solenosmilia variabilis, Madrepora oculata*), Antipatharia and Octocorallia have been sampled (Munõz et al., 2008). NEAFC is yet to act upon this new information.

![Figure 6. ICES recommendation for the protection of the Empress of Britain Bank as adopted in NEAFC Recommendation IX 2008 (NEAFC, 2007).](image-url)
Figure 7. ICES recommendations for adjustment of NW Rockall protected area and for new eastern Rockall protected area.

Figure 8. Hatton Bank showing area protected in 2007 and that proposed for protection by WGDEC (2007) and subsequently protected by NEAFC until late 2009 (NEAFC, 2007).
Mid-Atlantic Ridge

In 2004 NEAFC closed 5 areas in the Mid-Atlantic Ridge region to fishing as a precautionary and interim measure to protect benthic marine ecosystems. These regions were chosen to provide a variety of ridge and seamount habitats placed at different latitudes along and to either side of the Mid-Atlantic Ridge. Recent synthesis of current knowledge on the biogeographic classification of the deep ocean indicates that the sites selected do present areas lying in different water masses along the MAR (UNESCO, 2009) and may also represent different bathyal provinces and so are likely to exhibit some general differences in fauna beyond those that would reflect local environment (i.e. differences in the physical characteristics of the features). Beyond this aim of biogeographical representivity the choice of sites was arbitrary as a result of the limited information on the presence of vulnerable marine ecosystems at the time and a lack of effort to synthesise any data that were available (Norwegian Government, 2008). These sites were Hecate Seamount, a complex of seamounts around Faraday Seamount, an area of the Reykjanes Ridge and the Altair and Antialtair Seamounts to the south (Norwegian Government, 2008). With the exception of the Reykjanes Ridge, these protected areas were all small, perhaps too small to meet the conservation objectives for which they were originally set up (representivity of deep-water ecosystems along the MAR). On the basis of new scientific observations, the Norwegian Government proposed 5 new protected areas along the mid-Atlantic Ridge, encompassing some of the existing protected areas but because of a larger size including a wider depth and range of habitats (Fig. 10). These sites were chosen to represent colder northern regions of the mid-Atlantic Ridge (Reykjanes Ridge), the zone of the Sub-Arctic Front around the Charlie Gibbs Fracture Zone, an area of high biological productivity, and an area in the southern section of the mid-Atlantic Ridge representing the warmer areas just to the north of the Azores EEZ. The Altair and Antialtair Seamounts were retained but areas expanded to include the seamount flanks.

Figure 9. ICES proposed extension to Hatton Bank closed areas on the basis of Spanish data indicating the presence of cold-water coral habitats in three areas to the west of existing protected area (WGDEC, 2008).
Figure 10. Proposed Mid-Atlantic Ridge and Seamount Protected Areas. Adopted by NEAFC in 2009 (Norwegian Government, 2008).

It was already known that there were a number of observations of the occurrence of *Lophelia pertusa* on the Reykjanes Ridge (e.g. WGDEC, 2006), and further evidence of the presence of colonies of these corals further south along the ridge were presented by Mortensen et al. (2008), based on ROV footage from the Mar-Eco project. Along the mid-Atlantic Ridge *Lophelia pertusa* was only observed as relatively small colonies, up to 50cm in diameter, although in places large areas of dead coral skeleton were also observed. Whether corals had died naturally or observations were a result of past fisheries impacts (deep-water trawl fisheries have existed on the MAR since the 1960s-1970s) is unknown although the possibility that small colonies represent recolonisation following damage is an intriguing one (Mortensen et al., 2008). Various octocorals were also observed on the Mar-Eco mid-Atlantic Ridge investigations and areas with corals supported a higher abundance of other megafauna (Mortensen et al., 2008). Despite existing data, knowledge of the location of VMEs on the Mid-Atlantic Ridge is sparse. Implementation of effective VME encounter and move on rules and efforts to model the distribution of corals in this region would be valuable.

It is interesting to note that following the closures in 2004, fishing effort actually increased on the Faraday, Altair and Antialtair Seamounts (ICES, 2007b). There seem to have been no efforts by NEAFC to follow up the VMS signatures that were likely to have been fishing in the protected areas and clearly lack of enforcement of such high-seas protected areas by flag states and NEAFC is a major concern.

The Wyville-Thomson Ridge
This area is within the European EEZ. In 2003 the area to the south of the Wyville Thomson Ridge was closed to fishing as a result of the discovery of the Darwin Mounds, an area of low relief submarine
hills with coral growing on their summits (Fig.11). This area had been impacted by fishing, especially the French roundnose grenadier fishery in the Rockall Trough (Wheeler et al., 2005). ICES have recommended that the Wyville Thomson Ridge itself be closed to fishing because of the presence of *Lophelia pertusa* (WGDEC, 2009), although this should be done whilst considering potential displacement of fishing activity.

Figure 11 Wyville-Thomson Ridge: protected and proposed protected areas (WGDEC, 2009).

**Deep-sea sponges**

Sponge grounds occur in the North Atlantic at depths of between 200 and 1500m. In the NE Atlantic, they comprise two distinct types of aggregations, those formed by glass sponges (Hexactinellida) and those formed by silaceous sponges (Demospongiae). Glass sponge beds, formed mainly by the species *Phoronema carpenteri*, are found on the upper slope at 740 – 2000m, depending on location (WGDEC, 2007), from Iceland to West Africa, with mass occurrences being reported west of Scotland, in the Porcupine Seabight (Fig. 12a) and off Morocco (Le Danois, 1948; Rice et al., 1990; Barthel et al., 1996). These sponges live on mud and generate spicule mats which are associated with increased biomass of macrofauna (Bett & Rice, 1992). Demosponges form dense grounds dominated by a few species of massive sponge. These are referred to as “ostur” (cheese bottom) reflecting the large by-catches of these sponges taken by fishers in northern waters. The dominant species on these grounds include: *Geodia barreti, Geodia macandrewi, Geodia mesotriaenia, Geodia phlegraei, Stryphnus ponderosus* (now recognised as two species) and *Thenea muricata*. There is evidence to suggest that there is a distinct boreal “ostur” comprising *Geodia barreti, Geodia macandrewi, Stryphnus ponderosus* and other species, found around the Faores, Norway, Sweden, parts of the Barents Sea and south of Iceland, and a cold-water “ostur” dominated by *Geodia mesotriaenia* and other species found north of Iceland, in the Denmark Strait, off East Greenland and north of Spitzbergen (Klitgaard & Tendal, 2004; Fig. 12). Recent surveys have also indicated that important sponge grounds may occur on the UK continental slope north of the Wyville-Thomson ridge and trawl surveys by Spanish researchers have encountered high by-catches of the sponges east of the Hatton Bank and in the Hatton-Rockall Basin (WGDEC, 2007).
Figures 12 A. *Pheronema carpenteri*; distribution in the Porcupine Seabight. B. “Ostur” distribution in the NE Atlantic.

“Ostur” have a high diversity associated with them, with 242 species being identified as associated with these sponges including some obligate associations (Klitgaard, 1991; 1995; Warén & Klitgaard, 1991). It should be emphasised, however, that knowledge of these communities is restricted to a very few studies. Sponge grounds represent important benthic habitats in the deep waters of the northeastern Atlantic. They have been demonstrated to be associated with increased biomass of associated fauna and so may be viewed as structural species within distinct communities. Sponges are especially vulnerable to bottom fishing gear because of their upright structure (Freese et al., 1999), the fragile nature of tissues and skeletons (especially glass sponges) and susceptibility to smothering with sediment (WGDEC, 2009). Bottom trawls in particular, can take enormous bycatches of sponges with up to 50t in a haul reported from areas south of Iceland, 12t in areas of the Norwegian Shelf and 1-3t off the Faroes. Experimental trawling on sponge grounds has also shown that 30-60% of colonies left on the seabed are damaged (Freese, 2001). Survival of damaged colonies depends on the extent of damage (Henry & Hart, 2005). Wounded sponges may become infected by necrotizing bacteria and subsequently die (Freese, 2001). Little is known about the growth rates of sponges in deep water. In shallow waters, growth rates of 0.76-5.6cm per year have been estimated, with colonies living for up to 220 years (Leys & Lauzon, 1998). It is likely that deep-water sponges, living at the depths associated with glass and silaceous sponge grounds in the NE Atlantic grow at much slower rates. Some Canadian sponge reefs, located on the deep shelf have existed at the same locality for up to 9000 years. Thus, sponge grounds fit definitions of vulnerable marine ecosystems in that they are important as diverse benthic communities, vulnerable to trawl damage and probably have a very low resilience to fishing impacts.

To date there has not been a systematic evaluation of interactions between fisheries and sponge grounds in the NEAFC regulatory area. Localities where it is likely that there are significant impacts on sponge grounds by deep-water bottom fisheries on the high seas are on the northern mid-Atlantic Ridge (Reykjanes Ridge), and on the eastern Hatton Bank and Rockall/Hatton basin. No action has been taken to undertake a study on sponge / fishery interactions or indeed to close any areas to fishing on the basis of the presence of sponge habitats. Some sponge grounds may have been protected by existing closures for *Lophelia pertusa* but this has not been evaluated.

*Coral gardens* Octocorallia, Antipatharia and Stylasterida may form dense stands associated with many other species of invertebrates and fish. These habitats have been termed coral gardens, coral forests or coral meadows. Defining these habitats is difficult but they appear to exhibit a high density of corals compared to the surrounding seabed and are often associated with a higher species
richness or a distinct community of other mega- and macrofaunal species. The functional relationships between the coral stands and associated fauna are often unclear (see below). A number of studies have examined the density of octocorals and other corals forming these habitats and indicate that densities may vary between 0.1 - >10 colonies per m² and are generally higher than background densities by a factor of 10 (Orejas et al., 2002; Mortensen and Buhl-Mortensen, 2004, 2005; Stone, 2006). To some extent the density of corals in such habitats reflects size with larger species occurring at lower densities that smaller species or mixed coral gardens with a variety of taxa (WGDEC, 2007).

Octocorals, Antipatharia and Stylasterida are associated with distinct communities of animals but knowledge on these is much less than those associated with cold-water coral reefs. In the case of octocorals, analyses of just 25 colonies of octocorals from the Atlantic coast of Canada identified 114 species of associated animals Buhl-Mortensen & Mortensen, 2005). In Alaska 97% of juvenile rockfish and 96% of juvenile golden king crab were associated with emergent epifaunal invertebrates especially octocorals and sponges (Stone, 2006). Identifying why such associations occur is difficult. In many cases fish may use coral in a similar way to other complex topography such as rocks and boulders on the seabed for shelter and for foraging. Other large predators may also use coral habitat as foraging areas. The endangered Hawaiian monk seal has been observed as foraging preferentially for fish amongst beds of octocorals and black corals off Hawaii (Parrish et al., 2002).

Rogers et al (In press) suggest the following definition for a coral garden:

Coral communities formed by one or more of the coral groups Scleractinia, Octocorallia, Antipatharia or Stylasterida where the density of colonies reaches >10 times background densities, is usually >0.1 colonies per m², and where there is an enhanced diversity of associated fauna or a distinct associated faunal community compared to the background benthic, epibenthic and epizoan fauna.

Coral garden communities are extremely vulnerable to damage from bottom fishing gear (Stone, 2006; Edinger et al., 2007a; Waller et al., 2007). Species are slow growing and indeed species of octocorals and antipatharians are amongst the most long-lived species on the planet (ages of >4000 years for Leiopathes sp). Such communities show a very low resilience to fishing impacts and observations indicate no recovery of such communities decades after fishing impacts (Waller et al., 2007). Coral gardens therefore meet criteria for classification as vulnerable marine ecosystems. Compilation of records of deep-sea octocorals indicate that they are distributed throughout the world’s oceans including areas such as the Arctic and off continental Antarctica where Scleractinia are rare (Fig. 13). Whilst there is no clear pattern of distribution (see Fig. 14) high levels of diversity have been observed in the North Pacific, especially around the Hawaiian Islands, the southwestern Pacific, especially off New Zealand, the North Atlantic, especially on the Mid-Atlantic Ridge as well as seamounts and on the flanks of oceanic islands in the eastern North Atlantic and to a lesser extent in the Pacific and Atlantic sectors of the Southern Ocean (Rogers et al. In press). Records from the Indian Ocean are notably sparse. High productivity in temperate latitudes may partially drive this distribution but at present this is speculation.
Thus, the NEAFC area may be considered as an important region in terms of abundance and diversity of octocorals on the base of existing knowledge. Within the region, knowledge of the distribution of coral garden communities is extremely sparse. Most records of octocorals come from the northern Mid-Atlantic Ridge, the Mid-Atlantic Ridge around the Azores, from non-ridge seamounts, such as the Josephine Bank, from along the continental slope from Norway to West Africa and from the slopes of oceanic islands, including the Azores and Canary Islands as well as around Iceland and the Faroes (WGDEC, 2007; Rogers et al., In press; Fig. 15). The distribution of stylasterids and antipatharians is less well known but is probably similar but with differences in depth distribution (see Rogers et al., 2007).
Figure 15. Distribution of non-reefal corals in the North Atlantic region based on ICES data (WGDEC, 2007).

At present there has been one study of the interactions of deep-sea bottom fisheries with octocorals / antipatharians in the NEAFC Regulatory Area. This is despite the known occurrence of octocoral gardens in the region (e.g. seamounts on the high seas and around the Azores). Such interactions are likely to take place in high seas deep-water fisheries on the Mid-Atlantic Ridge and on the Hatton / Rockall Bank areas. Spanish observer studies have indicated limited by-catch from bottom-fishing gear in the Hatton Bank area but note that such organisms were rare on trawl grounds (probably because they have been destroyed by past fishing activity (WGDEC, 2007; Fig. 16). NEAFC have not undertaken assessment of such interactions and indeed their discussions to date have mainly been concentrated on cold-water coral reef habitats and sponge grounds.
Figure 16. Distribution of catches of (A) Octocorallia and (B) Antipatharia on the Hatton and Rockall Banks from bottom trawls (black symbols) and long lines (red symbols) based on Spanish observer study (WGDEC, 2007).

Figure 17. Coral garden habitat from the slope of Faial Island, Azores, depth ~350m. Species include Acanthogorgia hirsuta, Viminella flagellum and Narella spp. Note the lost long line along the top of the rock outcropping (Rogers & Rebikoff Foundation, 2008).

General considerations
ICES were requested to identify the current temporal and spatial extent of deep-water fisheries in the North East Atlantic using VMS data. In 2009 ICES WGDEEP advised that:

The quality of the data is not yet sufficient to provide information on the spatial and temporal extent of current deep-water fisheries in the NE Atlantic.
The reasons for this advice were that there was high interannual variability in data, suggesting that data were misreported or missing and that in many cases only one species was reported from catches (70% vessels; WGDEEP, 2009). This is highly unlikely in demersal fisheries and so it would seem that catches were misreported or that a portion of catch was unreported. Notwithstanding this, these analyses did reveal some new information on where particular fish species were being fished and therefore the potential impacts on VMEs, at least in general terms. ICES made a number of recommendations to NEAFC regarding VMS data, notably to increase the transmission rate of VMS units and to note what fishing gear was deployed in fishing operations (because of the risk of confusing use of different types of gear).

NEAFC also requested that ICES assist them in developing a system for categorising fisheries using VMS and catch data. However, ICES reported that only 27% of vessels for which VMS data were available had reported catch. This severely limited the possibilities of providing the requested work. There has been no consideration of interactions of fisheries with other potential VMEs in the NEAFC Regulatory Area.

Conclusions

- VMEs are present in the deep-sea in the NEAFC regulatory area beyond areas of national jurisdiction. These include cold-water coral reefs, sponge grounds and coral gardens. There are scattered data on the presence of other potential VMEs (e.g. occurrence of high densities of xenophyophores or reefs formed by *Filograna*) in the NE Atlantic region.
- NEAFC has closed significant areas to fishing because of the presence of cold-water coral reefs.
- NEAFC has not closed all areas for which there is strong evidence of the presence of cold-water coral reefs, specifically areas outside of the current closures on the Hatton and Rockall Banks.
- NEAFC has not closed areas to fishing because of the presence of non-cold water coral reef VMEs specifically, but existing closures may confer some degree of protection to VMEs such as sponges and coral gardens.
- No impact assessments have been undertaken by NEAFC analysing the impacts of fishing on sponge or coral garden habitats even though there are data on these habitats in at least part of the NEAFC region. In some cases, these data are fishery independent and take the form of scientific surveys or deep-water photographs.
- Attempts to identify where deep-sea bottom fisheries on the high seas are interacting / impacting benthic communities that constitute VMEs are hampered by a lack of data on where fisheries are taking place, especially at fine geographic scales.
- There are some indications that bottom fishing may still occur in areas that have been closed to bottom fishing (lack of enforcement).

The NEAFC Move on Rules
The current NEAFC move on rule is triggered when a catch of >100kg of live coral (*Lophelia pertusa*, antipatharians, gorgonians, cerianthid sea anemones or sea pens) or >1000kg of live sponge (NEAFC, 2008, Paragraph 4). These trigger levels apply to a trawl tow or gillnet or long line set (Paragraph 2.2). When an encounter takes place, it is reported to the flag state and/or Secretary (of NEAFC) and the vessel moves on 2nm from where the best guess encounter position. Each year these encounter reports are reviewed by PECMAS and ICES and a decision is made on whether the accumulated
evidence from encounters indicates the presence of a VME (NEAFC 2008, Paragraph 2.2). For new fishing areas the encounter rules are the same except that the 2nm zone around the encounter position is automatically closed to fishing and then the temporary closure examined by PECMAS / ICES at the end of the year prior to making a decision about maintaining or lifting the closure (NEAFC 2008, Paragraph 3.2).

The threshold values for coral and sponge by-catch, in the NEAFC Regulatory Area, that trigger the move-on rule are not supported by any explicit assumptions of biomass-density relationships that produce some critical threshold for a VME, nor any related assumptions about catch efficiency in fishing gear. Clearly, both the area impacted, and the catch efficiency, of bottom trawls, gillnets or long lines for corals and sponges are markedly different (WGDEC, 2006). However, this is in no way reflected by the trigger levels for VME encounters in the NEAFC rules.

The next significant issue related to the NEAFC encounter rules is the actual quantity of by-catches that trigger move on. Limited studies that do address this issue indicate that by-catch may be a very poor indicator of seabed species composition and density. Freese et al. (1999) quantified catch efficiency of trawl caught invertebrates by comparing density estimates based on area swept of the trawl with density estimates from seafloor imagery at deep-water sites (206 - 274 m depth) off southeast Alaska. They found that nets retained only a fraction of the organisms on the seabed swept during tows and for some sessile organisms, such as octocorals and sponges no quantifiable estimates of retention were made presumably because of the size and fragility of species encountered. Light, flexible, and fragile specimens are either not retained by the net or once in the net are fragmented in the catch process and are extruded through the meshes.

Fisheries research surveys have been accompanied by recording of by-catch of benthic invertebrates, especially in the NAFO area off the coast of eastern Canada. Spanish surveys in NAFO Division 3LMNO, based on 30 minute tows at 3 kts, did encounter large by-catches of sponges of up to 5t per tow. Thus, the NEAFC threshold level for sponges would have triggered the VME encounter move on protocol in some instances in this region for the fishing gear deployed. However, no encounters with live coral, including both small and large octocorals, antipatharians and scleractinians would have triggered a move on from these surveys (maximum catch was 69kg; Murillo et al., 2008; see also WGEAFM, 2008b). Data from standardised research trawls from DFO surveys on the eastern coast of Canada (15 minute tows or standardised to 23,391 m²) indicate catches of up to 1,578.7kg per haul of sponges were taken (WGDEC, 2009). Only two cases of coral by-catch exceeding the threshold to trigger the move on rule have been recorded. One was in an area east of the Hudson Strait, NW Atlantic, where no previous fishing had taken place. Here by-catch of up to 500kg of large octocorals (Primnoa resedaeformis and Paragorgia arborea), were taken per tow in the Northern Shrimp Survey (Edinger et al., 2007b). The other case was in the Gulf of Alaska at 365m depth, where 1000kg of Primnoa were removed in a single trawl during an NMFS survey (Krieger, 2001). In both instances massive octocoral (gorgonian) colonies were the principal by-catch.

These data cannot be extrapolated to commercial trawls in terms of tow lengths and times (mean of 4 hours in Cardenas et al., 1997). It is not possible to simply extrapolate catches from short duration tows to longer duration commercial tows because sponge and coral habitats have an aggregated distribution meaning that the relationship between tow length, gear type and by-catch are not linear (WGDEC, 2007; WGEAFM, 2008b). However, a trigger level of 1000kg of sponge for bottom trawls is more than an order of magnitude higher than the level estimated for research trawls of duration 15-30 minutes in the North West Atlantic (WGEAFM, 2009). A 1000kg threshold would miss areas that Murillo et al (2008) considered as having high sponge by-catch. A threshold level for sponge by-catch an order of magnitude less than that currently adopted would seem more appropriate given the scientific analyses undertaken by NAFO (WGEAFM, 2009, Kenchington et al., 2009). A trigger level estimated for bottom trawling is certainly not appropriate for passive fishing gear such as gillnets or
long lines. For habitat forming corals the situation is similar. A 100kg trigger level for octocorals would miss the majority of coral garden habitats formed by large octocorals and probably 100% of coral garden habitats formed by small octocorals, antipatharians and stylasterids. For corals a trigger level of less than 10kg would seem more appropriate if they are to be treated as a single category of organisms (even this is not appropriate for small habitat forming octocorals, antipatharians and stylasterids). Such a weight would seem appropriate given coral by-catch in stock assessment surveys in areas such as the NW Atlantic (e.g. Edinger et al., 2007b). However, given the analyses undertaken by scientists for NAFO lower trigger levels would be appropriate for smaller coral species or species with poor retention in nets (WGEOFM, 2008b). It is worth noting that because of the catch efficiency of fishing gear many times the landed by-catch may be left on the seabed destroyed or damaged. Thus, repeated trawling events that do not trigger the move-on rule may rapidly destroy a VME given the very high threshold levels set by NEAFC.

For cold-water coral reefs, often the reef is formed of a relatively thin layer of live coral and the majority of the reef is formed by dead coral framework. Dead coral framework still represents cold-water coral reef and is, indeed, the main habitat for many reef-associated species (e.g. see Rogers, 1999; Freiwald et al., 2002). Not only is the 100kg trigger level unjustifiable, but the differentiation between live and dead coral is also completely unjustifiable. We would also point out that the NEAFC move on rules specify *Lophelia* and in fact should specify all Scleractinia or at a minimum, all framework-building species (*Lophelia pertusa, Solenosmilia variabilis, Madrepora oculata, Desmophyllum dianthus, Dendrophyllia cornigera*).

For trawls the 2nm move on rule for fished areas makes no sense. If mean tow time is 4 hours (Cárdenas et al., 1997) and the usual speed of trawling 3.5 knots (WGDEC, 2009) then a trawl will cover a mean linear distance of 14km (up to 20nm is reported for the NAFO regulatory area; WGEOFM, 2008b). VMEs are aggregated in their distribution and there is no way that there can be any reasonable idea of where a VME is actually encountered during normal fishing operations. Even for static gear, such as longlines, doubts have been raised about identifying where VMEs occur from the position of a longline set and the specific location of VME taxa on the longline (segment and hooks; Government of New Zealand, 2008). Only cold-water coral reefs may be detected through irregularities in bottom topography on fisheries echosounders but this would require a constant watch to be maintained during trawling operations and notes taken on the geoposition of any seabed mounds. Therefore, a vessel would have to move 2nm away from the entire trawl track for a move on rule to be effective (but see below).

NEAFC distinguish between fished and non-fished areas in the response to a VME encounter. In a previously non fished area (an exploratory fishing ground), when a VME is encountered the area around it is closed in a 2nm diameter. Only later when the closure is considered by PECMAS / ICES can a decision be made to maintain or lift such a closure. This makes sense, as if a VME is present it is protected immediately from fishing. However, in an area with a history of fishing, although the encountering vessel must move on 2nm (a nonsense with a trawler), the area remains open to fishing until PECMAS / ICES make a decision at the end of the year as to whether or not the encounter represents a VME. This makes no sense as in theory the VME encounter area may be trawled time and time again by any vessel fishing in the area until the decision to close or not to close is made. A VME encounter is identical whether or not it occurs in an area with a fishing history.

Conclusions
- The threshold levels set by NEAFC for VME encounters apply to sponges and corals only.
- The threshold levels for sponges are probably an order of magnitude too high.
- The threshold level for corals are also too high and would not result in any by-catch levels actually triggering move on in most areas of the North Atlantic with a very few exceptions.
• Using the same threshold levels for active and passive fishing gears has no logical basis.
• Using the same threshold levels for different types of corals (and other VME taxa) is also likely to underestimate the occurrence of VMEs formed by smaller octocorals, antipatharians and stylasterids.
• Distinguishing by-catch of live and dead Lophelia has no logical basis given our knowledge of the structure of cold-water coral reefs.
• Differentiating the post VME encounter protocol between areas with a fishing history and those without is scientifically unjustifiable. A VME has the same conservation value whether or not it is in an area with a history of fishing.
• The 2nm move on rule is impractical as it is impossible to identify where a VME encounter occurs along a tow for commercial bottom trawling and therefore has no conservation value.
The North West Atlantic

The northwestern Atlantic Ocean ranks tenth in importance in terms of capture fisheries, producing about 2.2 million tonnes of fish in 2006 (FAO, 2009). Fishing yields in this region have been in decline since 2000 (FAO, 2009). The regional fisheries management organisation for the area is the Northwest Atlantic Fisheries Organisation (NAFO), which replaced the International Commission for the Northwest Atlantic Fisheries (ICNAF), in 1979 (Fig. 18). The mandate of NAFO extends to all fishery resources within the Convention Area except salmon, tuna and marlins and whales (Bensch et al., 2008).

Figure 18. The NAFO Regulatory Area (NAFO)
At present regulatory measures (total allowable catches or quotas) are in place for 11 species including: cod (*Gadus morhua*), redfish (*Sebastes* sp.), American plaice (*Hippoglossoides platessoides*), yellowtail flounder (*Limanda ferruginea*), witch flounder (*Glyptocephalus cynoglossus*), white hake (*Urophycis tenuis*), capelin (*Mallotus villosus*), skates (*Rajidae*), Greenland halibut (*Reinhardtius hippoglossoides*), squid (*Illex sp.*) and shrimp (*Pandalus* sp. and *Penaeus* sp.) (NAFO CEM, 2009). Several of these species are found in deep water and are caught in the high seas portions of the NAFO Regulatory Area, including redfish, white hake, skates and Greenland halibut.

Many other species occur in the NAFO Regulatory Area and are almost certainly targeted or taken as by-catch in high-seas, deep-sea fisheries including: blue antmora (*Antimora rostrata*), rough head grenadier (*Macrurus berglax*), roundnose grenadier (*Coryphaenoides rupestris*), marlin spike grenadier (*Nezumia bairdii*), three-bearded rockling (*Gaidropsarus ensis*), silver rockling (*Gaidropsarus argentatus*) long fin hake (*Urophycis chesteri*), stripped wolfish (*Anarhicas lupus*), spotted wolfish (*Anarhicas minor*), northern wolfish (*Anarhicas denticulatus*), Arctic eelpout (*Lycodes reticulatus*), Esmark’s eelpout (*Lycodes esmarki*), spiny eel (*Notacanthus cheniitii*), alfonsino (*Beryx splendens* and *Beryx decadactylus*), slickheads (*Alopecephalus* spp.), black scabbardfish (*Aphanopus carbo*), wreckfish (*Polyprion americanus*), black cardinal fish (*Epigonus telescopus*), barreelfish (*Hyperoglyphe perciformis*), Mediterranean roughy (*Hoplostethus mediterraneus*), orange roughy (*Hoplostethus atlanticus*), Cornish blackfish (*Schedophilus medusophagus*), hagfish (*Myxine glutinosa*), large-eyed rabbitfish (*Hydrolagus mirabilis*), narrownose chimaira (*Harriotta raleighana*), spiny dogfish (*Squalus acanthias*), black dogfish (*Centroscyllium fabricii*), deep-sea catshark (*Apristurus profundorum*), great lantern shark (*Etmopterus princeps*), bluntnose sixgill shark (*Hexanchus griseus*), Portuguese dogfish (*Centroscyllium coelolepis*) (Kulka et al., 2003; Muñoz et al., 2005; Murua et al., 2005; Murua & Cárdenas, 2005; González-Troncoso et al., 2006; Grant, 2006; Kulka, 2006; González et al., 2007; Kulka et al., 2007a; Thompson & Campanis, 2007). This list is by no means inclusive of all targeted or by-catch species and for a more extensive list of potentially vulnerable deep-water species see WGEAFM (2008a).

**Management of fisheries for deep-sea species of low productivity**

**Redfish**

*Sebastes* sp. (deep-sea red fish, *Sebastes mentella*; golden redfish, *Sebastes marinus*; Acadian redfish, *Sebastes fasciatus*; beaked redfish, *Sebastes mentella* and *Sebastes fasciatus*)

Redfish are long-lived and slow growing species and are generally viviparous with larval eclosion occurring immediately before or after birth. For these reasons the species are regarded as low productivity or vulnerable species (WGEAFM, 2008a; see above). Management of redfish stocks in the NAFO area is complicated by large fluctuations in catches from year to year (NAFO SC, 2008). Redfish have been targeted in high seas areas of the NAFO Regulatory Area, particularly in 3M, around the Flemish Cap. Initial catches in this region rose from around 20,000t in 1985 to 81,000t in 1990 followed by a steep decline in catches to around 1000t in 1998/1999. As well as being subject to a directed fishery, redfish were also being caught at this time as a by-catch from the shrimp fisheries in the region. As stocks declined fishing effort directed towards these species also decreased but there was an increase in catches after 2000 when Russian and Portuguese fleets increased efforts to catch redfish in the region. Catches have since risen to 6,500 – 8,500t in the last few years and it has been suggested this is a result of some recovery in biomass of the targeted fish stocks. It is notable that these catches have been consistently above recommendations by the Scientific Committee for the recovery of the stock (e.g. NAFO Fisheries Commission, 2005; NAFO SC, 2008). In 2009 NAFO increased the quota for redfish in Area 3M to 8,500t (NAFO TACS, 2009) despite a recommendation by the Scientific Committee to maintain catches at 5000t per annum (NAFO FC,
In the last few years the Russian fleet has began to target pelagic redfish on the Flemish Cap. As yet no data are available on this fishery and its impacts on the redfish stock within the area as a whole is unclear (NAFO SC, 2008). Note that ICES provide advice on pelagic redfish for the whole North Atlantic area and that NEAFc have consistently set TACs for this species several times bigger than scientific recommendations (NAFO SC, 2008).

In areas 3LN, which also include high seas areas such as the Flemish Pass and the southern tip of the Grand Banks the story has been similar. Here, catches increased sharply from 1985, rising from 21,000t to 79,000 in 1987 followed by a steep decline to about 450t in 1996. During this period catches were consistently above TAC levels. In 1998 a moratorium was established preventing directed fishing of Sebastes spp. in this region. Despite this, by-catch of redfish meant catches actually increased over 1998 to 2000 (NAFO Scientific Council, 2005). The moratorium in area 3LN has been lifted this year and a precautionary TAC of 3,500t set (NAFO SC, 2008), although this is allocated as a 10% limit on by-catch of other fisheries in the Area. The stock remains at a very low level compared to its size prior to 1985.

Redfish are also fished in Area 3Q but there was little specific information on the current status of this stock and indeed the Scientific Committee were unable to provide management advice for this area because of lack of data (NAFO FC, 2008). Despite this a TAC of 20,000t was set by the Fisheries Commission in 2008 (NAFO FC, 2008). Catches in recent years have averaged 13,000t.

Roundnose grenadier (Coryphaenoides rupestris)

Roundnose grenadier is a long-lived, late maturing and slow growing species and therefore fits the FAO criteria for a low-productivity species. Roundnose grenadier, were first exploited by Russian fleets in the late 1960s, catches peaking in the early 1970s at around 80,000t and then declining rapidly. The fishery developed largely in the absence of any knowledge of the biology of the species and by the 1990s it had declined markedly in the NW Atlantic. Effort then switched to roughhead grenadier (Macrurus berglax). Analyses of catches of roundnose grenadier in research trawls concluded that catches had declined by 99.6% from 1978-2003 (Devine et al., 2006; Supplementary Information) meaning that the stock fitted the IUCN definition for Critically Endangered (Devine et al., 2006). Subsequent study indicates that the decline in roundnose grenadier populations was a result of overfishing (Devine & Haedrich, 2008). Catch history in recent years is confused by systematic misreporting of catches of roughhead grenadier as roundnose grenadier (Murua et al.,
between population Atlantic, the catastrophically warrants Wolffish concerns. Stocks roundnose production already this Wolffish datasets and wolfish recent years. Blue in halibut fisheries – 2008). Catches of M. berglax peaked at 9,000t in 2000 but have declined since with catches at 3,000 and 1,500t in 2004 and 2007 respectively (Costas and Murua, 2008). It has been suggested that decreased catches may have occurred because of efforts to regulate the fishery for Greenland halibut in this area (Costas and Murua, 2008). Note that several papers have identified significant levels of systematic misreporting of catches of roughhead grenadier as roundnose grenadier. Why this is occurring is unclear. As yet there is no management regime in place for roughhead grenadier in the NAFO Regulatory Area.

Blue antimora, blue hake or flat-nosed codling (Antimora rostrata)

This is a widely distributed fish, occurring at depths between 400m – 4000m, in the NE and NW Atlantic, northern Mid-Atlantic Ridge and elsewhere. In the NAFO Regulatory Area blue hake are caught within the Canadian EEZ, but also on the eastern margins of the Grand Banks, the Flemish Pass and Flemish Cap (Kulka et al., 2003). Blue hake do not concentrate at sufficient densities to warrant directed fisheries to date but are taken as by-catch in commercial trawl and long line fisheries in the NAFO Regulatory area (Kulka et al., 2003). Devine et al. (2006; supplementary material) report a decline in catches of blue hake of 92.7% in research trawls from 1978 – 1994. There is little else in terms of specific information on blue hake in the region. The resilience of the species is not understood at the present time and it is not possible to evaluate the current status of stocks in the NW Atlantic although the results of Devine et al. (2006) present cause for serious concern.

Wolffish or Catfish: striped wolfish (Anarhicas lupus), spotted wolfish (Anarhicas minor), northern wolffish (Anarhicas denticulatus),

Wolffish are a group of very large blennies, notable for their ferocious appearance and disposition. They have very unusual and conservative life histories that include internal fertilisation, the production of large eggs and larvae (2cm long in A. lupus) which are brooded under rocks by the males for 4 – 9 months. The level of parental care is extraordinary in striped wolfish, the male
actively aerates and turns the eggs and covers them in skin mucus to prevent infection (Kulka et al., 2007b). They are long lived (> 20 years) and tagging studies have indicated that they are sedentary. Juvenile wolffish may settle close to their nest sites (natal behaviour; Fuller & Watling, 2008). Wolffish are apex predators and may exert considerable effects on ecosystem structure and the composition of benthic communities (Fuller & Watling, 2008). In all respects, wolffish fit the FAO description of a low productivity species, mainly because of the life history of the species (Kulka et al., 2007b).

The three species reviewed here are distributed in the North Atlantic only and are found within national waters and in the high seas areas of both the NAFO and NEAFC Regulatory Areas. The outer edges of the Grand Banks and the Flemish Cap comprise significant areas of habitat for these wolffish species (Kulka et al., 2007b). The depth range of these species is considerable as they are found from 20m – 1,500m depth with northern wolffish having the narrowest range (Kulka et al., 2007b). These species are found in a narrow range of environmental temperatures (1.5 – 5°C; Kulka et al., 2007b). Wolffish have been subject to directed fisheries off Greenland but off Canada they are caught as by-catch with about 1000t per year taken in the 1980s. The species have never been taken in directed fisheries in this area because they do not reach sufficient densities to maintain a commercial fishery. The decline in wolffish populations in the NW Atlantic is catastrophic with northern wolffish declining by 95% in three generations, and spotted wolffish declining by >90% in Canadian waters (Kulka et al., 2007b). Striped wolffish has declined significantly in Canadian waters and in US waters further south catches have declined 94.9% between 1983 and 2004 (Fuller & Watling, 2008). Major contractions in the distribution of these species have also been identified with a shift in distribution to deeper waters (Kulka et al., 2007b). At present it would appear that all three of these species of wolffish are heading for local extinction in the NW Atlantic, an area of global significance for these species, especially spotted and northern wolffish.

Canadian assessments of the threat status of these three wolffish species state that a definitive cause of their decline is not apparent. It is likely that it has resulted from a combination of environmental factors and fishing pressure. A significant part of the catch of wolffish in the NAFO Regulatory Area comes from outside of the Canadian EEZ and it is suspected that catches are being under-reported (Kulka et al., 2007b). Catch statistics for the period 1995 – 2002 indicate that significant quantities of wolffish were taken in NAFO Subareas 3LNO (18.7%) which include high seas areas on the southern part of the Grand Banks, and the Flemish Pass (Kulka et al., 2007b). These catches are retained for commercial purposes and it is likely that the fish stocks are continuous across national and high seas waters (Kulka et al., 2007b). It should be noted that there is often confusion in the identification of the three wolffish species and they are therefore simply reported as wolffish or catfish for commercial purposes (Kulka et al., 2007a). The need for management of by-catch of these species is clear yet at present there is no specific management regime for Wolffish in the NAFO Regulatory Area. In Canadian waters northern and spotted wolffish must now be released alive if caught as by-catch. In addition to direct mortality it is likely that trawling damages shelter and nesting sites for wolffish and the incremental destruction of essential habitat for this species may also be a contributory factor in its decline (Kulka et al., 2007b; Fuller & Watling, 2008).

Skates

Skates are low productivity species characterised by low rates of growth, high ages at maturity, lowfecundities and high longevity (Mchrie & Campana, 2009). In the NW Atlantic attention was drawn to the impacts of fishing on skates following the suggestion that the largest species in the area, barndoor skate (Dipturus laevis) was close to extinction (Casey & Myers, 1998). However, subsequent work has suggested that this species has increased over recent years on the Grand Banks (Gedamke et al., 2005) and has not gone extinct although numbers were reduced greatly in areas for which records are available in areas of Newfoundland (>99.9% decrease in 20-30 years; Casey & Myers,
The most commonly landed commercial species of skate in the NW Atlantic area include winter skate (Leucoraja ocellata), little skate (Leucoraja erinacea), thorny skate (Amblyraja radiata) and the smooth skate (Malacoraja senta). Analyses of data on these species from Canadian waters (Scotia Shelf) indicates that from 1970 to 2006 the abundance of mature winter, thorny and smooth skate declined by >90% whereas that for little skate increased (Mcphie & Campana, 2009). This pattern of declines in larger species and increases in smaller has been observed elsewhere in the world with other skate species (e.g. Dulvy et al., 2000). About 95% of the catches in the NAFO Regulatory Area are of thorny skate and mainly come from the Areas 3 LNOP which include the high seas. There are major uncertainties in the catches of these species prior to 1996 (NAFO SC, 2008). Catches are thought to have peaked at around 31,500t in 1991 and for areas 3 LNO averaged at about 9,050t from 2000 – 2007. Currently the biomass of the stocks, estimated from scientific surveys, are low compared to the 1980s but have remained stable in recent years and have even increased slightly from 2005 – 2007. Skates came into regulation by NAFO in 2004. NAFO SC (2008) recommended that catches of skates be maintained at around 6,000t to allow continued recovery of the stock but the NAFO Fisheries Commission set a TAC this year of 13,500t on the basis of evidence of increased stock size.

Sharks

Within the region, Porbeagle shark is subject to a directed fishery and as a result of significant declines in populations have been subject to low TAC within Canadian waters in recent years. The species is taken as by-catch in pelagic fisheries for tuna and billfish (NAFO SC, 2008). In recent years catches from pelagic longlines have increased and may reach a level where, combined with catches within Canadian waters, they are a threat to the species within the NW Atlantic region. However, these catches are generally <200m in depth (Campana & Joyce, 2004) and so this species does not qualify as a deep-water shark.

There are few data for other sharks in the region. It has been reported that the only sharks with commercial value in the area are the spiny dogfish (Squalus acantbias), a shallow-water species mainly taken on the Canadian Shelf (Kukla, 2006). Other sharks, notably the black dogfish (Centroscyllium fabricii) have little commercial value and are only taken as by-catch in the NAFO Regulatory Area. Several other species are also taken outside of the Canadian EEZ in the high seas areas of the NAFO Regulatory Area (Murua & Cárdenas, 2005; Kukla, 2006), including the Portuguese shark (Centroscymnus coelolepis), the deep-sea cat shark (Apristurus profundurum) and the great lantern shark (Etmopterus princeps). However, fisheries data for these is either non-existent or the species are aggregated as deep-sea sharks / dogfish. Status of these species within the region is unknown.

It should also be noted that rabbitfish (Family Chimaeridae) are also caught in NAFO Regulatory Areas 3LMNO. Two species, the large-eyed rabbitfish (Hydrologus mirabilis) and the bentnose rabbitfish (Hariotta raleighana) are taken in mixed species bottom trawl fisheries in the areas of the Grand Banks and Flemish Cap (González et al., 2007). As with other Chondrichthyes these species have a conservative life history and are low productivity species. There is no information on the state of populations of these species in the North West Atlantic region.

Conclusions
• The deep-water fisheries of the NAFO Regulatory Area have a record of severe overfishing and many stocks are at a fraction of historic abundance and biomass and are in recovery from, or remain in, a depleted state.
• The only deep-water low productivity species that are managed by NAFO are for skates and redfish.
• Other low productivity species are taken as by-catch in deep-water fisheries for Greenland halibut, redfish and skate. Some of these species are threatened with extinction in the NAFO Regulatory Area as a result of a combination of environmental change and overfishing. NAFO have made no attempt to regulate catch of these species and so these mixed-species fisheries are unregulated (IUU fisheries).
• New fisheries, such as the pelagic redfish fishery on the Flemish Cap are also not regulated in a manner that would be consistent with the FAO Guidelines with respect to exploratory fisheries.
• Systematic misreporting occurs in the deep-sea high seas fisheries in the NAFO Regulatory Area. Under-reporting of catches of some species or groups of species is suspected in the high seas deep-water fisheries.
• NAFO also do not identify fish catches to species level for several groups of regulated and unregulated fish including redfish, skate and sharks.
• The NAFO Fisheries Commission has consistently set catches above the levels proposed by the NAFO Scientific Committee for low-productivity deep-water species, in some cases to levels more than double the recommended TACs.

Protection of benthic marine ecosystems

The NAFO Regulatory Area is dominated oceanographically by cold, low salinity water flowing from the north in the Labrador Current. To the south the region is bound by the Gulf Stream which means that the region is characterised by very strong latitudinal gradients in temperature. Within the region there are areas of high primary production generated by input of nutrients from strong tidal mixing and, in areas, localised upwelling. The benthic ecosystems of the region are well studied in the south, especially on the northeastern shelf of the USA and the southeastern shelf of Canada, but less well studied in northern areas. However, the occurrence of cold-water coral habitats and deep-sea sponge grounds have been known in the region for nearly 90 years (e.g. Verrill, 1922; Deichmann, 1936; Breeze et al., 1997; Breeze & Davis, 1998; MacIsaac et al., 2001; Mortensen & Buhl-Mortensen, 2004; Gass & Willason, 2005; Mortensen & Buhl-Mortensen, 2005 Mortensen et al., 2005; WGDEC, 2009). The region has extensive offshore banks (topographic elevations associated with or on the continental shelf) but a relatively limited number of seamounts (isolated topographic elevations), estimated at 43 for the NAFO Regulatory Area of which a fraction have summit depths in the range of fishing as it is practiced at the present time (Kulka et al., 2007c).

In January 2007, six areas of seamounts were closed to fishing as a measure to protect benthic biodiversity (see Table 2 and Fig. 20). Although biological information on these seamounts was extremely scant there was some evidence of coral by-catch in trawls from some of the New England and Corner Rise Seamounts and it was suggested that deep-sea coral frameworks may exist in the Orphan Knolls region (Kulka et al., 2007c).
Table 2. NAFO Seamount areas protected in January 2007 from bottom fishing (NAFO CEM, 2009).

<table>
<thead>
<tr>
<th>Area</th>
<th>Coordinates 1</th>
<th>Coordinates 2</th>
<th>Coordinates 3</th>
<th>Coordinates 4</th>
</tr>
</thead>
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<tr>
<td>Fogo Seamounts 1</td>
<td>43°31.33' N</td>
<td>42°51.23' N</td>
<td>41°45.38' N</td>
<td>41°17.34' N</td>
</tr>
<tr>
<td></td>
<td>53°23.17' W</td>
<td>52°35.37' W</td>
<td>51°57.17' W</td>
<td>50°39.17' W</td>
</tr>
<tr>
<td>Fogo Seamounts 2</td>
<td>43°07.22' N</td>
<td>42°07.22' N</td>
<td>41°11.37' N</td>
<td>40°23.37' N</td>
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<tr>
<td></td>
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<td>52°35.37' W</td>
<td>51°57.17' W</td>
<td>50°39.17' W</td>
</tr>
<tr>
<td>Orphan Seamount</td>
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<td>49°00.30' N</td>
<td>48°00.30' N</td>
<td>47°00.30' N</td>
</tr>
<tr>
<td></td>
<td>46°00.00' W</td>
<td>45°00.00' W</td>
<td>44°00.00' W</td>
<td>43°00.00' W</td>
</tr>
<tr>
<td>Corner Seamounts</td>
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<td>34°00.00' N</td>
<td>33°00.00' N</td>
<td>32°00.00' N</td>
</tr>
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<td>25°00.00' W</td>
<td>24°00.00' W</td>
<td>23°00.00' W</td>
</tr>
<tr>
<td>Newfoundland</td>
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<td>42°20.00' N</td>
<td>41°20.00' N</td>
<td>40°20.00' N</td>
</tr>
<tr>
<td>Seamounts</td>
<td>44°00.00' W</td>
<td>43°00.00' W</td>
<td>42°00.00' W</td>
<td>41°00.00' W</td>
</tr>
<tr>
<td>New England</td>
<td>35°00.00' N</td>
<td>34°00.00' N</td>
<td>33°00.00' N</td>
<td>32°00.00' N</td>
</tr>
<tr>
<td>Seamounts</td>
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<td>35°00.00' W</td>
<td>34°00.00' W</td>
<td>33°00.00' W</td>
</tr>
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<td></td>
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<td>56°00.00' W</td>
<td>55°00.00' W</td>
<td>54°00.00' W</td>
</tr>
</tbody>
</table>

Figure 20 Map of seamount areas protected within NAFO Regulatory Area (Thompson & Campanis, 2007).

Some of these areas have been subject to significant fisheries for deep-sea species, particularly alfonsino (*Beryx* spp.), most notably a Russian Fishery in the 1978 – 1996, on the Corner Rise Seamounts and some exploratory fishing by other states (Kulka et al., 2007c; Thompson & Campanis, 2007). Subsequent to the cessation of the Russian alfonsino fishery some fishing, including exploratory fishing trips, still occurred on the Corner Rise seamounts mainly for alfonsino, wreckfish and black scabbard fish mainly by Spanish but also Canadian vessels (Kulka et al., 2007; Thompson & Campanis, 2007). Recent ROV surveys on the Corner Rise Seamounts identified the existence of some remaining coral habitat but large areas of the summits and upper flanks of two seamounts, Kükenthal and Yakutat, were denuded of large sessile animals and showed evidence of trawl damage in the form of seabed scars, other damage to the seabed and coral fragments (Waller et al., 2007).
In response to UNGA Resolution 61/105, the 2007 Annual Meeting of NAFO agreed to close an area along the southern slope of the Grand Banks to protect corals from bottom fishing. The upper boundary of the closed area was between 800 and 1000 metres depth. Presumably this closure was based on data on by-catch of corals from fisheries research trawl data. Subsequent analyses of the closed area showed that many records of octocorals and other corals actually occurred in waters shallower than the shallowest boundary of the closed area, just outside of the closed zone (WGDEC, 2008; see Fig. 22). It was suggested that perhaps the protected area should be extended to the 200m depth contour to protect all the deep-sea corals in this immediate area (WGDEC, 2008).
Figure 22. NAFO Coral protection area initiated January, 2008 showing records of seapens (Pennatulacea) in pink, gorgonians in yellow, soft corals in red, and black corals in black (WGDEC, 2008).

Post January 2008: A more systematic approach to identification of VMEs
In 2008, the NAFO Scientific Committee and the Working Group on Ecosystem Approach to Fisheries Management (WGEAFM) initiated a new approach to assessing coral and sponge by-catch data from fisheries research survey data obtained by Canada and Spain. These research trawls covered a substantial portion of the NAFO Regulatory Area, including the high-seas regions subject to bottom trawling (WGEAFM, 2009). Two approaches have been used to identify VMEs formed by corals and
sponges. The first involved the examination of cumulative catch data for VME species. This involved ranking the biomass of VME taxa in each trawl from lowest to highest and then plotting the increase in accumulative biomass with each additional trawl. If VME taxa show an aggregated distribution, as expected if they form patches of high density of individuals forming habitat, then at some stage the accumulation curve will show a marked sudden increase in biomass. This is because, for the majority of the seabed, the density of individuals of VME taxa is low, so that biomass accumulates very slowly. For tows that encounter a VME there is a large step in biomass of VME species in the trawl identified by the area of maximum curvature of the accumulation curve. This method was applied first to corals and then to sponges for the NAFO Regulatory Area.

The second method uses Geographical Information System (GIS) software to analyse the distribution of density of sponge by-catch in the NAFO Regulatory Area (WGEAFM, 2009). Effectively this identified a circular search radius around each point (cell) on a map and then estimates the number of VME features within that radius, dividing the number by the area around the cell. For sponge studies a 25km search radius was chosen as it recognises distinct geological features. Smaller radii (e.g. 10km) resulted in a highly fragmented picture of sponge density. The software used them produced contour maps of sponge density.

Using the accumulation curve method the presence of coral VMEs was assessed by NAFO WGEAFM (2008b). The report immediately identified that it was likely that different significance should be attached to the levels of by-catch of different types of corals as colonies have different weights and different morphology (shape and structure), making them more or less likely to be caught and retained in trawls (WGEAFM, 2008b). Subsequent analyses revealed that large catches of corals and sea pens indicating the presence of a potential VME were actually quite rare events in research trawls. Identifying where on the accumulative curve of biomass of coral catches was difficult but a highly conservative point was chosen representing the 97.5% quantile (upper bound of the 95% quantile). This represented a catch of 1.6kg for sea pens (Fig. 23), 0.2kg for small gorgonian octocorals (Acanella arbuscula; Fig. 24). For larger gorgonians, because they are more prone to breakage and fragmentation in a trawl, a more precautionary quantile of 90% was set representing a catch level per trawl of 2kg (WGEAFM, 2008b; Fig. 25), although it should be noted that in very exceptional circumstances, where the seabed has not been previously trawled, by-catch of such species has been high (Krieger, 2001; Edinger et al., 2007b).

For sponges, the area occupied by weight of sponges in trawls was broken into 25 kg bins and then plotted using GIS (Fig. 26; WGEAFM, 2009). The weight categories at which a marked increase in area occupied was found to lie between 100 and 75kg. Further analyses indicated that the 75kg weight threshold for a trawl catch was the level that indicated potential encounter with a VME. This was not compatible with the 97.5% quantile (close to 1000kg; Fig. 27) but was compatible with the maximum curvature of a plot of the cumulative weights of sponge by-catch in trawls (Fig. 28; WGEAFM, 2009). This threshold weight appeared to be consistent between approaches in identifying what weight of sponge by-catch in a trawl represented a likely encounter with a VME.
Figure 23. Cumulative distribution of catch (kg) of sea pens from research trawl surveys (WGEAFM, 2008b).

Figure 24. Cumulative distribution of catch (kg) of Acanella arbuscula from research trawl surveys (WGEAFM, 2008b).

Figure 25. Cumulative distribution of catch (kg) of large gorgonians (Paragorgia spp., Primnoa resedaeformis, Keratoisis ornata, Acanthogorgia armata, Paramuricea spp.) from research trawl surveys (WGEAFM, 2008b).
Figure 26. Area occupied by trawls with decreasing catch weight of sponges from (a) 3980 – 1kg and (b) from 250 – 25kg, using GIS density rasters (WGEAFM, 2009).

Figure 27. Cumulative distribution of weight of sponge catches from Spanish (30 minute tows) and Canadian (15 minute tows) research trawls. Box shows weights corresponding to the maximum curvature of catch cumulation curve (WGEAFM, 2009).

Figure 28. Figure 27 (above) zoomed in to show the curve between 10 and 300kg. Black arrow indicates the first long step in the cumulation curve, corresponding to 75kg of sponge catch, Red arrows indicate the 100 and 125kg points (WGEAFM, 2009).

On the basis of both the weight accumulation curve data and the GIS density mapping approaches areas where it is likely that coral and sponge VMEs exist were identified and proposed as closed areas to bottom fishing (Figures 29, 30 and 31).
Figure 29. Areas where catches of octocorals exceed the threshold values identified by WGEAFM (WGEAFM, 2008b).

Figure 30. Areas where the weight of catches of sponges exceeded the threshold identified by WGEAFM. Numbers represent NAFO numbering system for potential VME locations.
Figure 31. Weight density rasters at different search radii of 10, 25, 37.5 and 50km. 25km was viewed as the most useful search radius. Warm colours are indicative of high densities of sponges (Kenchington, 2009).

These areas corresponded to the northern, eastern and southern flanks of the Flemish Cap, southern parts of the Flemish Pass and the eastern and southern flanks of the Grand Banks. These areas were used to guide the closure of 11 further areas of the high seas to bottom fishing in September, 2009 to protect VMFs formed by sponges and corals (see Fig. 32). In addition to the previous NAFO Regulatory Area 3O, this adds to a total of 12 benthic areas in the high seas as well as a further 5 seamount areas closed to bottom fishing.
Conclusions

- NAFO have identified areas of high concentrations of corals and sponges using information on by-catch from research trawls.
- This information has been used to designate areas for protection from bottom fishing.
- In some cases, the exact outline of the protected areas does not reflect data on the positions of occurrence of VME taxa. The reasons for this are unclear.
- Aspects of the scientific advice on the potential occurrence of VMEs and establishment of thresholds of coral or sponge catch that indicate the presence of VMEs have been exemplary. Unfortunately the knowledge gained has not been reflected in the move-on rule (see below).

The move on rule

NAFO move-on rules were identical to the NEAFC move on rules until 2009. The only difference that now exists between NEAFC and NAFO move on rules is that in 2009 the threshold by-catch of corals and sponges triggering the move on rule was decreased from 100kg to 60kg for corals and 1000kg to 800kg for sponges. The problems associated with these thresholds are identified for NEAFC. For example, it was identified that within the NAFO area the by-catch of corals in research trawls would never have triggered a move on incident with a threshold value of 100kg of coral. In spite of the much longer duration of commercial trawl tows, a linear increase in commercial catch is not expected as coral or sponge VME occur in discrete patches (rarely more than 500m across) and encounters with such VMEs are relatively rare with trawls, although the chance of encountering more than one patch increases with increased trawl time (WGEAFM, 2008b). In September 2009 NAFO decreased the threshold for triggering the move-on rule for coral to 60kg. This is still more than an order of magnitude higher than that estimated using accumulation curves for large octocorals and more than two orders of magnitude larger than that for small corals. It should be emphasised here that the scientists advising NAFO undertook estimation of a by-catch which signified an encounter with a VME using extensive datasets from research trawls and based on a consistent and rigorous methodological approach (WGEAFM, 2008b, 2009). For sponges the situation is equally unsupportable and unjustified with a current trigger level of 800kg compared to a threshold weight of 75kg for research trawls estimated as indicative of the presence of a VME.
NAFO has begun the process of developing identification guides for VME taxa in the NAFO Regulatory Area (Kenchington et al., 2009b).

Conclusions

- The threshold levels set by NAFO for VME encounters apply to sponges and corals only.
- The threshold levels for corals is much too high exceeding estimation of threshold levels that indicate coral VMEs by more than one or two orders of magnitude depending on the category of coral (sea pens, small corals, large corals).
- The threshold levels for sponges is also set more than an order of magnitude above levels estimated by examination of by-catch data from research trawls.
- Using the same threshold levels for active and passive fishing gears has no logical basis.
- Scientific advice to NAFO identified that using the same threshold levels for different types of corals was inappropriate (smaller octocorals, antipatharians and stylasterids).
- Differentiating the post VME encounter protocol between areas with a fishing history and those without is nonsense. A VME has the same conservation value whether or not it is in an area with a history of fishing.
- The 2nm move on rule is impractical as it is impossible to identify where a VME encounter occurs along a tow for commercial bottom trawling and therefore has no conservation value. In the case of NAFO, commercial trawls are up to 20nm long.
References


EU (2006) Statement by the European Union to the United Nations General Assembly debate on


ICES (2007) 9.3.2.7.b NEAFC request to compile data on documented historical or present spawning/aggregation areas of blue ling in the NEAFC Convention area –additional information supplied by the EC POORFISH project. ICES Advice Book 9, Agenda Item 7F, Document AM2007/27, 16pp.

ICES (2007b) Widely Distributed and Migratory Stocks. 9.3.2.4. NEAFC request to continue to provide all available new information on distribution of vulnerable habitats in the NEAFC Convention Area and fisheries activities in the vicinity of such habitats. ICES Advice 2007, Book 9. 9pp.

ICES (2008) 9.3.2.3. NEAFC request on identification of vulnerable marine ecosystems, including definitions and assessment of fishing activities that may cause significant adverse impacts on such ecosystems. ICES Advice 2008, Book 9. 5pp.


ANNEX 1: UN GA RESOLUTION 61/105 PARAS 83-87

The General Assembly

83. Calls upon regional fisheries management organizations or arrangements with the competence to regulate bottom fisheries to adopt and implement measures, in accordance with the precautionary approach, ecosystem approaches and international law, for their respective regulatory areas as a matter of priority, but not later than 31 December 2008:

(a) To assess, on the basis of the best available scientific information, whether individual bottom fishing activities would have significant adverse impacts on vulnerable marine ecosystems, and to ensure that if it is assessed that these activities would have significant adverse impacts, they are managed to prevent such impacts, or not authorized to proceed;

(b) To identify vulnerable marine ecosystems and determine whether bottom fishing activities would cause significant adverse impacts to such ecosystems and the long-term sustainability of deepsea fish stocks, inter alia, by improving scientific research and data collection and sharing, and through new and exploratory fisheries;

(c) In respect of areas where vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water corals, are known to occur or are likely to occur based on the best available scientific information, to close such areas to bottom fishing and ensure that such activities do not proceed unless conservation and management measures have been established to prevent significant adverse impacts on vulnerable marine ecosystems;

(d) To require members of the regional fisheries management organizations or arrangements to require vessels flying their flag to cease bottom fishing activities in areas where, in the course of fishing operations, vulnerable marine ecosystems are encountered, and to report the encounter so that appropriate measures can be adopted in respect of the relevant site;

84. Also calls upon regional fisheries management organizations or arrangements with the competence to regulate bottom fisheries to make the measures adopted pursuant to paragraph 83 of the present resolution publicly available;

85. Calls upon those States participating in negotiations to establish a regional fisheries management organization or arrangement competent to regulate bottom fisheries to expedite such negotiations and, by no later than 31 December 2007, to adopt and implement interim measures consistent with paragraph 83 of the present resolution and make these measures publicly available;

86. Calls upon flag States to either adopt and implement measures in accordance with paragraph 83 of the present resolution, mutatis mutandis, or cease to authorize fishing vessels flying their flag to conduct bottom fisheries in areas beyond national jurisdiction where there is no regional fisheries management organization or arrangement with the competence to regulate such fisheries or interim measures in accordance with paragraph 85 of the present resolution, until measures are taken in accordance with paragraph 83 or 85 of the present resolution;

87. Further calls upon States to make publicly available through the Food and Agriculture Organization of the United Nations a list of those vessels flying their flag authorized to conduct bottom fisheries in areas beyond national jurisdiction, and the measures they have adopted pursuant to paragraph 86 of the present resolution;
ANNEX II: UN FAO Guidelines for the Management of Deep-sea Fisheries in the High Seas

Paragraph 47: Conducting Impact Assessments of Deep-Sea Fisheries

47. Flag States and RFMO/As should conduct assessments to establish if deep-sea fishing activities are likely to produce significant adverse impacts in a given area. Such an impact assessment should address, *inter alia*:

i. type(s) of fishing conducted or contemplated, including vessels and gear-types, fishing areas, target and potential bycatch species, fishing effort levels and duration of fishing (harvesting plan);
ii. best available scientific and technical information on the current state of fishery resources and baseline information on the ecosystems, habitats and communities in the fishing area, against which future changes are to be compared;
iii. identification, description and mapping of VMEs known or likely to occur in the fishing area;
iv. data and methods used to identify, describe and assess the impacts of the activity, the identification of gaps in knowledge, and an evaluation of uncertainties in the information presented in the assessment;
v. identification, description and evaluation of the occurrence, scale and duration of likely impacts, including cumulative impacts of activities covered by the assessment on VMEs and low-productivity fishery resources in the fishing area;
vi. risk assessment of likely impacts by the fishing operations to determine which impacts are likely to be significant adverse impacts, particularly impacts on VMEs and low productivity fishery resources; and
vii. the proposed mitigation and management measures to be used to prevent significant adverse impacts on VMEs and ensure long-term conservation and sustainable utilization of low-productivity fishery resources, and the measures to be used to monitor effects of the fishing operations.

Paragraph 42: Identifying Vulnerable Marine Ecosystems (VMEs)

42. A marine ecosystem should be classified as vulnerable based on the characteristics that it possesses. The following list of characteristics should be used as criteria in the identification of VMEs.

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

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

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

iv. Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics:
   • slow growth rates;
   • late age of maturity;
   • low or unpredictable recruitment; or
   • long-lived.
v. Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

Examples of potentially vulnerable species groups, communities, and habitats, as well as features that potentially support them are contained in Annex 1.

**Paragraphs 17-20: Determining Significant Adverse Impacts**

17. Significant adverse impacts are those that compromise ecosystem integrity (i.e. ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves; (ii) degrades the long-term natural productivity of habitats; or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types. Impacts should be evaluated individually, in combination and cumulatively.

18. When determining the scale and significance of an impact, the following six factors should be considered:

   i. the intensity or severity of the impact at the specific site being affected;
   ii. the spatial extent of the impact relative to the availability of the habitat type affected;
   iii. the sensitivity/vulnerability of the ecosystem to the impact;
   iv. the ability of an ecosystem to recover from harm, and the rate of such recovery;
   v. the extent to which ecosystem functions may be altered by the impact; and
   vi. the timing and duration of the impact relative to the period in which a species needs the habitat during one or more life-history stages.

19. Temporary impacts are those that are limited in duration and that allow the particular ecosystem to recover over an acceptable time frame. Such time frames should be decided on a case-by-case basis and should be in the order of 5-20 years, taking into account the specific features of the populations and ecosystems.

20. In determining whether an impact is temporary, both the duration and the frequency at which an impact is repeated should be considered. If the interval between the expected disturbance of a habitat is shorter than the recovery time, the impact should be considered more than temporary. In circumstances of limited information, States and RFMO/As should apply the precautionary approach in their determinations regarding the nature and duration of impacts.

**ANNEX III: European Union policy with respect to high seas bottom fisheries and the implementation of UN GA resolution 61/105**

The European Commission released a statement outlining the position of the European Community in advance of the 2006 UN General Assembly Sustainable Fisheries Resolution negotiations. The EC position included support for the reverse burden of proof with respect to assessing the impacts of bottom fisheries on the high seas and the requirement that an environmental impact assessment be a condition for authorization to engage in deep-sea bottom fishing on the high seas (e.g. prior authorization):

“The European Union will again be calling for an effective package of measures to tackle the impact of destructive fishing practices on the high seas at the UN General Assembly debate on sustainable
The Member States of the EU have given their unanimous support to the position that will be advanced by the European Commission on their behalf. Based on the conviction that Regional Fisheries Management Organisations (RFMOs) are key to the effective governance of high seas fisheries, the Commission will propose a radical overhaul to the regulatory approach by both RFMOs and States. Today, any activity that is not regulated is implicitly permitted. In the future, fishing with bottom gears that may have adverse impacts on vulnerable ecosystems would need to be assessed before it is authorised. This far-reaching change in the way in which fishing activities with potential destructive effects are regulated represents a decisive step forward in ensuring both better fisheries governance and effective environmental protection. The position which the Commission will advance this week in New York was unanimously approved during a coordination meeting held with Member States in Brussels on 9 November.”

“The EU is also calling for the reversal of the burden of proof in establishing in which areas of the high seas bottom fishing may continue to be carried out. That is, rather than assuming that bottom fishing within the existing footprint is harmless to deep sea ecosystems unless it can be demonstrated otherwise, flag states and RFMOs will require clear evidence of the nonharmful nature of fishing activities for the vessels concerned to retain their licences.” (EC 2006)

In response to the adoption of the UN GA resolution, The European Union declared, in a statement to the UN General Assembly, that the EU was prepared to act expeditiously” to implement resolution 61/105:

“The protection of the marine environment, and in particular vulnerable marine ecosystems, is a common responsibility. The European Union is committed to taking expeditious action, in conjunction with its partners, in following up on what has been agreed by the General Assembly.” (EU 2006)

In 2007, the Directorate General for Fisheries and Maritime Affairs of the European Commission (DG MARE) issued a Communication outlining the initiatives that the EU would take to implement the UN GA resolution adopted in 2006. Amongst others, these included the following:

“The requirement of an environmental impact assessment as a condition for the authorisation of individual fishing activities is the first and indeed the lynchpin of the set of recommendations issued by the General Assembly. This represents a radically innovative principle in fisheries management. In contrast with other resource exploitation activities carried out in the oceans and seas, where it is established practice to require prior impact assessments (e.g. installing offshore oil or gas platforms), the effects of fishing on marine habitats are generally assessed only after the fact, if at all.”

“It is important to underline that RFMO members can choose to apply stricter rules to their vessels and operators if they so wish. The EU should aim at ensuring that RFMO measures attain a high degree of protection and effectiveness in preventing destructive fishing impacts. However, the EU must reserve itself the right to adopt stricter rules for itself if it considers that the RFMO measures do not go far enough in this respect.”