

The impact of deep-sea fisheries and implementation of the UNGA Resolutions 61/105 and 64/72

Report of an international scientific workshop



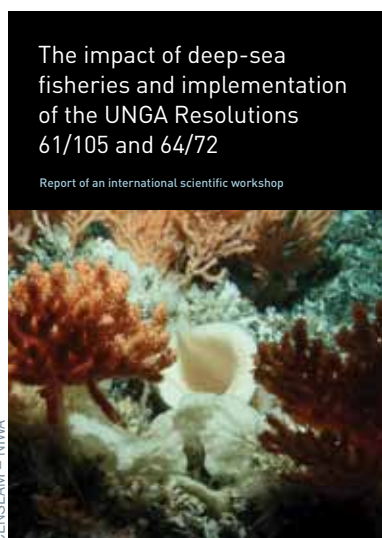


Crinoids at the vicinity of Saldanha hydrothermal field, Azores

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Cover photo: This image shows the summit of a seamount on the Macquarie Ridge, south of New Zealand, with a variety of sponges and primnoid corals that completely cover the seafloor. Seamounts can host dense concentrations of benthic invertebrates.

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List of acronyms

ABNJ	Areas beyond national jurisdiction	NOCS	National Oceanography Centre, Southampton
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources	NPFC	North Pacific Fisheries Commission
CBD	Convention on Biological Diversity	PSMA	Port State Measures Agreement
CPUE	catch per unit effort	RFMO	regional fisheries management organisation
EEZ	exclusive economic zone	ROV	remotely operated vehicle
EIA	environmental impact assessment	SAI	significant adverse impact
FAO	Food and Agriculture Organization of the United Nations	SEAFO	South East Atlantic Fisheries Organisation
GFCM	General Fisheries Commission for the Mediterranean	SIOFA	South Indian Ocean Fisheries Agreement
ICES	International Council for the Exploration of the Sea	SPRFMO	South Pacific Regional Fisheries Management Organisation
IEO	Instituto Español de Oceanografía (Spanish Institute of Oceanography)	UNCLOS	United Nations Convention on the Law of the Sea
IUU	illegal, unregulated and unreported fishing	UNEP	United Nations Environment Programme
MCS	monitoring, control and surveillance	UNFSA	United Nations Fish Stocks Agreement
NAFO	Northwest Atlantic Fisheries Organization	UNGA	United Nations General Assembly
NEAFC	North East Atlantic Fisheries Commission	UNSG	United Nations Secretary-General
		VME	vulnerable marine ecosystem
		VMS	vessel monitoring systems

Executive summary

The scientific workshop to review fisheries management, held in Lisbon in May 2011, brought together 22 scientists and fisheries experts from around the world to consider the United Nations General Assembly (UNGA) resolutions on high seas bottom fisheries: what progress has been made and what the outstanding issues are. This report summarises the workshop conclusions, identifying examples of good practice and making recommendations in areas where it was agreed that the current management measures fall short of their target.

In September 2011, the UNGA will review the actions taken by States and regional fisheries management organisations (RFMOs) to implement the bottom fishing resolutions 61/105 (adopted in 2006) and 64/72 (adopted in 2009). Both call on Flag States and RFMOs to manage deep-sea fisheries for sustainability with minimal impact on the environment, or else prohibit such fishing from taking place.

Five topics were identified in the UNGA resolutions where scientific assessment was needed. These were:

1. impact assessments;
2. identifying vulnerable marine ecosystems;
3. sustainability of deep-sea fish stocks and bycatch species;
4. move-on rule; and
5. monitoring, control and surveillance.

Each of these is addressed in the report with an assessment of the key issues and recommendations as to how the objectives of the resolutions can be achieved. No RFMOs have responded in the same way to the resolutions. Instead, RFMOs have taken independent action with varying degrees of effectiveness. The Commission for the Conservation of Antarctic Living Marine Resources (CCAMLR) has come closest to fully implementing the provisions of the UNGA resolutions. Examples of where RFMOs have made progress include: the prohibition of bottom trawling on the high seas in the CCAMLR area; the prohibition of bottom trawling below 1,000 metres in the Mediterranean by the General Fisheries Commission of the Mediterranean (GFCM); the banning of bottom gillnets by several RFMOs, the closure of substantial areas to high seas bottom fishing by some RFMOs - Northwest Atlantic Fisheries Organization (NAFO), North East Atlantic Fisheries Commission (NEAFC) and South East Atlantic Fisheries Organisation (SEAFO).

Overall however, we conclude that:

- the UNGA resolutions have not been fully implemented;
- deep-sea fisheries are not being managed for longterm sustainability; and
- vulnerable marine ecosystems (VMEs) are not being given sufficient protection from significant adverse impacts (SAIs).

Generally, there has been a failure of RFMOs to collect the necessary data for environmental impact assessments, so these assessments have been non-existent, partial or inconclusive. Many areas where VMEs are likely to occur are still being fished and the precautionary principle is not being applied. When VMEs have been identified, they have been restricted to corals and sponges, whilst other vulnerable fish species caught as bycatch have been ignored. The move-on rule is often the only management regulation in place to protect VMEs but most RFMOs have set bycatch threshold limits so high that the regulation is ineffective. The workshop expressed concern about the effectiveness and appropriateness of the move-on rule, in that it may actually increase impacts on VMEs in some areas where VMEs are closely spaced; for example, previously unfished seamounts.

One striking feature of the study of deep-sea ecosystems is the paucity of scientific information, due to the vastness of the oceans and the complexity of the environment. Hence much fishing activity is carried out in the absence of knowledge on fish stock structure, genetics and life-history characteristics of either the fished species or the bycatch species. This makes it impossible to use conventional fisheries management measures such as catch quotas, which are based on estimates of stock biomass. Hence other approaches, such as closures of large areas, will need to be taken.

Monitoring, control and surveillance of remote deep-sea bottom fisheries is a further complication hindering effective management. Better use of tracking systems such as vessel monitoring systems (VMS), with more frequent and detailed reporting, should be combined with effective port state controls. Finally, the workshop was extremely critical of the current data policies of most RFMOs, which are reluctant to share fisheries data, including VMS, with the wider scientific community.

Introduction

This report reflects the views of a scientific workshop held in May 2011 at the Calouste Gulbenkian Foundation, Lisbon, on the implementation and effectiveness of UNGA resolutions 61/105 and 64/72 in the management of deep-sea fisheries on the high seas and their impacts on deep-sea ecosystems.

Marine scientists specialising in deep-sea ecosystems were asked to address key questions (Annex 4) regarding the implementation of the resolutions, and the results and effectiveness of actions taken to date in protecting vulnerable marine ecosystems (VMEs) and sustaining deep-sea fish populations.

The deep sea is thought to host the highest biodiversity on the planet. However, the science of the deep sea is still not well known because of the vast areas concerned (64 percent of the Earth's surface lies more than 200 metres below sea level) and the relatively small amount of scientific activity in our oceans. Only about 0.0001 percent of the deep-seafloor has been subject to biological investigation (UNEP, 2007). New habitat-types are still being discovered and our understanding of the ecological processes in the deep sea is only gradually increasing (Ramirez-Llodra et al., 2010). While we are still in the process of discovering deep-sea species and communities, we know that deep-sea fish species (>500 m water depth) are often more long-lived and have lower recruitment than shallow-water species (Koslow et al., 2000; Morato et al., 2006a) and that deep-seafloor communities are vulnerable to impacts from bottom fishing (Althaus et al., 2009; Clark and Rowden, 2009; Clark and Koslow, 2007). We also know that it can take decades to centuries for deep-sea ecosystems to recover from damage, and sometimes recovery is not possible (Althaus et al., 2009).

Fishing is recognised as the most widespread human activity in the marine environment (Benn et al., 2010). Fishing fleets are working in all oceans, including in many areas where there is little knowledge of the habitat (Swartz et al., 2010). Bottom trawling now extends to depths of 2,200 metres (Morato et al., 2006b; Rogers and Gianni, 2010). Other activities in the deep-sea are now subject to international regulation which in some cases appear to be more rigorous than those controlling bottom impact fishing (see ISA case study page 15).

Following the adoption of United Nations resolutions 59/25 in 2004 and 61/105 in 2006 on deep-sea fisheries, the management of bottom fisheries and the protection of deep-sea ecosystems in the high seas have been a high priority for the international community and have been the subject of extensive debate and negotiation across a wide range of fora including the UNGA, the Food and Agriculture Organization of the UN (FAO), Conferences of Parties to the Convention of

Biological Diversity (CBD), and RFMOs with the legal competence to manage bottom fisheries in the high seas.

Trawlers perform most bottom fishing in the high seas. The total global catch in high-seas bottom fisheries in 2006 was estimated to be 250,000 tonnes, valued at USD450 million (360 million Euro) and representing 0.03 percent of the landed value of marine capture fisheries worldwide (Bensch et al., 2008). Many reports and studies continue to point to bottom trawling in the deep sea as a particular concern (Benn et al., 2010; Hogg et al., 2010; Roberts et al., 2009). Benn et al. estimate that the cumulative annual extent of seabed deeper than 200 metres impacted by bottom trawling on Hatton and Rockall Banks was one to two orders of magnitude greater than all the other activities in the northeast Atlantic combined.

Deep-sea bottom fisheries are known to impact both target and non-target species. Fish that escape from fishing nets and discards from nets are unlikely to survive. Bailey et al. (2009) found that all fish species in their study area suffered similar declines in abundance, indicating that the mortality and injury occurring in the net were having powerful effects even on species that were not ultimately landed. The deep-water environment is generally thermally stable and most deep-sea fish do not normally experience the large fluctuations in water temperature that occur during hauling to the surface. These temperature changes combined with the physical effects of decompression make it harder for bycatch species to survive. Living in an environment lacking wave action and with generally lower current regimes, deep-water fish are also less likely to have evolved abrasion-resistant skin and mucus to protect them when injured. As a result, they probably suffer greater levels of mortality and injury even when they escape through the meshes of trawl nets (FAO, 2005).

There is extensive documentation of a wide range of invertebrate bycatch in fishing gear (Ardron, 2005; Gass and Willison, 2005; Mortensen et al., 2005; Shester and Ayers, 2005; Stone, 2006; Clark and Koslow, 2007; Edinger et al., 2007; Althaus et al., 2009; Clark and Rowden, 2009). Bottom fishing has been shown to not only damage or destroy long-lived emergent epifaunal animals such as corals and sponges, but also to harm the three-dimensional complexity of the seabed, reducing species diversity and faunal biomass (Koslow et al., 2001; Reed et al., 2005; Stone, 2006; Waller et al., 2007; Althaus et al., 2009; Clark and Rowden, 2009).

While the intensity of impacts differs between gear types and can be influenced by fishing practices (ICES, 2006; FAO, 2008), all bottom contact fishing methods (for example, benthic longlines, gillnets and pots) are known to have some adverse impacts (Stone, 2006; Edinger et al., 2007; FAO, 2008). However, the size and weight of the gear and the extent of the seafloor impacted by tows means that bottom trawling is likely to have the most serious adverse impacts on vulnerable deep-sea benthic species.

In addition to the direct impacts from fishing gear, the indirect effects of fishing also may impact benthic VMEs. For example, smothering or burying of hard substrata by increased sediment load caused by the trawl gear stirring up the seabed, removal of target fish species and dumping of bycatch or offal have been shown to have an impact on ecosystems and have the potential to impact VMEs – particularly if food webs are affected (Clark and Koslow, 2007; DeVries et al., 2007).

While SAIs of fishing on deep-water coral communities have been observed in all oceans, particularly the northeast Atlantic (Hall-Spencer et al., 2002; Fosså et al., 2002; Wheeler et al., 2005), northwest Atlantic (Mortensen et al., 2005; Edinger et al., 2007), northeast Pacific (Stone, 2006; Krieger, 1998, 2001; Stone et al., 2005) and southwest Pacific (Koslow and Gowlett-Holmes, 1998; Koslow et al., 2001; Clark and O’Driscoll, 2003; Rowden et al., 2004; Althaus et al., 2009; Clark and Rowden, 2009), recovery of these ecosystems from mechanical impacts of fishing has been less well studied. In some areas, growth of stylasterid corals on the seabed previously impacted by bottom trawling has been observed, possibly demonstrating an ability either to withstand trawling impacts or colonise areas relatively quickly after disturbance (Clark, Rowden et al., 2010; Clark and Rowden, 2009). However, given the slow growth rates of habitat-forming corals, which may take hundreds of years to develop (Tracey et al., 2007; Roark et al. 2006), observations show that it is likely that such ecosystems will recover only very slowly if at all, and in many areas, even many years after the cessation of fishing, there is no evidence of recovery (Waller et al., 2007; Althaus et al., 2009).

UN General Assembly Resolutions

The UNGA adopted a series of resolutions, beginning in 2004 with Resolution 59/25 and followed in 2006 by Resolution 61/105, that called on high seas fishing nations and RFMOs to take urgent action to protect VMEs from destructive fishing practices, including bottom trawl fishing, in areas beyond national jurisdiction (UNGA, 2004; 2007). The key paragraphs of resolution 61/105 are contained in Annex 1 of this report. This



Iridogorgia standing at Saldanha hill, Azores.

resolution called on States and RFMOs to conduct impact assessments to determine whether VMEs would suffer SAIs. High seas fishing nations are called upon to stop bottom fishing where VMEs are known or likely to occur unless the fishing can be managed to prevent SAIs on VMEs. Furthermore, the resolution called for the management of high seas bottom fisheries to ensure the long-term sustainability of target and non-target (bycatch) deep-sea fish stocks. Subsequently, measures to implement UNGA resolution 61/105 have been adopted by a number of States and RFMOs, including those active in high seas bottom fisheries in the North Atlantic, northwest Pacific, South Pacific and Southern Ocean.

The main action points of Resolution 61/105 are summarised as follows:

1. Conduct impact assessments to determine whether bottom fishing activities would have SAIs on VMEs, and ensure that if fishing activities would have SAIs that they are managed to prevent such impacts, or else prohibited;
2. To close areas of the high seas to bottom fishing where VMEs such as cold-water corals, are known or likely to occur, unless fishing in these areas can be managed to prevent SAIs to such ecosystems;
3. To establish and implement protocols to require vessels to cease fishing in areas where an encounter with vulnerable marine ecosystems occurs during fishing activities;
4. To sustainably manage the exploitation of deep-sea fish stocks;
5. To implement these measures, in accordance with the precautionary approach, ecosystem approach and international law, by no later than 31 December 2008.

Introduction

In 2008, following the adoption of Resolution 61/105 and after a series of consultations and negotiations to draft guidelines, FAO member States adopted the FAO *International Guidelines for the Management of Deep-Sea Fisheries in the High Seas* (FAO Guidelines). The guidelines sought, *inter alia*, to elaborate the science-based criteria for VME identification, conducting impact assessments of bottom fisheries and determining whether SAIs would occur (FAO, 2009a).

In 2009, following a review that indicated implementation of Resolution 61/105 was insufficient, the UN General Assembly adopted resolution 64/72 (UNGA, 2009). The key paragraphs of resolution

64/72 are contained in Annex 2 of this report. While reaffirming resolution 61/105, it asserted that the measures called for should be implemented by flag states and RFMOs in accordance with the FAO Guidelines, prior to allowing or authorising bottom fishing in the high seas. Resolution 64/72 calls for states and RFMOs to conduct impact assessments on bottom fishing on the high seas and to “ensure that vessels do not engage in bottom fishing until such assessments have been carried out”. Furthermore, the resolution calls for stock assessments and conservation measures to ensure the long-term sustainability of deep-sea fish stocks and non-target species and the rebuilding of depleted stocks.

CASE STUDY

The Spanish habitat-mapping programme in the high seas

Since 2005, Spain – by itself or in collaboration with other nations – has been developing a research programme in the Atlantic Ocean with the aim to: (i) map the seabed; (ii) identify vulnerable marine ecosystems (VMEs); (iii) study the interactions with bottom fisheries; and (iv) select suitable areas to preserve VMEs. The programme facilitates the provision of advice to RFMOs (NEAFC, NAFO, and SEAFO) and the EU for implementing the UNGA resolution 61/105 on protecting VMEs in the high-seas. The identification of VMEs in order to select suitable protection areas requires an interdisciplinary approach. The methodology used was described by Durán Muñoz et al. (2009) and was based on conventional fisheries science, geomorphology, benthic ecology, sedimentology, and oceanography.

Northwest Atlantic (Slopes of the Grand Banks, Flemish Cap and Flemish Pass)

The NEREIDA programme (Figure A) conducts research in the northwest Atlantic. This is a Spanish-led multidisciplinary international research project involving active participation by Spain, Canada, the UK and the Russian Federation (ICES, 2011). NEREIDA field work was completed in 2009 and 2010 using two platforms: the Spanish oceanographic Research Vessel *RV Miguel Oliver* (six multidisciplinary surveys) and the Canadian vessel *CGS Hudson* (two ROV surveys). Data were collected using a high resolution multibeam echo sounder (Simrad EM-300) (~68,900 km²), very high-resolution seismic profiles (Topas PS 018), box corers (N=341), rock dredges (N=104), trawls (N≈2500), drop cameras, and ROVs (2,143 photographs and about 116 hours of video). VMS data from the area will be used as an indicator of fishing pressure. The programme is expected to produce analyses that can be used to refine boundaries of

currently closed areas in the NAFO regulatory area (NAFO, 2011) and to identify other areas where vulnerable marine ecosystems occur, particularly cold-water corals (Murillo et al., 2011) and sponges. First results are anticipated in 2011, for the Sackville Spur sponge grounds closed area.

Northeast Atlantic (Hatton Bank)

The research undertaken in the Hatton Bank under the ECOVUL/ARPA Spanish project (Figure B) was summarised by Durán Muñoz et al. (2009) and Sayago-Gil et al. (2010). Effort data collected by scientific observers on board Spanish commercial freezer-trawlers (period 1996–2006) were used to identify the footprint of the deep-sea fishery. Three science-industry cooperative surveys were conducted between 2005 and 2008 to study the impacts of bottom fishing as well as the distribution of VMEs indicator taxa (Durán Muñoz et al., 2011). Furthermore, three multidisciplinary deep-sea surveys were undertaken between 2005 and 2007, using the multipurpose Spanish Research Vessels (*RV Vizconde de Eza* and *RV Miguel Oliver*). Nearly 18,760 km² of multibeam bathymetry and 1,121 km of very high-resolution seismic profiles were obtained from the western flank of Hatton Bank. Additionally standardised trawl sets (N=38) were deployed in the fishing grounds to study the benthic communities. Rock dredges (N=22) and box corers (N=13) provided samples of hard substratum and soft sediment, which were mainly used to calibrate the backscatter data. Based on the results of Spanish surveys and international studies, a fisheries closure was implemented by NEAFC and the EU in the Hatton Bank. The total protected area amounts to approximately 16,000 km² and depths range from 500 to about 1,500 m (European Commission, 2009c; Durán Muñoz and Sayago-Gil, 2011). The area is closed to all bottom fishing operations. The closures will be reviewed in 2011.

Southwest Atlantic (Patagonian shelf and slope)

The research undertaken in the Southwest Atlantic by Spain (Figure C) was developed under the Spanish the ATLANTIS

The measures progressively agreed by the UNGA resolutions essentially follow from, and give effect to, the general provisions for fisheries conservation and the protection of marine biodiversity contained in the 1995 UN Fish Stocks Agreement (UNFSA). Articles 5 and 6 of the UNFSA oblige States, *inter alia*, to:

- “assess the impacts of fishing ... on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks” [Article 5(d)]
- “minimize ... impacts on associated or dependent species, in particular endangered species” [Article 5(f)]
- “protect biodiversity in the marine environment” [Article 5(g)]

- “take measures to prevent or eliminate overfishing and excess fishing capacity and to ensure that levels of fishing effort do not exceed those commensurate with the sustainable use of fishery resources” [Article 5(h)]
- “apply the precautionary approach widely... in order to protect the living marine resources and preserve the marine environment” and “be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures” [Articles 6.1 and 6.2]
- “develop data collection and research programmes to assess the impact of fishing on non-target

project (Portela et al., 2010). The study area is located in the high-seas between latitude 42°S–48°S at depths reaching 1,500 m. Data collected by Spanish scientific observers (period 1989–2007) show that the bottom trawl fishery footprint is located at depths less than 300 m. Thirteen multidisciplinary deep-sea surveys were undertaken between 2007 and 2010, using the RV *Miguel Oliver*. Nearly 59,105 km² of multibeam bathymetry and 91,905 km of very high-resolution seismic profiles were obtained. Rock dredges (N=102), box corers (N=209) and CTD (N=519) were collected, as well as photographs and video using ROV. Standardised trawl sets (N=413) were carried out and survey indexes (biomass and abundance) of commercial resources were calculated. Based on the results of the ATLANTIS project, nine large areas along the Patagonian shelf and slope were identified as VMEs, and designated as candidate areas for closure (a total of about 41,300 km²). On 1 July 2011, following this advice, the Spanish Government implemented a fishing closure for the Spanish fishing bottom fleets in the high seas of the southwest Atlantic.

Southeast Atlantic (Walvis Ridge)

Between 2008 and 2010, three multidisciplinary deep-sea surveys were carried out by Spain in collaboration with Namibia, on board the RV *Vizconde de Eza* (Lopez-Abellan et al., 2008). The study area (Figure D) is located in the high seas around the Walvis Ridge (Valdivia Bank) including the Ewing Seamount. The objective of the research was to conduct an experimental study to localise and identify vulnerable marine ecosystems associated with seamounts in the SEAFO region. It also provided a biological characterisation of seamounts

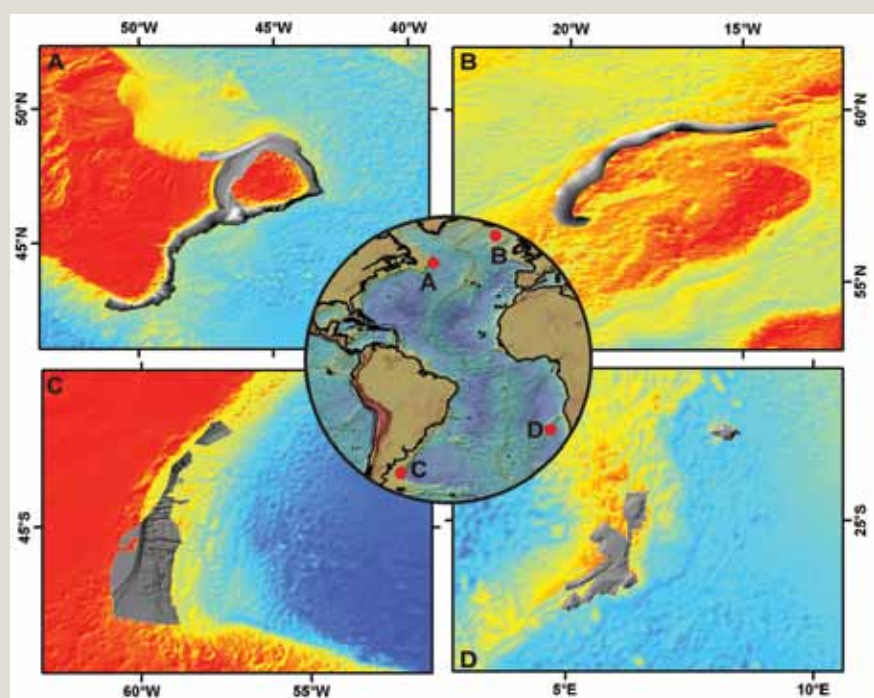
surveyed, together with a more feasible procedure to follow throughout the SEAFO area. Nearly 15,800 km² of multibeam bathymetry and around 1,500 km of very high-resolution seismic profiles were obtained during this survey.

Figure A-D: Maps showing the location of the four study areas (red circles) of the Spanish habitat mapping programme along the high seas of the Atlantic Ocean.

Details of the four areas covered with multibeam echosounder are presented: A, Grand Banks of Newfoundland; B, Hatton Bank; C, Patagonian Shelf and slope; D, Walvis Ridge).

General bathymetry obtained from ETOPO (Amante and Eakins, 2009).

Bathymetry colour scale: red, shallower water; blue, deeper water.



Introduction

and associated or dependent species and their environment, and adopt plans which are necessary to ensure the conservation of such species and to protect habitats of special concern” [Article 6.3(d)]

The UNGA has decided to review the actions taken by States and RFMOs to implement the UNGA resolutions on deep-sea fisheries in September 2011, with a view to calling for further measures if needed. The review will be preceded by a two-day workshop at the UN involving a range of stakeholders to discuss and debate the implementation of the resolutions.

The scope and purpose of the workshop

This report, based on the Lisbon workshop, is intended to inform the UNGA review on the extent to which UNGA resolutions 61/105 and 64/72 have been implemented. The report also contains recommendations regarding additional actions that may be required to protect deep-sea ecosystems and to manage deep-sea fisheries in a sustainable manner.

There is a clear need to provide scientific input into the UNGA review, and therefore the workshop in Lisbon in May 2011 aimed to review the implementation of the UNGA resolutions on deep-sea fisheries from a scientific perspective – noting that the UNGA resolutions call for the use of “the best scientific and technical information available to identify where vulnerable marine ecosystems are known to occur or are likely to occur and adopt conservation and management measures to prevent significant adverse impacts on such ecosystems” and that States “develop or strengthen data collection standards, procedures and protocols and research programmes for identification of vulnerable marine ecosystems, assessment of impacts on such ecosystems, and assessment of fishing activities on target and non-target species”.

Specifically, the participants at the Lisbon workshop:

- Reviewed the implementation of paragraphs 80 and 83 to 87 of UNGA resolution 61/105, adopted in 2006, and paragraphs 117 and 119 to 127 of UNGA resolution 64/72, adopted in 2009. These paragraphs of the resolutions can be found in Annexes 1 and 2 and on the website of the UN Division for Ocean Affairs and the Law of the Sea at www.un.org/Depts/los/general_assembly/general_assembly_resolutions.htm.
- Identified gaps in implementation.
- Provided recommendations for improved implementation.

The workshop involved nineteen scientists from academic institutions and government laboratories plus three policy experts, in all from ten countries. Input was also received from an additional three scientists who were unable to be present. Prior to the workshop, all participants were sent a questionnaire (Annex 4) based on four key points arising from the resolutions:

1. Impact assessments;
2. Identification of vulnerable marine ecosystems (VMEs) and area closures;
3. Sustainability of deep-sea fish stocks;
4. The move-on rule and encounter protocols;

During the workshop a fifth point was added:

5. Monitoring, control and surveillance.

Workshop output

The five key points are addressed individually in the following sections, starting with a brief outline of the relevant background information and, where applicable, the responses to questions posed in the questionnaire, the key findings, and any recommendations proposed by the workshop.



Deploying a deep acoustic towbody from the research vessel Tangaroa to survey deep-sea fish stocks off New Zealand. Acoustic surveys are regularly carried out to monitor the size of spawning aggregations of species such as orange roughy and oreo dories.

Impact assessments

Background

The relevant paragraphs of the UNGA resolutions and the FAO Guidelines are: resolution 61/105, paragraph 83 (a); resolution 64/72, paragraph 119(a), and FAO Guidelines paragraphs 16–20, 42 and 47. The nature of the impact assessments, including specific information that should be included, is outlined in paragraph 47 of the FAO Guidelines. Assessments 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 fishing 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 are likely to be significant adverse impacts, particularly those 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 utilisation of low-productivity fishery resources, and the measures to be used to monitor effects of the fishing operations.

In general, the requirements are straightforward, however, two areas present a challenge for very different reasons: firstly, both ii) and iv) are problematic because in many deep-sea fisheries there is no systematic effort to even identify what is being caught – that is, what target and bycatch species are suffering mortality as a result of fishing; secondly, there is a genuine scientific challenge in identification of VMEs, especially in areas of the world where deep-sea science has not been very active. Examples include low and high latitudes and the Indian Ocean.

For a number of high seas bottom fisheries, no impact assessments have yet been conducted. For instance, no State has conducted an impact assessment for any of the high seas bottom fisheries in the Atlantic or Indian Oceans. Assessments that have been completed for the bottom fisheries in the Pacific and Southern Oceans have varied considerably in quality and detail and without consistency across RFMOs (Rogers and Gianni, 2010). Some have been either preliminary or partial in relation to the criteria established under the FAO Guidelines. Thus far, the most comprehensive and detailed assessments have been produced by New Zealand with respect to bottom fisheries in the South Pacific and the Southern Ocean, and a number of countries for their bottom longline fisheries in the Southern Ocean (Rogers and Gianni, 2010).

However, even the comprehensive and detailed assessments have not necessarily been able to clearly determine whether individual bottom fishing activities would or would not have significant adverse impacts on VMEs, or whether any mitigation measures, other than area closures, would effectively prevent significant adverse impacts on these ecosystems. In most cases, this is due to a combination of factors, including insufficient baseline information on the presence, likely occurrence and ecology of VMEs in the areas to be fished; insufficient information on the precise areas in which bottom fishing will or is likely to take place; insufficient information on the interaction of the bottom fishing gear with VMEs; and insufficient information on the extent, severity, duration, and likely scale of the impact of bottom fishing on VMEs known or likely to occur in areas subject to bottom fishing. The assessment by Japan with respect to bottom fisheries in the North Pacific was seriously flawed with respect to scientific analysis and conclusions (Rogers and Gianni, 2010). This raises an important point – there is no formal independent scientific peer-review process for impact assessments.

Some progress has been made in mapping and identifying VMEs (Murillo et al., 2011; Durán Muñoz et al., 2009); fishing footprints and understanding the impacts of fishing (Durán Muñoz et al., 2011; Portela et al., 2010). However, in some RFMOs, this information is not being considered in management decisions outside of closed areas. There are also efforts to map VMEs based on predictive modelling (Davies and Guinotte, 2011; Davies et al., 2008; Tittensor et al., 2009), but these efforts are generally being made through academic science and not being used in RFMO decision making.

In the CCAMLR Regulatory Area, all countries have submitted impact assessments for bottom longline fisheries (bottom trawling is not allowed in high seas areas) and, where impact assessments were not

Impact assessments

submitted, countries were not allowed to fish until such time as they completed an assessment (CCAMLR, 2010). While the assessments varied considerably in detail and quality, most States asserted that while impacts on VMEs from bottom longline fishing are not known, such fishing presented little risk of significant adverse impacts because the extent of the fishery in relation to the size of the CCAMLR Regulatory Area is small and longline gear is much less destructive than bottom trawl gear.

The Northwest Atlantic Fisheries Organization (NAFO) initially requested assessments by 31 December 2008, but no countries submitted assessments at that time or subsequently. In 2010, both bottom fishing RFMOs in the North Atlantic, NAFO and the North-East Atlantic Fisheries Commission (NEAFC) amended their rules to require impact assessments if proposed bottom fishing is outside of the existing bottom fishing areas, or if there are significant changes to the conduct or technology of existing bottom fisheries, or new scientific information indicating a VME in a given area. The Contracting Party proposing to participate in bottom fishing shall submit to the Secretary an initial assessment of the known and anticipated impacts of its bottom fishing activities on vulnerable marine ecosystems (NAFO, 2011; NEAFC, 2011).

In the North Pacific Regional Fisheries Management Organization (NPRFMO), States engaged in bottom fishing have conducted impact assessments (<http://nwpbfo.nomaki.jp/Assessment.html>) that concluded that, in general, significant adverse impacts to VMEs do not exist (Rogers and Gianni, 2010). Of the nations engaged in high seas bottom fisheries in the region, the most comprehensive impact assessment was provided by Japan. However, interpretation of data has not been precautionary and is not in line with studies elsewhere on what constitutes a VME (Rogers and Gianni, 2010). Part of the Japanese assessment included camera drop surveys in which dense colonies of octocorals are clearly visible (for example, Fisheries Agency of Japan, 2008a). Nevertheless, the data was dismissed, as it was “not possible to reach any conclusion that they constitute VMEs” (Fisheries Agency of Japan, 2008b). The assessment notes that the FAO Guidelines provide no quantitative guidance regarding what constitutes a VME, and that the communities in the northwest Pacific do not resemble the extremely high density communities from the Antarctic (Fisheries Agency of Japan, 2008b). Comparison between the Emperor Seamount benthic communities and those of the Antarctic are misleading and fail to reflect the work done in other regions to quantify densities of octocorals (for example: Stone, 2006; ICES, 2007; Edinger et al., 2009; Rogers and Gianni, 2010). Furthermore, there is no assessment of impacts on non-target species of fish/sharks.

In the South Pacific Regional Fisheries Management

Organization (SPRFMO), New Zealand has submitted detailed information on its high seas bottom fisheries (New Zealand Ministry of Fisheries, 2008). However, the New Zealand submissions to SPRFMO do not constitute impact assessments consistent with the FAO Guidelines. Recognising that VMEs are likely to occur on seamounts throughout its fishing footprint, New Zealand has agreed a compromise with the fishing industry in which approximately 60 percent of the fishing footprint remains open to bottom fishing.

Within RFMOs that have closed areas to protect VMEs there is a reluctance to conduct impact assessments, as it is often stated that VMEs have already been protected. However, if comprehensive impact assessments were actually conducted, new areas requiring protection would be likely to come to light. The failure to complete impact assessments is less a lack of scientific information and more the result of the politics of the situation and a lack of commitment to make impact assessments by individual States and RFMOs.

Key findings

UN resolutions 61/105 and 64/72 are clear that impact assessments must be completed, and if they are not, the RFMO must not allow fishing to occur. The scientific review conducted at the workshop identified shortcomings in current impact assessment practices together with a number of other issues:

- Existing impact assessment criteria do not adequately deal with “fisheries creep”, which is defined as continued fishing at the edge of a VME or a newly fished or lightly fished area.
- A part of impact assessments is the submission of a Fisheries Plan. All fisheries plans must have a spatial aspect and identify the area in which a vessel / State intends to fish. (In the European Union regulation for non-RFMO areas, a State has to submit a fishery plan, which includes the area where the state intends to fish and where there will be no harm to VMEs. Vessels must then stay within that area (European Commission, 2008a)).
- RFMOs should review assessments in a timely manner and provide management advice based on the information submitted, prior to the commencement of the fishing season.
- Where surveys have not yet occurred, predictive modelling of potential VME locations should be used where available as part of impact assessments.
- Assessments should include:
 - past fishing effort in the area;
 - identify what constitutes a VME within the proposed fishing area;
 - distribution of VMEs within and nearby the proposed fishing area.

CASE STUDY

A moratorium on bottom trawling? An example from the Azores

The Azores is the most isolated archipelago in the northeast Atlantic, and forms part of the volcanic mid-ocean ridge. The waters around the islands contain a variety of VMEs, including cold-water coral gardens and reefs, deep-water sponge aggregations, volcanic hydrothermal vents, as well as important spawning grounds for fish such as alfonsino, black cardinal fish and orange roughy. The accession agreement that brought Portugal into the European Union in the mid 1980s included temporary provisions that allowed the Azorean Government to maintain a great deal of control over fisheries management, and access to Azorean waters continued to be limited to local and some mainland Portuguese vessels. In recognition of its unique marine environment, the Azorean Government (in close collaboration with Azorean scientists and fishers) introduced various measures to ensure the sustainability of the region's fisheries and dependent local communities. This Azorean regime complemented a trawl ban, based on effort limitation, introduced by the EU. In 2004 this special arrangement came



Panoramic view of a coral garden at the 200 m summit of Condor Seamount, Azores.

to an end when the fishery beyond 100 nm was opened to all European vessels. This brought a storm of protest from scientists, local stakeholders and NGOs. After some months, the European Council decided to temporarily ban trawling in order to protect deep-water corals in an area roughly corresponding to the EEZs of the three island groups – an area covering several hundred thousand square kilometres. This ban was made permanent in 2005.

Fishing activity off the Azores does include bottom fishing by longlining. The effects of longlining are considerably less than for bottom trawling but nevertheless they do cause some damage such as the landing of very long-lived specimens of *Leiopathes* sp. The average longline bycatch in the Azores is preliminarily estimated at an average of 2.26 individual specimens of cold water coral per set or 0.565 per 1000 hooks. This value represents only a tiny fraction of what could be the bycatch rates of a small trawler if permitted to fish in the area. Some unverified extrapolations have concluded that one trawl in a pristine habitat could have the same impact of about 9,000 longline sets (University of Azores, Department of Oceanography and Fisheries, unpublished data).

- assessment of the impacts of fishing activity on adjacent VMEs (for example, from the suspension of sediment).
- Strategic environmental impact assessments that lay out general guidelines for activities would be beneficial to determine where fishing can and cannot occur, and would reduce the burden on individual States.
- The burden of proof has been reversed from conventional approaches (European Commission, 2008a). Where there is no assessment, there should be no fishing. Furthermore, where there is no proof that there will be no harm, fishing should not take place.
- RFMOs need to examine the cumulative impact of all fisheries. In the future, consideration may have to be given to the combined impact of fisheries plus other activities in an area (for example, oil and gas and mining).

Assessments need to be timely, and management decisions based on assessments must take place before the fishing season.

Existing information

There are vast differences in the types and amount of information that is available on the high seas. In areas where there has been fishing activity for many years, survey information, observer data and research information is sometimes available. However, with the exception of CCAMLR, the work done by Spain in the southwest Atlantic (Portela et al., 2010) and work done beyond its exclusive economic zone (EEZ) by New Zealand (for example, Clark, 2008; Clark and Roberts, 2008; Clark, Dunn et al., 2010; Anderson, 2006), this information does not exist for the vast majority of the southern hemisphere. Where this information does not exist, predictive habitat modelling can be used to identify vulnerable ecosystems and species' distributions in areas that have not been sampled (Davies et al., 2008; Davies and Guinotte, 2011).

Fishing intensity

Impact assessments will differ depending on the level of existing and historical fishing effort. It also cannot be assumed that the risk of SAIs to VMEs is necessarily

Impact assessments

lower in historically fished areas than in unfished areas or vice versa. While there is evidence showing the complete destruction of VMEs by bottom trawling in some high intensity fishing areas, for example coral cover from Tasmanian seamounts (Koslow et al., 2001), in other areas where fishing is less constrained, such as along the continental margins, substantial areas of reef still remain (Mortensen et al., 2001). In addition, many RFMOs have made efforts – albeit not that successfully – to rebuild and restore fish populations. Such efforts could be extended to VMEs as well.

Mitigation

Mitigation measures should allow for the maintenance of regional biodiversity. This will vary from ecosystem to ecosystem, and is heavily dependent on the bottom fishing gear used. CCAMLR Parties conclude that the impact of the activity is constrained to a relatively small area. Since it is a longline fishery, the case is made that the impact is far less than bottom trawling and likely to be minimal. Within the context of the agreed international approach to managing deep-sea fisheries on the high seas, RFMOs need to find a balance between mitigation measures and where fishing can occur. Mitigation measures such as area closures, gear and depth restrictions would greatly reduce SAIs. Examples of mitigation measures taken include:

- In 2004, NEAFC adopted an interim ban on bottom fishing in an area on the Reykjanes Ridge (the northern part of the Mid-Atlantic Ridge) and four seamounts adjacent to the Ridge.
- In 2005, The General Fisheries Council for the Mediterranean (GFCM) imposed a ban on fishing below a depth of 1,000 m (FAO, 2006b).
- Between 2006 and 2009, NAFO closed 17 areas to fishing, including seamounts and areas of known concentrations of corals and sponges.
- In 2007, following evidence presented by the International Council for the Exploration of the Sea (ICES) of VMEs, areas on the Rockall and Hatton Banks were closed to fishing by NEAFC.
- In 2008, Japan, in its impact assessment for the NPRFMO, did not agree to any mitigation measures for bottom trawling, but did agree that the foot rope of gillnets should be set at 100 cm rather than 70 cm off the seafloor (Fisheries Agency of Japan, 2008c).
- In 2009, NEAFC closed large areas to bottom fisheries on the Mid-Atlantic Ridge to protect VMEs. The closures are guaranteed to remain in place until 2015. In 2009, NEAFC also extended the Hatton Bank protected area in line with recommendations from ICES.
- Gillnets have been banned by some RFMOs, either below a certain depth or from the entire region (e.g. NEAFC, SEAFO, SPRFMO).
- A three-zone approach (light, medium and heavily fished) in New Zealand (Penney et al., 2009) to

determine the details of where the move-on-rules or closures should be applied. The fished areas were divided into 200 20-minute blocks and the past fishing activity calculated for each based on VMS data. All lightly fished blocks have been closed to bottom trawling (representing 62 blocks or 31 percent of the fished area). Of the remaining moderately and heavily fished areas, 20 blocks of representative areas have been closed bringing the total closed area to 40 percent of the fished area or 40,000 km². Whilst this method has merit, the size of each block was considered by the workshop participants to be much too large, since it could contain multiple habitats/VMEs. Moreover, there needs to be measures in place to protect VMEs in those areas that remain open to fishing. In the case of New Zealand's footprint, there is a move-on rule for moderately fished blocks, but no measures to prevent SAIs in the heavily fished blocks.

Fishing footprint

Making a distinction between the existing fishing footprint and new fishing areas, as well as distinguishing between heavily fished, moderately fished and lightly fished areas, can be useful in implementing the UNGA resolutions. The fishing footprint should be based on accurate and verifiable data on the areas actually towed or fished, using, for example, the previous five years of VMS data and detailed log-book data. It should also take into consideration information on intensity and frequency of fishing effort. The workshop felt that the current definition of the fishing footprint in some areas was too large. In SPRFMO, for example, the fishing footprint was defined as geographic 'blocks' of ocean space measuring 20 by 20 minute latitude and longitude (a footprint of approximately 1,000 km² in New Zealand's case), within which any bottom fishing, including even a single tow of a trawl net, had occurred during the period 2002–06 (Rogers and Gianni, 2010). Within the existing fishing footprint, more extensive distribution of corals, sponges and other VMEs may have previously occurred, for example in the Grand Banks ecosystem in the northwest Atlantic (Murillo et al., 2011). In areas that have been heavily fished, assessments of past, cumulative impacts on the ecosystem are needed, particularly if there is direct link between the habitat and the fish stock productivity. Where the original state of the ecosystem is unknown, predictive modelling can provide a useful proxy.

Restoration

The UN Convention on the Laws of the Sea (UNCLOS) [Article 119.1(b)] calls for maintaining or restoring populations. The FAO Code of Conduct (Article 7.6.10) provides that States and fisheries management organisations and arrangements “should make every effort to ensure that resources and habitats critical



Icefish, Southern Ocean.

to the well-being of such resources which have been adversely affected by fishing or other human activities are restored". As part of a regional plan, it is important to ensure that areas previously impacted are able to be restored and ensure reproducing populations across a wide depth range. Assessments will be needed to determine which areas are suitable for regeneration and recovery based on CBD criteria.

Exploratory fishing

Stringent exploratory fishing protocols, including 100 percent observer coverage, should apply to vessels wishing to fish in an unfished area. For example, exploratory fisheries in CCAMLR continue to be classified as exploratory until sufficient information is available to, *inter alia*, evaluate the distribution, abundance and demography of the target species, and review the fishery's potential impacts on dependent and related species (CCAMLR, 2010). Prior impact assessments, as called for in paragraph 119(a) of resolution 64/72, should be required before allowing exploratory fishing.

Data gaps

For areas outside the North Atlantic, there is very little information available. Collecting the information for the areas with no previous fishing activity or unreported fishing activity can be very expensive. Nevertheless, where appropriate, non-destructive sampling should be undertaken before any fishing can occur. Where there are substantial uncertainties in both fished and unfished areas, it may be possible to combine the fishing activity with gathering scientific information on the relevant aspects of the ecosystem to reduce uncertainties and increase information that can be used in assessing impacts and identifying VMEs. This has already been done in the South Georgia longline fisheries and proved very cost effective. For example, cameras could be used to assess the presence of VMEs and acoustic sampling used to assess fish populations. Camera information should be transmitted with VMS data, and decisions made based on the photographic evidence. Preliminary multibeam mapping by the fishing industry could also

be used to assess areas that could be fished. Such cooperative ventures would require an increased level of engagement from scientists and industry, with a willingness to share data. At the same time however, it should be noted that the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC) recommended that exploratory fishing with bottom contact gear in the deep-sea should be considered unacceptable because of the long-term damage such gear does to bottom habitats (ICES, 2010). They further recommended that exploratory fishing with bottom contact gear is unnecessary because modern data management tools and computer modelling techniques can provide a mechanism for making predictions about where VMEs are likely to be present. WGDEC also recommended that the burden of proof regarding whether any particular area of the seabed can be fished with bottom contact gear without causing damage to VMEs must reside with the entity proposing to do the fishing and that this can be done through the use of bottom cameras or other non-destructive devices (ICES 2010).

Recommendations

The failure of RFMOs to collect necessary data for environmental impact assessments could result from the lack of appropriate systems and protocols. We therefore suggest the following:

- RFMOs must require member States to conduct impact assessments in their area. States should have a template identifying the data that is required, including information that is known, where there is a lack of data, and what is being done to mitigate potential impacts. Meaningful timelines for the submission of assessments must also be included to coincide with science and management meeting schedules.
- Where there are substantial uncertainties regarding the existence of VMEs in an area, or whether fishing in the area would cause significant adverse impacts to VMEs, or the long-term sustainability of deep-sea fish stocks (in particular rare and/or endangered species), fishing should not be permitted until such uncertainties are resolved.
- RFMOs should identify actions to be taken based on the outcomes of the impact assessment.
- An international science panel with regional representation should be created to review on an annual basis all impact assessments (could be linked to RFMO joint meetings).
- In the event of lack of compliance or lack of progress with implementation of UNGA resolutions, fishing should only be allowed in areas where there is certainty that there are no VMEs and that the sustainability of deep-sea fish stocks can be ensured.

Identifying VMEs

The relevant paragraphs of the UNGA resolutions and the FAO Guidelines are: resolution 61/105, paragraphs 83 (b) and (c); resolution 64/72, paragraph 119(b); FAO Guidelines paragraph 42.

A variety of measures to protect known or suspected VMEs have been implemented by RFMOs, including closed areas and prohibiting specific gear-types. For example, bottom trawling is prohibited in the CCAMLR Regulatory Area, and gillnets are banned in the NEAFC, SEAFO, SPRFMO Regulatory Areas either below a certain depth or from the entire area because of the high risk of bycatch and ghost fishing. Most RFMOs have implemented area closures, although the extent and types of closures vary. Some RFMOs have not closed all areas where there is evidence of the presence of VMEs, while others have closed very few areas despite evidence of destruction of VMEs by bottom fishing. Lack of information on deep-sea ecosystems, preventing RFMOs from identifying where VMEs exist, is cited as the main reason for not implementing closures. Scientific information on the likely occurrence of VMEs has not been used in many cases, or has been misinterpreted or dismissed. Additionally, evidence suggests that some RFMOs limit their interpretation of which species form VMEs or what structurally constitutes a VME (for example, only considering cold-water corals and sponges), rather than use the VME definitions provided in the FAO Guidelines.

There is a general failure to apply the precautionary approach to VME protection. Many areas of the seafloor were impacted before the UNGA resolutions were adopted. Little satellite-based vessel monitoring data (VMS data) is available pre the mid-1990s. Consequently, it is difficult to assess extent of impacts and to assess, for example, which seamounts have been fished. Although Japan is now adding data on the North Pacific, comprehensive data on past trawling, gillnets and all bottom contact gear is needed.

Serial depletion of fish stocks and habitat destruction of unmapped and unexplored seamounts by the trawling industry is completely outside the spirit of the UNGA resolutions.

Key findings

VME criteria

Criteria for identifying VMEs have not been applied consistently in all areas. Some initial steps have been taken, for example by CCAMLR, NEAFC and NAFO. A science-based assessment of what constitutes a VME is required for each individual area and agreed scientific approaches should be applied consistently across

bioregions. Criteria from one area cannot be used to identify VMEs in another area. For example, as described earlier, the Japanese impact assessment for the North Pacific relied on criteria from an Australian report for the Antarctic (see Rogers and Gianni, 2010). The identification of species, particularly non-target species, would be improved by the provision of identification guides (for example CCAMLR, 2009; SEAFO, 2009;

CASE STUDY

International Seabed Authority (ISA) recommendations for the guidance of contractors for impact assessment

In 2000, the ISA adopted Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area¹ (the Regulations) (ISBA/6/A/18).

The Authority requires each Contractor to: i) gather environmental baseline data; ii) establish environmental baselines against which to assess the likely effects of its programme of activities under the plan of work for exploration on the marine environment; and iii) establish a monitoring programme together with the Authority and the sponsoring State(s), the results of which should be reported annually.

Mindful of the need to help Contractors, guidelines were produced to assist Contractors in interpretation of the Regulations. These Recommendations (ISA, 2010) are specific in their details, in contrast to the FAO impact assessment Guidelines (Para 47) that lack detail.

The ISA Recommendations detail the baseline data requirements, which encompass information on physical oceanography, geology, chemical oceanography, sediment properties, biological communities, bioturbation and sedimentation. In addition to an analysis of the data, raw data should be provided in annual reports to obtain a better understanding of the region to enable effective environmental protection.

Activities requiring environmental impact assessments are specified in the Recommendations. They comprise: sampling with epibenthic sled, dredge or trawl (if the sampling area of any one sampling activity exceeds 10,000 m²); the use of specialised equipment to study

¹The "Area" means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction (UNCLOS, Article 1.1)

Kenchington et al., 2009; Best et al., 2010). However, a major problem is the lack of any systematic effort to document what is being caught other than main target species. This prohibits any effort to identify the ecosystem-level impacts of the fishery.

To date, it is predominantly structural species, such as corals and sponges, which have been identified for

the effect of artificial disturbances that may be created on the seafloor; and testing of collection systems.

The previous environmental impact assessment, the details of the methods and equipment to be used in the exploration activities and the location of the test area and boundaries must be submitted to the Secretary-General of ISA at least one year prior to any planned activity.

Depending on the activity to be carried out, Contractors must provide to the Secretary-General information on, *inter alia*: the methods and types of equipment to be used for nodule collection; the depth of penetration into the seabed; the volume and depth of overflow discharge, together with the physical and chemical characteristics of the discharge; the location and boundaries of the test area, test plans and probable duration of the test.

Contractors are also required to provide the Secretary-General with observations and measurements made during the course of the activity, including the dimensions, penetration depth and pattern of the collector tracks on the seafloor, together with details of the sediment collected, re-sedimentation and discharge from the surface vessel.

Following an activity and dependent on the nature of the activity, the Contractor must report to the Secretary-General, *inter alia*: details relating to re-deposited sediment and the abundance, diversity and, where possible, the behaviour of the different types of benthic fauna subjected to re-sedimentation. In addition, changes in the abundance and diversity of benthic fauna in the collector tracks must be reported, including rates of recolonisation, possible changes in the benthic fauna in adjacent areas apparently not perturbed by the activity, as well as the levels of trace metals found in dominant benthic fauna subjected to resettled sediment from the discharge plume.

In addition, and annexed to the Recommendations, is an Explanatory Commentary that explains the rationale behind the Recommendations, as well as methods to be used in carrying out sampling and a glossary of technical terms.

The environmental data collected by the contractors serves two purposes. First, a comprehensive Environmental Impact

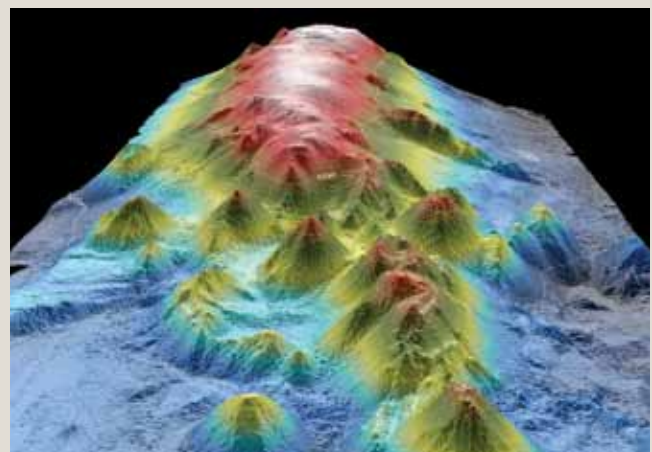
protection, but other vulnerable fish species, including species such as sharks and rays, have so far not been considered for protection, although some RFMOs have identified vulnerable fish populations, in accordance with the FAO Guidelines. The exception to this is CCAMLR, which has gone further than other RFMOs in trying to identify VMEs other than corals and sponges and also has specific programmes directed at vulnerable bycatch

Assessment can be created for any specific application for mining exploitation. This must be agreed before mining takes place. Second, the data for all contractors will be combined to develop a regional environmental management plan.

The ISA plans are subject to regular review so that they can be amended based on the latest scientific knowledge. The ISA recognises that mining contractors play a major role in generating new science and new data. The ISA strives to engage contractors with policy-makers and scientists so that the latest scientific knowledge can guide best environmental practice (BEP), and that the approaches to BEP are consistent between the contractors.

Issues relating to BEP are being guided particularly by a recent ruling by the Seabed Disputes Chamber of the International Tribunal for the Law of the Sea (ITLOS), made in 2010 (ISA, 2011). This addresses, *inter alia*, the obligation of “due diligence” and application of the precautionary principle on the part of the sponsoring State. It also addresses the obligations of the sponsoring State to apply the “best environmental practices” and to adopt measures to ensure the provision of guarantees in the event of an emergency order by the Authority for protection of the marine environment and to provide recourse for compensation.

ISA are currently in the process of producing recommendations for polymetallic sulphide and cobalt crust exploration.



Condor de Terra seamount. (Bathymetry data credits: EMEPC/EMAM)

Identifying VMEs

species such as rays and macrourids (Rogers and Gianni, 2010). However, there is a need to use the full set of criteria in more comprehensive assessments of the likelihood of VMEs (Rice, 2010). Few RFMOs have moved to protect vulnerable fish species caught as bycatch (the main exception is CCAMLR). Fishers generally do not have the skill to identify bycatch species, and even target species may not be identified to species level, for example, deep-water sharks are often pooled together in catch records. Currently no life-history criteria are applied – for example, longevity, reproduction and recruitment. Little account is taken of spawning areas. The exception to this is southern blue ling for which, based on advice from ICES (Large et al., 2010), the European Commission (EC) introduced protection areas for spawning aggregations in EU waters within ICES division VIa. In the high seas of the northeast Atlantic, NEAFC prohibited the use of bottom-contact gear between 15 February and 15 May in one spawning area for blue ling. The prohibition is currently for a three-year period, 2010, 2011 and 2012.

Mapping

Comprehensive mapping incorporating historical data, bycatch data, move-on-rules and new multibeam surveys has not been widely applied except in the southwest Atlantic (Portela et al., 2010), Hatton Bank, North East Atlantic (Moura et al., 2008; Durán Muñoz et al., 2009; 2011; Sayago-Gil et al., 2009; Durán Muñoz and Sayago-Gil, 2010a; 2010b; 2011;) and northwest Atlantic (NAFO, 2009; ICES, 2011; Murillo et al., 2011). In other areas, VMEs are being identified solely on the basis of encounter (for example, CCAMLR in the Ross Sea).

In situ surveys have not been widely applied. One example is the NEREIDA programme, a Spanish-led multidisciplinary international research project involving active participation by Spain, Canada, the UK and the Russian Federation. The driving force for this initiative is to collect data for the identification of vulnerable marine ecosystems in the NAFO regulatory area, especially those that are dominated by large deep-water corals and sponges (Sackville Spur, Flemish Pass, Beothuk Knoll and the southeast Grand Banks, Flemish Cap and the Orphan Knoll). Other Spanish surveys include the ECOVUL/ARPA Spanish project on the Hatton Bank in the northeast Atlantic (Durán Muñoz et al., 2009; Sayago-Gil et al., 2010b), the ATLANTIS project in the southwest Atlantic on the Patagonian Shelf and slope (Portela et al., 2010) and the Walvis Ridge in the southeast Atlantic (see case study: Spanish habitat mapping programme in the high seas).

Predictive modelling

Given that there is little scientific information from large areas of the high seas and that they are reported inconsistently by the RFMOs, better methods are needed for their prediction on a global scale. Although

predictive habitat modelling has improved with the use of higher resolution bathymetry and improved modelling methods (for example, Wilson et al., 2007; Davies and Guinotte, 2011), it is not yet being used for management purposes. Some RFMOs have acknowledged its' potential use and CCAMLR, NAFO, SPRFMO and ICES for NEAFC are all engaged in such work to varying extents.

Area closures

Some VMEs have been identified and fishing activity prohibited, for example in the southern regulatory area of NEAFC, where 30–50 percent of fishable areas are closed. In the southwest Atlantic, Spanish surveys have identified VMEs (Portela et al., 2010). Nine large areas along the Patagonian Shelf and slope were identified as VMEs and were designated as candidate areas to close (a total of 41,300 km²). Following this advice, on 1 July 2011, the Spanish Government implemented a fishing closure for the Spanish fishing bottom fleets in the high seas of the southwest Atlantic (see case study: Spanish habitat mapping programme in the high seas).

Concern was expressed about the length of time taken to get closures in place once areas with VMEs are identified. Given that the recovery times of many deep-sea habitats and populations are very long (hundreds to even thousands of years, if at all) and that damage is cumulative (Fossá et al., 2002; Althaus et al., 2009), precaution needs to be applied in areas where VMEs are likely to occur. Initial temporary precautionary closures could be lifted or followed by permanent closures once further information is available. Currently many VME closures are not permanent but have generally been renewed: for example, in the southern NEAFC region and NAFO seamount closures. Because our knowledge of the deep sea is so limited, the measures taken by NEAFC to close large areas is recognised as good practice and should be applied elsewhere.

The token and inappropriate use of the move-on-rule is no defence for not implementing the core requirement of the UNGA to carry out a prior impact assessment and put in place mitigation measures to prevent significant adverse impacts on VMEs before fishing commences in new areas.

Buffer zones

The need for buffer zones around closed areas was identified. Secondary impacts of fishing activities such as sediment re-suspension and sediment gravity flows (Ferre et al., 2008) are not being considered when the boundaries for closed areas are decided. More studies are needed on the effects of sediment plumes. Furthermore, ICES (2008) suggests that with 2-hourly VMS reporting intervals a 6 nautical mile (nm) buffer zone is needed around closed areas in waters up to 1,000 m



A large catch (about 65 t) of clean orange roughly caught in a 20 minute trawl from a spawning aggregation off New Zealand.

deep to stop fishing vessels “cutting corners” or making other incursions into the area.

Spatial scale of closures

The spatial scale of closures and other measures should reflect the scale of the VME or topographic feature to which they are being applied. For example, move-on rules and bycatch thresholds fail to confer protection when applied to seamounts. ICES (2011) concludes that because of the small size of the trawlable area on most seamounts and the fragility of seamount fauna, the use of an encounter rule alone, without additional management measures, would over time lead to a steady degradation of these habitats.

Recommendations

- A science-based assessment of what constitutes a VME is required for each bioregion and agreed scientific approaches should be applied consistently across bioregions.
- The provision of training and at-sea guides would help observer identification of known VMEs – particularly of non-target species.
- Criteria in the FAO Guidelines for the identification of VMEs should be applied to identify other species that qualify as VMEs and require protection, including vulnerable target and non-target fish species.
- Predictive habitat modelling should be used in the absence of other information on the presence of VMEs.
- Given the long recovery times of deep-sea VMEs, temporary closures may need to be made permanent.
- Buffer zones should be applied to closed areas. These should be of a size that will prevent “edge-effect” fishing incursions encountering VMEs and also offer protection against secondary impacts of fishing.
- The spatial scale of closures and other measures need to reflect the scale of the VMEs or topographic features to which they apply.
- The closure of representative areas of VMEs is a useful approach and should be encouraged, provided that effective management measures are in place to ensure that VMEs are protected in areas that remain open to bottom fishing.

Sustainability of deep-sea fish stocks and bycatch species

The relevant paragraph of the UNGA resolutions is resolution 64/72, paragraph 119(d).

Sustainability of deep-sea fish stocks and bycatch species is one of the most significant failures in the implementation of the UNGA resolutions. Many high seas bottom fisheries target low productivity species such as orange roughy, grenadiers and deep-sea sharks. Many deep-sea species differ from most shallow water species in that they tend to be very long lived, slow growing and late maturing (Koslow et al., 2000; Drazen, 2008; FAO 2009a), and for most stocks caught in high seas bottom fisheries we lack the spawning stock biomass, stock structure and life history data that most fisheries biologists would think essential for sustainable exploitation. This makes them vulnerable to overfishing with little resilience to overexploitation and depletion (Morato et al., 2006b). However, there are exceptions such as the high seas bottom fisheries for Argentinean hake. In addition to the target species, large numbers of species, including low-productivity species, are likely to be taken as bycatch in many high seas bottom fisheries – particularly in bottom trawl fisheries. Bycatch from deep-sea bottom fisheries is often not recorded, or is recorded at a very basic level, not allowing an accurate

determination of fishing mortality at the species level. While some biological attributes are known for most target species, similar knowledge is often lacking for the bycatch species, although life history characteristics of bycatch species are likely to be similar to the target species. It is true to state that for many deep-sea bottom fisheries on the high seas, it is not possible to assess the impacts of fishing mortality on bycatch species.

For some species, a drastic reduction of effort may lead to stabilisation of stock. For example, a 10-year time-series (1998–2008) from a trawl survey along the continental slope to the west of Scotland shows that following the regulation of the fishery in 2003, the initial rapid decline in deep water grenadiers after the onset of unregulated fishing during the 1970s appears to have stabilised – although at much lower levels than the virgin biomass (Neat and Burns, 2010). Temporary closure may lead to recovery. For example, following a rapid decline in abundance, the orange roughy fishery on the Challenger Plateau, northwest of New Zealand's South Island, closed in 2000. Acoustic survey results from 2005 and 2006 to 2009 confirmed a large increase in spawning biomass, which may be partially attributable to the closure (New Zealand Government, 2010).



NIMAFISH

Orange roughy can form high density aggregations. This image covers an area of 3m by 2m seafloor on the summit of a seamount off New Zealand.

Key findings

Sustainability

It is extremely unlikely that the management measures, where they are currently in place, are sufficient to ensure the long-term sustainability of deep-sea fish stocks and non-target species or the rebuilding of depleted stocks. For many such species, there is no assessment of the impacts of the fisheries on target and non-target species. The possible exception to this is the management by CCAMLR of the South Georgia Patagonian toothfish (*Dissostichus eleginoides*) longline fishery. This species is now harvested to planned levels of biomass. The fishery was certified as sustainable by the Marine Stewardship Council (MSC) in 2004 and was unconditionally recertified in 2009, making it the first fishery to receive such unconditional recertification (Rogers and Gianni, 2010). The presence of scientific observers on all vessels operating in the CCAMLR region has resulted in improved data collection and species identification.

Management measures

Management measures are applied unevenly across RFMOs (Rogers and Gianni, 2010). Some fisheries in some areas (for example, CCAMLR, NAFO, NEAFC and SEAFO) have regulations in place to manage target species and some species that are of commercial value taken as bycatch by bottom fisheries in the high seas. However, other fisheries have no management measures in place for deep-sea species – for example in the North and South Pacific Ocean and the Indian Ocean deep-sea fisheries in the high seas. Failure to account for the targeted catch of grenadier in the NAFO area has led to significant decline of several unmanaged species (Devine et al., 2006; Devine and Haedrich, 2008). Other fisheries only have catch limits for some target species. Even where management measures are in place, they generally have not prevented the depletion of target species. There are few formal stock assessments for most target species and fewer still for non-target species.

Precautionary approach

In general, with the possible exception of CCAMLR, the precautionary approach has not been applied to the management of the exploitation of deep-sea species when information is lacking. In 2004 NEAFC established a cap on fishing effort for deep-sea species, and in 2006 NEAFC Contracting Parties agreed to further reduce fishing effort by 35 percent. However, over the duration of these regulations the reported catch has risen from 25,000 tonnes in 2004 to more than 45,000 tonnes in 2008, with the highest catches over 90,000 tonnes being reported for 2007 (Rogers and Gianni, 2010).

Stock information

Stock information on deep-water species is poor. Despite

many years of work, the stock structure, genetics and population dynamics are largely unknown for most species impacted by fishing. Even for the most studied and best-known shallow-water species, biological information that could change how these stocks are managed is still being discovered and there are still arguments about the sizes of stocks, their trends and the causes of any declines (Smith et al., 2011). This is an even greater problem for deep-water fisheries.

The bathydemersal species are the least well known of the world's fishes. Mora et al. (2008) estimated that only around 56 percent of species have been scientifically identified and more than 1,500 species remain to be discovered. Deep-water fisheries in many parts of the world are therefore highly likely to encounter previously unknown species. Even in the best-studied areas of the oceans, there are rare and unknown species. Apart from establishing large area closures to prevent species depletion and extinction, it is very difficult to ensure their long-term sustainability. Reporting of catch is essential and observer manuals should require the collection of unknown species and these should be delivered to scientific laboratories for identification.

Monitoring

To ensure the long-term sustainability of fish species, ideally the life history characteristics, age structure and distribution of target and bycatch species should be known in order to establish effective management measures. The information needed for effective monitoring should:

- Be precise in terms of location of catch and bycatch species per set/tow (for example, start and finish of trawl or long-line set).
- Include a comprehensive accounting of species, including identification of species and quantity of catch.

In some cases, it may be possible to manage some deep-sea fisheries in the absence of detailed knowledge of the life history of the species in question. This would require precise monitoring of trends in the status of deep-sea fish stocks, particularly relative abundance. Such monitoring could include:

- Acoustic survey for aggregating species.
- Monitoring catch per unit effort (CPUE) and other indicators (for example, size distribution, sex) for non-aggregating species, to obtain as much biological information as necessary to determine the trends apparent from the catch. Monitoring of trends in the catch however is unlikely to be suitable for rare species. The only way to ensure at least some protection for such species is to close large areas of the ocean to fishing where such species are known or likely to occur.

Sustainability of deep-sea fish stocks and bycatch species

In the short term, such monitoring could be carried out by commercial fishing vessels and could be accomplished effectively by, for example, cameras on deck, 100 percent observer coverage, and frequent VMS transmissions. Research surveys should include non-commercial species.

The establishment of effective partnerships between the fishing industry and scientists could greatly improve the status of knowledge on target and bycatch species taken in deep-sea bottom fisheries.

Ecological impact

In the North East Atlantic, the peak area of fin-fish species biodiversity lies within a depth range of 1,000–1,500 m. Biodiversity within this depth range is higher than on the shelf and on the upper slope (Stuart et al., 2003). Unfortunately, this is the same depth range as fishing activities and this has serious implications for biodiversity and non-target species (Priede et al., 2011). In this area, over 60 non-target fin-fish species have been identified. There is no doubt that fishing changes the ecology of marine communities. Further, Bailey et al. (2009) propose that the impacts of fishing may extend over a wider and deeper area than that fished, since species travel over a wide area of seabed. Since the fishing removes the apex predators in these habitats, ecosystem-level changes outside of the immediate area/depth of fishing are possible. Comparisons of survey trawls in the Porcupine Seabight and Porcupine Abyssal Plain area of the northeast Atlantic also indicate a significant decrease in total abundance of demersal fish down to 2,500 m following the start of commercial bottom trawl fisheries in this area in the late 1980s (Priede et al., 2011). Although the estimated fishery area is about 52,000 km², the potential impact probably extends to around 142,000 km² and to many non-target species (Ibid.).

It should also be pointed out that many deep-sea fish species undergo ontogenetic vertical migrations so that bigger and older fish are found deeper, as is the case for many scavenging species and Patagonian toothfish. Hence, impacts at one depth may be transferred to deeper waters through reduction in biomass of fish that would migrate into deeper waters.

At present, there is also almost no information on the role of deep-sea species in wider ocean food webs. For example, it is known that sperm whales and killer whales prey on Patagonian toothfish around the waters of South Georgia. Fishing of Antarctic toothfish in the Ross Sea has been implicated in the migration away from the region of killer whales that predate this species (Ainley et al., 2009). The importance of deep-sea demersal fish (especially aggregating species found around seamounts) to higher predators is almost entirely un-investigated.

This means that the wider ecosystem implications of removal of biomass of such species are unknown at the present time. Clearly, this is an area that is in need of urgent scientific study.

One of the challenges posed by these key findings is that data obtained entirely within the fishery (for example, by observers on fishing vessels) will not detect the wider impacts of the fishery. Such impacts might spread into VMEs that are themselves closed to fishing. For this reason, a role for periodic surveys independent of fisheries will remain – including monitoring of areas adjacent to closed areas, or areas deeper than fishing presently reach. Relatively cheap approaches such as baited underwater cameras could be used, as these can be deployed into closed areas and deeper water from standard fishing vessels.

Recommendations

- Given the vulnerability of deep-sea stocks, fishing should only be permitted under limited conditions. For fishing to be permitted, the following steps need to be incorporated collectively into the management of deep-sea fisheries:
 - Ensure that there is no increase in the fishing effort and catch, and no expansion in the geographic extent of existing fisheries, unless there is robust scientific evidence that this intended increase or expansion does not threaten the sustainability of target and bycatch species.
 - Ensure that a monitoring and data collection programme is in place for current and new fishing operations.
 - If data are not forthcoming from the fishery, the fishery should be closed until a scientific/fishery-independent programme can conduct a stock assessment or stock assessments. This should include an assessment of the impacts of fishing mortality on non-target species.
 - Robust monitoring is needed to detect trends in stock abundance and bycatch species.
 - Where there are declining trends in species or insufficient increase in stock abundance to ensure the rebuilding of depleted stocks, the management response needs to be robust, timely and precautionary.
- Target catch limits should not exceed natural mortality (M) and fishing should not proceed until a reasonable estimate of natural mortality has been established.
- For previously unexploited stocks or areas, a precautionary catch limit should be set and the permissible catch levels should be very low to avoid serial depletion. For example, in the case of orange roughy, catch limits of 50 tonnes per seamount.
- Prerequisites for effective deep-sea fisheries

management include the following: the precise location of catch and bycatch species per set/tow (start and finish of trawl); identification of species and quantity, including all bycatch species; standardised reporting; all catch including bycatch must be reported; and 100 percent observer coverage. More than one observer would provide more detailed data.

- The management toolbox for deep-sea species must include: catch limits for targeted and bycatch species; limits on effort; closures (both temporal and spatial) to protect spawning/nursery grounds – for example, deep-sea shark migration routes and North Atlantic blue ling spawning areas (NEAFC, 2010).
- As a precautionary approach, set aside a substantial portion of the representative range of species to be off-limits to fishing.
- Bycatch: in mixed species fisheries, complete catch-data must be made available and the fishery should be managed according to the most vulnerable species in the catch; spatial or temporal closure of a fishery would be triggered by exceeding the limits set for the bycatch species – even if the target catch limit has not been met; closure of a fishery would be triggered

if the most vulnerable bycatch species has shown a significant decline or a failure to recover to levels sufficient to ensure its long-term sustainability. This is dependent on having good knowledge of information such as life history for bycatch species.

- Recovery: the difference in the recovery potential of low productivity deep-sea species as opposed to medium productivity shallower water species needs to be recognised.
- An immediate response to depleted species should be the closure of spawning areas or known areas of mating aggregations.
- Monitoring needs to be done in real time and catch limits need to be very precautionary and low, especially since the margin for error is very narrow with long-lived species.



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Mauritanian reef, North Atlantic.

The move-on rule

The relevant paragraphs of the UNGA resolutions are: resolution 61/105, paragraph 83(d), and resolution 64/72, paragraph 119(c).

The requirement to establish rules to ensure that fishing ceases when potential VMEs are encountered is a complex area of the UNGA resolutions. The rules are important because there is little information on the distribution of benthic ecosystems in many areas of the deep-sea, and hence VMEs are frequently not known prior to fishing activity. It is unlikely that scientific research will be able to identify the location of VMEs on a global scale in the near future because of the vastness of the areas that need to be mapped and researched. The move-on-rule therefore assumes that unknown VMEs will be encountered, requiring the fishing vessel to identify the VMEs whenever they encounter them and take evasive action. Many RFMOs require vessels to move away 2 nm from the encounter, which is presumed to be at the centre of the trawl track. Since individual trawls can be up to 20 km long this provides little protection (Figure 1).

UNGA resolution 61/105, paragraph 83(d) (UNGA, 2007) requires vessels to cease fishing in an area where a VME has been detected and to report the encounter to the appropriate RFMO. This was strengthened in UNGA resolution 64/72, paragraph 119(c) by adding the requirement of RFMOs to define what constitutes an encounter with a VME in terms of bycatch threshold levels and indicator species based on best scientific information. Moreover, paragraph 119(c) also recognised the importance of prior impact assessments to determine the best approach to bycatch threshold levels and move-on rules. The FAO Guidelines (FAO, 2009a) lists examples of species groups and habitat-forming species that are considered potentially vulnerable to fishing impacts. These include cold-water corals, sponges, emergent faunal communities such as hydroids,



Live coral with *Sebastes*, Rockall Bank, North Atlantic.

bryozoans and sessile protozoans, and endemic seep and vent communities. Rogers et al. (2008) reviewed the science behind the FAO Guidelines and attempted to define the levels of bycatch that would be sufficient to trigger a vessel to cease fishing and move on from an area. They suggested a complex set of rules, based on the number of encounters with corals, sponges or other habitat-forming epifauna within fixed areas, but they also suggested that fishing should cease if more than 5 kg of stony coral, coral rubble, sponge or other habitat forming epifauna was recovered in a single haul.

Unfortunately, the encounter protocols or move-on rules have generally set the bycatch limits at such high levels that the rule becomes meaningless. For example NAFO and NEAFC in the North Atlantic, and SEAFO all allow the catch of 60 kg of “live” coral or 800 kg of sponges before the move-on-rule is triggered. Further, the concept of live and dead coral is problematic because the living coral usually caps a framework of dead coral skeletons, and hence the majority of the reef is usually dead. The

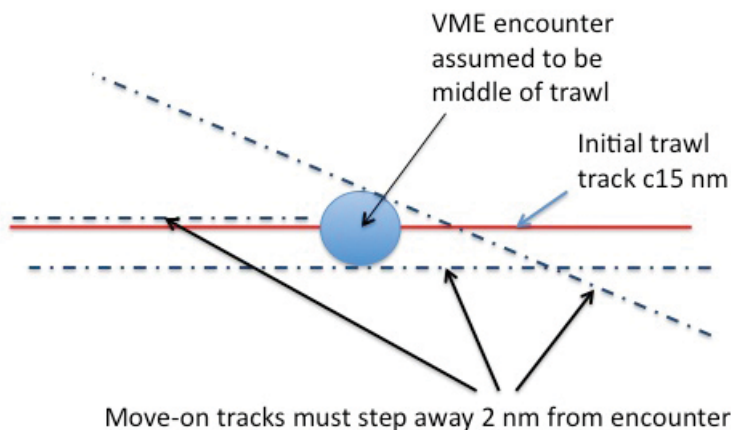


Figure 1. The move-on rule assumes the VME encounter was in the middle of the trawl track, but it could occur anywhere along the track. Move-on distances are usually calculated from the middle of the track – hence the area which must be moved away from in this example is the blue circle. However, since the trawl tracks can be 10–15 nm long, the actual protected area is very small and most of the original track has no protection.

Table 1 – Bycatch thresholds for triggering a move-on			
	Stony corals	Black corals or octocorals	Sponges
Scientists' recommendations ¹	5 kg coral or coral rubble	2 kg	5 kg
Scientists' recommendations ²		0.2 kg for small octocorals, 2 kg for large octocorals, 1.6 kg for sea pens	
NEAFC ³	60 kg live coral		800 kg live sponge
NAFO ³	60 kg live coral		800 kg live sponge
SEAFO ³	60 kg live coral		800 kg live sponge
SPRFMO ⁴	30 kg (New Zealand)	1 kg Antipatharia (New Zealand) 1 kg octocorals (New Zealand)	50 kg (New Zealand)
CCAMLR ³	10 kg (or 10 litres of VME species per 1,000 hooks or 1,200 metres of longline gear)		10 kg (or 10 litres of VME species per 1,000 hooks or 1,200 metres of longline gear)

¹ Rogers et al., 2008, ² WGEAM, 2008, ³ Rogers and Gianni, 2010, ⁴ New Zealand Ministry of Fisheries, 2008

living soft parts of the corals are likely to be preferentially destroyed by trawling. Recent studies have shown that cold-water coral reefs are complex patchworks of actively growing areas and dead areas where the coral structure remains intact. The vast majority of species associated with the complex reef ecosystem are not corals but other invertebrates, and these are often just as abundant in the patches of dead coral as surrounding areas of live coral (Henry and Roberts, 2007). Hence, it is likely that recovered dead corals could indicate harm to a VME, from a living reef complex.

More than 1,300 species of animals have been identified in association with *Lophelia pertusa* reefs in the northeast Atlantic (Roberts et al., 2006), whilst coral blocks dredged from two banks off the Faroe Islands and weighing 18.5 kg contained 4,625 individuals representing 256 species (Jensen and Frederiksen, 1992). Conservation measures should, therefore, be aimed at the cold-water coral ecosystem and not just at the coral species. Focussing only on living coral retained in trawls, especially with values as high as 60 kg per trawl, will lead to massive destruction of the cold-water coral VMEs and is inconsistent with the spirit and expectations of the UNGA resolutions.

Further plaguing the setting of any threshold levels for VME bycatch species is that the retention of VME organisms is variable and can be very unpredictable in nets designed to retain fish. Fragile organisms such as sponges are poorly represented in bottom trawls, even in areas where they are abundant, but can be shown by subsequent seabed imagery surveys (Freese et al., 1999) to have been impacted by trawling, with most

fragments left behind on the seafloor. Freese et al. also show catch efficiencies for bottom trawl nets of less than 1 percent for asteroids, echinoids and molluscs, and 4.6 percent for holothurians. Penney et al. (2009) also argue that bottom trawls do not retain invertebrate taxa efficiently, and report seamount trawls taken from areas with dense and diverse structural fauna arriving on deck with little or no coral bycatch. If the catch efficiency rates determined by Freese et al. (1999) are multiplied by the threshold limits of VME bycatch set by NAFO, NEAFC and SEAFO, then very large impacts on VMEs will be caused before move-ons are triggered. These can easily be in the order of 6,000 kg of “live coral” or 80,000 kg of live sponge (Auster et al., 2011), and soft corals may never be retained in the nets no matter what their density.

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 bycatch data from fisheries research surveys in the NAFO Regulatory Area (WGEAFM, 2009). The method identified the likelihood that, as different types of coral colonies have differing morphology and weights making some more likely to be retained in trawls than others, then different significance should be attached to the levels of bycatch of different types (WGEAFM, 2008). Analysis showed that large catches of corals and sea pens indicating the presence of potential VMEs were quite rare events. Existing bycatch threshold levels for corals and sponges were found to exceed the scientific estimation (1.6 kg per trawl for sea pens, 0.2 kg per trawl for small gorgonian octocorals, 2 kg per trawl for larger gorgonians, and 75 kg for sponges) by one to two orders of magnitude (WGEAFM, 2008). The current

The move-on rule

bycatch threshold levels (Table 1) are likely to have little or no conservation value (Rogers and Gianni, 2010).

Key findings

Reporting

Few if any encounters with VMEs have been reported outside the CCAMLR area. For the encounter protocol to be effective, 100 percent observer coverage is needed. All data collected at the vessel-level (observer data) should be transmitted in a timely manner to the RFMO secretariat, collated to assess cumulative encounters in an area, and then be reported back to the scientific council. This needs to be done constantly on a near-real-time basis.

Definition of VME

Most RFMOs only apply a move-on rule to encounters with corals and sponges. This has resulted in the move-on rules for VME encounters applying to only a limited

number of VME-related species. The exceptions are CCAMLR and New Zealand in the South Pacific, which include a broader range of species as indicators of VMEs.

Density of VMEs

The impact of the rule varies according to the density of VMEs (dense, medium or widespread) in an area where an encounter takes place. For example, on large seamounts the current move-on rule of 2 nm may cause more damage to the same VME, since a seamount should be considered a singular ecosystem. A more effective measure would be to protect selected VME seamounts completely, as recommended by ICES (2011). Once a VME is encountered, the information must be made available to all new vessels in the area.

When to apply

The move-on rule is likely to be most useful in areas already fished. This is because the density of VMEs in fished areas is likely to be lower than in unfished areas,

CASE STUDY

Northeast Atlantic marine protected areas

The current legal instrument guiding international cooperation on the protection of the marine environment of the northeast Atlantic is the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention). The OSPAR Commission is made up of representatives of the Governments of 15 Contracting Parties and the European Commission, representing the European Union.

The 2003, the OSPAR Commission adopted recommendation 2003/3 to establish the OSPAR Network of Marine Protected Areas (MPAs) and to ensure that, by 2010, there is an ecologically coherent network of well-managed MPAs. The aim of the network is to “protect, conserve and restore species, habitats and ecological processes which are adversely affected as a result of human activities”, “prevent degradation of and damage to species, habitats and ecological processes following the precautionary principle” and “protect and conserve areas that best represent the range of species, habitats and ecological processes in the OSPAR area” (OSPAR, 2003a). The network “should take into account the linkages between marine ecosystems and the dependence of some species and habitats on processes that occur outside the MPA concerned”, as well as “taking account of needs of, in particular, highly mobile species, such as certain birds, mammals and fish, to safeguard the

critical stages and areas of their life cycle (such as breeding, nursery and feeding areas) (OSPAR, 2003b). Management plans are required to accompany all OSPAR MPA proposals and guidelines on MPA management and a scorecard to help assess the effectiveness of such plans have also been developed (OSPAR, 2003b; 2007).

As well as referring to the establishment of MPAs within national 200 nm zones, the recommendation also refers to areas beyond the jurisdiction of the Contracting Parties. Within areas beyond national jurisdiction (ABNJ), both Contracting Parties and observers (non-governmental organisations) can make proposals for OSPAR MPAs with the support of at least one Contracting Party. Proposals undergo a formal approval procedure within OSPAR as well as reviews by ICES.

Six marine protected areas were established at the 2010 OSPAR meeting (see figure) covering a total area of 285,000 km², protecting a series of seamounts and sections of the Mid-Atlantic Ridge and hosting a range of vulnerable deep-sea habitats and species. Four of the MPAs (Altair, Antialtair and the Josephine Seamounts, as well as an area of the Mid-Atlantic Ridge north of the Azores) were established in collaboration with Portugal. The establishment of these sites raises a number of issues – for although locations beyond 200 nm are technically “high seas”, any seabed that is part of an UNCLOS outer limit continental shelf extension comes under the control of the relevant coastal State. Hence the water column and seabed may be subject to different jurisdiction for these four MPAs, joint agreement. The joint

and hence the chance of encountering another VME is reduced. Nonetheless, such remnant VME areas in historically fished areas need to be identified through benthic surveys, VMS and/or logbook data from recent years. This is because they may still harbour depleted, threatened or endangered species and thus require enhanced protection to provide opportunities for recovery or regeneration. A three-zone approach (light, medium and heavily fished) could be applied to determine where the move-on rule is applied (Figure 2), though if grid squares are used they should be much smaller than the 20 x 20 minute squares used by New Zealand (Penney et al., 2008, see below). In areas that are only lightly fished or unfished, closures should be seen as the preferred management approach. As they are currently formulated, move-on rules in unfished areas are prone inadvertently to increasing the rate of harm through the dispersion of fishing activities throughout the new region. Hence, in combination with closures, greater precaution is required – lower bycatch thresholds and greater move-on distances.

Limitations of trawls to determine VMEs

The retention-efficiency of the fishing gear influences the amount of bycatch retained. This can vary, even when using the same gear over the same VME. More VME species are likely to be retained at the end of a trawl, when there are fish in the net, than at the start of a trawl when the net is empty. Furthermore, as tows may be as long as 20 nm in length, and are often 5 nm, it is not possible to identify the exact location of the VME encounter(s), or whether the bycatch is the result of a single or multiple encounter(s). Such technical issues cast doubt on the conservation value of move-on rules in general, in particular for mobile fishing gear. If used, they should be seen as management measures of last resort, and should not be expected to address the VME issue on their own.

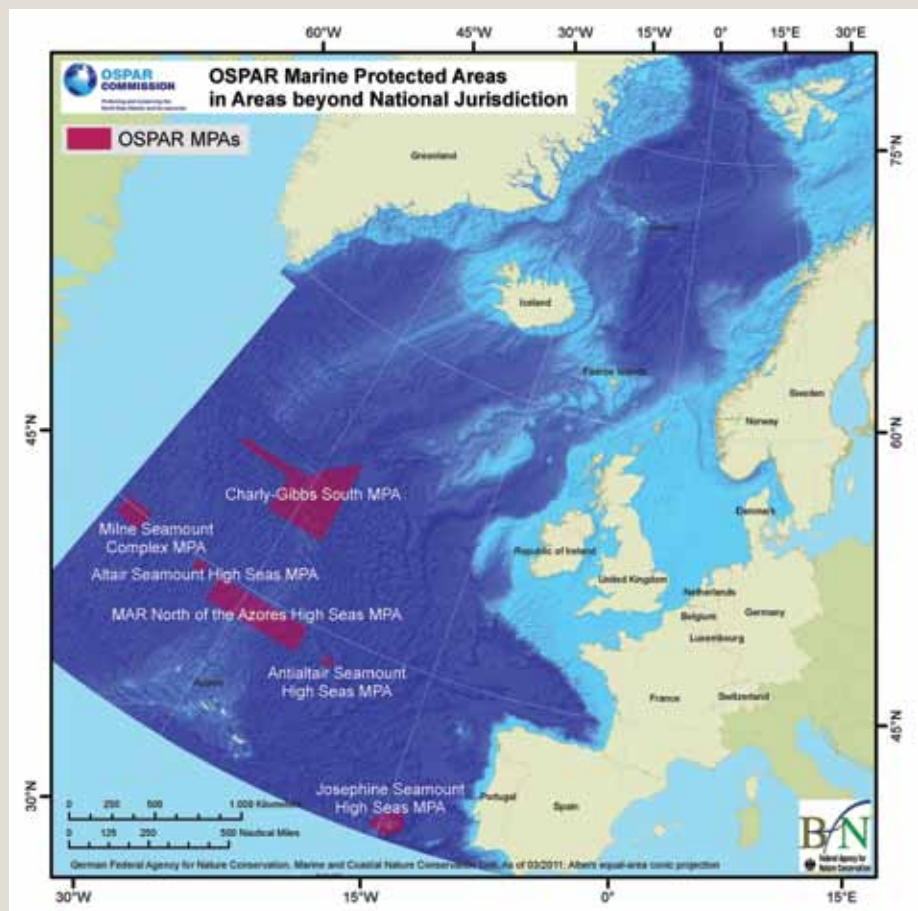
Threshold values

Move-on bycatch thresholds are generally set too high. Currently thresholds range from 10 kg or 10 litres of VME species per 1,000 hooks or 1,200 metres of longline

agreement between OSPAR and Portugal harmonises the arrangement for these four MPAs by allowing Portugal to manage the seabed in collaboration with OSPAR, who will manage the water column. Another complicating factor is that OSPAR does not have competent authority for controlling:

- fishing activities, which is covered by the North East Atlantic Fisheries Commission (NEAFC); or
- mining, which is covered by the International Seabed Authority (ISA); or
- shipping, which is covered by the International Maritime Organisation (IMO).

Hence OSPAR now needs to reach further agreements with these bodies before full protection can be given to the six new sites. NEAFC has already imposed closures for bottom fisheries in four of the new MPA locations, though Milne Seamount and Josephine Seamount do not currently have any protection.



OSPAR Marine Protected Areas (MPAs) in the high seas in areas beyond national jurisdiction, as created in 2010.

The move-on rule

gear in the CCAMLR area to 60 kg for coral and 800 kg for sponge pet longline, pot or gillnet set or trawl tow established by NAFO, NEAFC and SEAFO (Table 1). Bycatch threshold limits need to be appropriate for the specific biogeographic region and taxa concerned, so within a single RFMO there may need to be multiple thresholds that may vary between biogeographic regions within the RFMO regulatory area (ICES, 2010). (See also, for example, the work undertaken by NAFO (WGEAFM, 2008: 2009) described earlier).

Move-on distances

Where there is an association between specific seabed features and both benthic communities and fish aggregations, the move-on rule is unlikely to result in a simple move away from an area containing VMEs to an area that does not. It is more likely to result in a move to another area also probably containing both fish and VMEs (Auster et al., 2011). Under these circumstances, move-on can be counter-productive. The resulting cumulative impacts are extended into surrounding areas, also containing fragile communities with long recovery times, where low fishing-effort can inflict lasting damage (Clark and Koslow, 2007). Move-on distances in unfished areas should be much greater than those in already fished areas.

Recommendations

- 100 percent scientific observer coverage to improve compliance.
- Different sets of criteria to trigger a move-on need to be developed for different areas depending on the complexity of the habitats, otherwise they can cause an increase in the number of impacts.
- In unfished areas, the move-on rule should be applied with much greater precaution, lower thresholds and higher move-on distances than in other areas. It should not be used in isolation, or as a substitute for conducting a prior impact assessment before authorising fishing in an area, but in concert with closures and other more effective measures.
- In areas with small seamounts, the move-on-rule is not suitable and these areas should be closed to bottom contact mobile gear until a suitable alternative is developed.
- Move-on rules should list thresholds for a wide range of species not just corals and sponges.
- Bycatch threshold levels need to be set at appropriate levels, which will generally be much lower than at present.
- Research is needed to determine catch efficiency of nets for VME species.

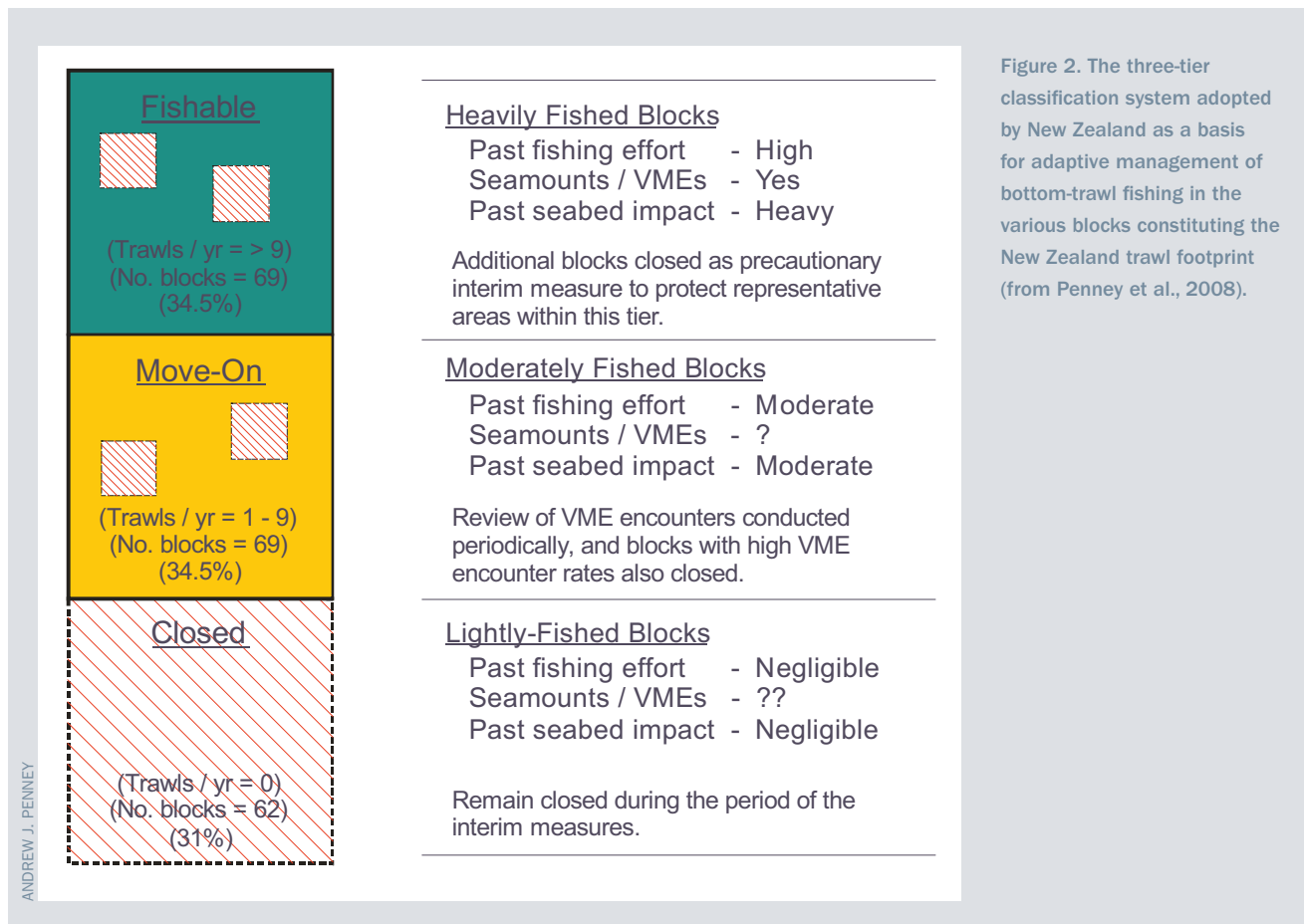


Figure 2. The three-tier classification system adopted by New Zealand as a basis for adaptive management of bottom-trawl fishing in the various blocks constituting the New Zealand trawl footprint (from Penney et al., 2008).

Monitoring, control and surveillance

The relevant paragraphs of the UNGA resolutions and the FAO Guidelines are: resolution 61/105, paragraphs 32 and 47–50; resolution 64/72, paragraphs 62–65 and 70; FAO Guidelines, paragraph 54 (see Annex 3 of this report).

To provide an appropriate framework for promoting compliance with agreed conservation and management measures, UNGA resolution 64/72 calls upon States to adopt comprehensive monitoring, control and surveillance (MCS) measures, as well as compliance and enforcement schemes, individually and also within the regional fisheries management organisations or arrangements in which they participate.

Without effective implementation, conservation and management measures in the deep sea in areas beyond national jurisdiction will be meaningless. Effective MCS measures are critical to ensuring compliance with regulations. By their nature, deep-water fisheries in the high seas operate in remote areas. The problems for effective MCS for such activities are self-evident. While there are a range of technologies currently in use – including onboard observers, manned patrols, aircraft and satellite monitoring – there is urgent need for a more systematic use of technology and investment in MCS systems.

Key findings

IUU fishing

In addition to legitimate fishing activities carried out by ‘cooperative vessels’ (that is vessels participating in a managed activity where monitoring systems are obligatory), there remains the issue of illegal, unreported and unregulated (IUU) fishing. The total global value of IUU fishing is estimated to be between USD10 billion and USD23.5 billion annually, approximately representing between 11 and 26 million tonnes of fish (Agnew et al., 2009). Identifying the incremental ecological impacts of such fishing over and above those of non-IUU fishing is difficult, but the impact in the high seas is likely to be high (MRAG, 2005). Until its extent is known, sound scientific judgements concerning the health and management of stocks are not possible.

Measures to combat IUU fishing might include: i) non-voluntary surveillance by, for example, Satellite Aperture Radar; ii) increased commitments/requirements for flag States to deter IUU vessels and the activities of their nationals on such vessels; iii) robust port state controls (including the enactment of the FAO Port State Measure Agreement); and iv) market-based measures.

The IMO ship identification number scheme, mandatory for all² ships since 1 January 1996 and adopted as a



A section of heavily trawled seafloor on “Morgue seamount” showing tracks from trawl doors and bobbins.

measure to enhance “maritime safety, and pollution prevention and to facilitate the prevention of maritime fraud”, comprises a permanent identification number that is included in the ship’s certificates and remains unchanged upon transfer of the ship to other flag(s). However, vessels that engage solely in fishing are currently exempt from the requirement to have an International Maritime Organisation (IMO) ship number, assigned and validated by IHS Fairplay³. Flothmann et al. (2010) report that the lack of an International Maritime Organization (IMO) ship number made IUU vessels nearly impossible to track. Vessels not complying with UNGA resolution 61/105 – for example, by fishing in a closed area, catching corals or sponges in excess of the bycatch threshold limit, or not moving on – should be viewed as IUU and appropriate measures taken.

Vessel Monitoring System (VMS)

VMS plays a key role in monitoring, control and surveillance programmes nationally and in areas beyond national jurisdiction – the high seas. VMS is intended to assist management agencies in monitoring compliance with measures to control fishing activities related to time (for example, fishing seasons, days at sea, and such like) or area (for example, closed areas, EEZ and RFMO boundaries, and so on). VMS is a ‘cooperative system’, meaning only participating vessels are monitored. Fisheries VMS can only observe vessels that ‘cooperate’

² Other vessels exempt from the scheme are: ships without mechanical means of propulsion, pleasure yachts, ships engaged on special service (e.g. lightships, SAR vessels), hopper barges, hydrofoils, air cushion vehicles, floating docks and structures classified in a similar manner, ships of war and troopships, wooden ships.

³ http://www.ihsfairplay.com/about/imo_standards/imo_standards.html

Monitoring, control and surveillance

by carrying transceivers and using them properly. Cooperative systems, sometimes referred to as voluntary or participatory systems, are usually a legal requirement for participation in a fishery (FAO, 2007a). Although no binding global agreements regarding the use of VMS currently exist, most RFMOs as well as many States have made its use mandatory on larger commercial fishing vessels (flagged to and/or fishing in the waters of the State) (Brooke et al., 2010). For example, all vessels fishing in the NAFO Regulatory Area are required to operate VMS (NAFO, 2011); and Contracting Parties in the NEAFC Regulatory Area must implement a VMS for all fishing vessels exceeding 20 m between perpendiculars or 24 m overall length that fish, or plan to fish, in the NEAFC Regulatory Area (NEAFC, 2011).

Details of the approved VMS equipment and operational use vary with the requirements of the vessel's flag State. Vessels using a VMS carry a unit that transmits and receives signals. Transmissions are sent via a communications satellite to a Fisheries Monitoring Centre (FMC) within the vessel's flag State.

The cost of a VMS unit is approximately USD1,000–4,000, with operating costs of a few hundred dollars a year (Brooke et al., 2010). The VMS data are usually only reported to the vessel's flag State or the EEZ coastal State, and few arrangements exist for data sharing. The South Pacific Forum Fisheries Agency and the European Union are exceptions to this rule. In areas beyond national jurisdiction, enforcement of VMS regulations is the responsibility of flag states, though this may be administered through the RFMOs (ibid.).

As the VMS usually monitors only the vessel position (and in some cases speed and course) and not its activity, further corroboration of violations of, for example, fishing activity and species, is required by boardings or on-board observers (NOAA, 2005). The usefulness

of VMS data can be extended by integration with other information on, for example, catches, boarding and inspection, and permanent vessel data. However, the variety of data types and formats can limit such usefulness. Issues of confidentiality further restrict the integration of information (Brooke et al., 2010).

VMS data typically comprise an identifier, time and date, vessel position, and occasionally course and vessel speed. Analysis of VMS records is vital to be able to assess fishing activities in relation to regulatory actions involving: fishing quotas, harvesting limits, position relative to areas closed to fishing, special management of fishing zones, and license limitations (ICES, 2008). VMS data has also become increasingly important for uses other than as a mechanism to monitor compliance. Alternative uses include the design of marine protected areas (Hall-Spencer et al., 2009), estimating the spatial extent of fishing (Eastwood et al., 2007; Benn et al., 2010), studying the impacts of bottom trawling on benthic ecosystems (Hiddink et al., 2006), and assessing fishing patterns in relation to VMEs (ICES, 2008).

Currently, VMS data is transmitted to the flag State and is then, sometimes much later, passed to RFMOs. A near real-time system of monitoring of VMS data is needed for the high seas, particularly in closed areas. Not all Flag States collect VMS data. Although RFMOs collect VMS data, it is unclear how it is used to ensure compliance. Current reporting is inadequate to ascertain whether there have been infractions against VMEs or any subsequent prosecutions.

The current hourly or 2-hourly intervals between VMS signal transmissions are too long to adequately monitor vessel activity. In response to a request for advice from NEAFC in 2009 on the use of quality of VMS data, ICES (2009) asserted that the quality of the VMS data available at that time was insufficient to provide information on the spatial and temporal extent of the current deep-water fisheries in the northeast Atlantic. It was proposed that the usefulness of the data could be improved by including, *inter alia*: catch reports, the type of gear being used, more frequent reporting of vessel position and the inclusion of vessel speed and heading. A year earlier, ICES (2008) recommended, *inter alia*: increasing the VMS signal frequency (to 30 minutes or less) and including the gear type in the VMS signal. Increased VMS reporting would not only improve enforcement of spatial and temporal measures, but would also provide finer resolution data of, for example encounters with bycatch species and VMEs. Based on an estimated cost per transmission of USD0.07 (IWC, 2005), an increase in the reporting frequency from once every two hours to once every 30 minutes for 200 days



Giant Umbrellula (sea pen), Southern Ocean.



Scientists in discussion at sea.

DAMIEN GUIHEN/NATIONAL UNIVERSITY OF IRELAND, GALWAY

at sea would result in an increase in annual operating costs per vessel of around USD500 (from about USD168 to about USD672 per vessel (Brooke et al., 2010). To increase the reporting frequency to every 15 minutes would result in an annual increase per vessel of about USD850 to USD1,344. Such relatively small incremental costs would be offset by much better data on vessel activities and much less cost and effort required to identify and pursue illegal activities.

Issues of confidentiality frequently prevent VMS data from being made available to the wider scientific community (Benn et al., 2010; Gerritsen and Lordan, 2010), inhibiting the analysis of potential VME encounters. There are no clearly defined routes for access to this data in either Europe or the USA. Current European legislation provides that access to VMS data to be used for 'scientific publication' can be withheld for three years after the date of collection (European Commission, 2008b). Aggregated VMS data, that is the number of vessels in a grid square, are made available more often. However, data in this format are not sufficient to assess fishing activity. As the identity of individual vessels is not required, a more useful alternative would be anonymous detailed data containing a randomly assigned vessel code – replacing the vessel identifier, time/date, vessel position and where available vessel speed and course.

Anecdotal stories of VMS tampering are rampant in all regions of the world, but most RFMOs have not assessed the extent of the problem. Widely held perceptions of VMS confidentiality have largely blocked independent assessments of this potentially significant issue.

Automatic Identification Systems (AIS)

If fishing vessels also carried AIS, as used by other vessels to support vessel traffic routing and safety at sea, then VMS tampering could be more easily identified by comparing the two signals. However, as with IMO numbers (noted above), fishing vessels are currently exempt from AIS requirements in most coastal waters and in the high seas. Such exceptions greatly complicate MCS, not to mention the increased safety risk to the seamen themselves.

Electronic logbooks

The use of electronic logbooks that record vessel location and allow further data to be added by vessel crew is increasing. From January 2011, the use of electronic logbooks became mandatory in the European Union (EC Council Regulation 1966/2006 (European Commission, 2006)), while Australia, Canada and the USA are also implementing the use of electronic logbooks in their fisheries (Brooke et al., 2010). As data are only reported upon the vessel's return to port, the information is not real-time. However, when integrated with other information, such as VMS data, electronic logbook data allows for close monitoring of vessels. One limitation to the effectiveness of this data is that their accuracy depends on the information logged by the vessel crew (Brooke et al., 2010).

Onboard observers

Information on the ways in which fishing vessels operate while at sea is becoming increasingly important. Information on what fish are caught, and how, when and where they are caught, informs the management of fish stocks and the ecosystem of which they are a part. The role of at-sea information is two-fold:

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i) compliance and ii) fishery science (FAO, 2002). The primary role of on-board observers is to monitor the vessel's compliance with relevant measures in force at the time, including: recording details of fishing gear, verifying the vessel's position when engaged in fishing activities, reporting evidence of possible infringements, reporting catch composition, and monitoring bycatch, discards and catches of undersized fish. In addition, observers may also undertake biological sampling, for example, to determine spawning condition. The use of a video camera system filming the net coming onboard could corroborate observer data. The usefulness of such a system could be further enhanced by automatic fish recognition software. The identification of species, particularly non-target species, would be improved by the provision of identification guides (for example Hibberd and Moore, 2009).

Current requirements for observer coverage vary between regions. No observers are required for vessels operating in the NEAFC Regulatory Area (unless in an exploratory fishery in a new area), while all vessels operating in the NAFO Regulatory Area are required to carry a compliance observer. In CCAMLR, all vessels carry at least one international science observer in addition to one observer from the flag State; and SPRFMO interim measures require that all participants (in the negotiations to establish a South Pacific Regional Fisheries Management Organisation) "appoint observers to each vessel flying their flag and undertaking or proposing to undertake bottom trawling activities ... and ensure an appropriate level of observer coverage on vessels flying their flag and undertaking other bottom fishing activities in the Area."

Port State measures

Following voluntary port state measures agreed in 2004 (FAO, 2007b), the FAO approved a legally binding Port State Measures Agreement (PSMA) in November 2009 (FAO, 2009b). The PSMA, which is not yet in force, would require port states to designate the ports that may be accessed by foreign-flagged fishing vessels, and to deny port access and port services to foreign vessels that may have engaged in, or supported, IUU fishing. Although the provisions of the Agreement are intended to relate only to foreign-flagged vessels, States must ensure that their own vessels are subject to equally effective measures.

An example of good practice is that of NEAFC which, in 2007, introduced Port State Controls that effectively closed European ports to landings and transshipment by foreign vessels of frozen fish, caught in Convention Area, unless they are verified to be legal by the Flag State of the vessel. This is supported by direct inspection in the European ports designated by NEAFC (NEAFC, 2011). The list of designated ports is also incorporated into



A Soviet trawler typical of fleets which fished throughout the world's oceans in the 1970s and 1980s. These types of vessels pioneered the development of many deep-sea fisheries.

European Union legislation (European Commission, 2009a; European Commission, 2009b).

Compliance

It is currently unclear how protection of VMEs is being enforced by RFMOs. Compliance Committees of RFMOs need to fully review and make publicly available information on all aspects of the UNGA resolutions, including compliance assessments as well as suspected non-compliance and what follow-up actions were taken. Compliance with existing and new VME measures will be critical to their success, requiring greater RFMO reporting and accountability than seen to date.

Recommendations

- Estimates of IUU should be part of RFMO reporting.
- RFMO requirement that all fishing vessels have IMO ship numbers.
- Mandatory VMS, where not already required.
- The time interval between VMS transmissions should be reduced to 15 minutes.
- VMS data should record the gear type and size, the start and end position of fishing, and fishing time.
- 100 percent observer coverage is needed to ensure data quality. Where appropriate, for example in 24-hour fisheries, two observers are needed on each vessel.
- Electronic logbooks should record fishing times and locations.
- Fisheries data (including VMS data, landings and effort data and encounters with VMEs) should be made available on a timely basis to independent researchers.
- Annual data on fishing activity, catch, bycatch, reports on encounters, monitoring of closed areas, identification and scale of VMEs, compliance, as well as suspected non-compliance and follow-up activities, should be made openly available by RFMOs.

CASE STUDY (pages 31-33)

SEAFO seamount closures in data-poor areas

In 2006, following recommendations from the SEAFO Scientific Committee, SEAFO took a precautionary approach and introduced closed areas to protect VMEs that were likely to exist on 13 seamount assemblages in the SEAFO Convention Area (CA) – Conservation Measure (CM) 06/06 (SEAFO, 2006). The SEAFO Fisheries Commission (SFC) implemented closure areas around 10 of these assemblages. On the basis of available information, these were considered to be either unexploited or lightly exploited. Closure would remain in place until the necessary scientific information had been collected in order to permit an assessment of the areas concerned.

All fishing activities for species covered by the SEAFO Convention were prohibited from 1 January 2007 to 31 December 2010 in the areas defined (figure A). The measures proposed that the Commission would consider allowing access from 1 January 2008 on a small scale and a restricted exploratory fishery for an area not exceeding 20 percent of the fishable area of each seamount. The SEAFO Scientific Committee would recommend to the Commission representative areas that may be fished, based on existing survey and commercial data from the seamount areas. The Scientific Committee was also requested to provide the Commission with a protocol for the collection of the data required to assess the stocks on the seamounts, with a view to developing future recommendations on management measures for these areas.

It was further recommended that, for fishing to resume in closed areas, there should be mapping of vulnerable habitats (corals, sponges) and that research proposals should be submitted to the Scientific Committee for consideration before any activity took place (SEAFO, 2007). The Committee also agreed that exploratory fishing surveys in unexplored areas should not be permitted, as they may cause irreversible damage to the seamounts. Instead, it was agreed that in these areas, a preliminary evaluation of the habitat



Broken coral and trawl marks, Rockall Bank, North Atlantic.



Blackbelly rosefish, *Helicolenus dactylopterus*.

vulnerability to exploitation and mapping should be carried out using tools with minor impact effect over the bottom (for example, multibeam sonar). For already-exploited areas, the Committee agreed that plans for exploratory fisheries should be reported to the SEAFO Secretariat for evaluation by the Scientific Committee (SEAFO, 2007b).

In 2007, Conservation Measure (CM) 11/07 was adopted (SEAFO, 2007a). This was based on advice in the Scientific Committee 2007 report on measures to be taken before fishing can resume in the closed areas, also noting the need for the precautionary approach, and laying down conditions for the resumption of fishing activities in areas closed through CM 06/06. The Measure established that, in the absence of advice from the Scientific Committee, the areas should remain closed to fishing. It continued that areas should remain closed until VMEs had been identified and mapped, and an assessment made of the impact of any resumption of fishing there. Contracting Parties may submit Research Fishing Plans for evaluation of the impact on both the sustainability of fish stocks and possible impacts on VMEs. The Scientific Committee would submit its recommendation to the Commission for a decision on re-opening areas.

In 2008, the only new information provided was a survey report by the Spanish Instituto Español de Oceanografía and the Namibian National Marine Information and Research Centre. This was an exploratory study to locate and identify bioconstructions associated with seamounts as potential VMEs (SEAFO, 2008). The closures remained in force.

The Committee noted that more information on the spatial distribution and extent of seamount areas and their associated fauna was required for the review of closed areas scheduled for 2010, and recommended that the best available bathymetry data be compiled (by a consultant) and a detailed map of bottom topography of the SEAFO CA developed. It also recommended that the use of predictive methods to identify the possible areas of VMEs be explored (SEAFO, 2008).

CASE STUDY (pages 31-33)

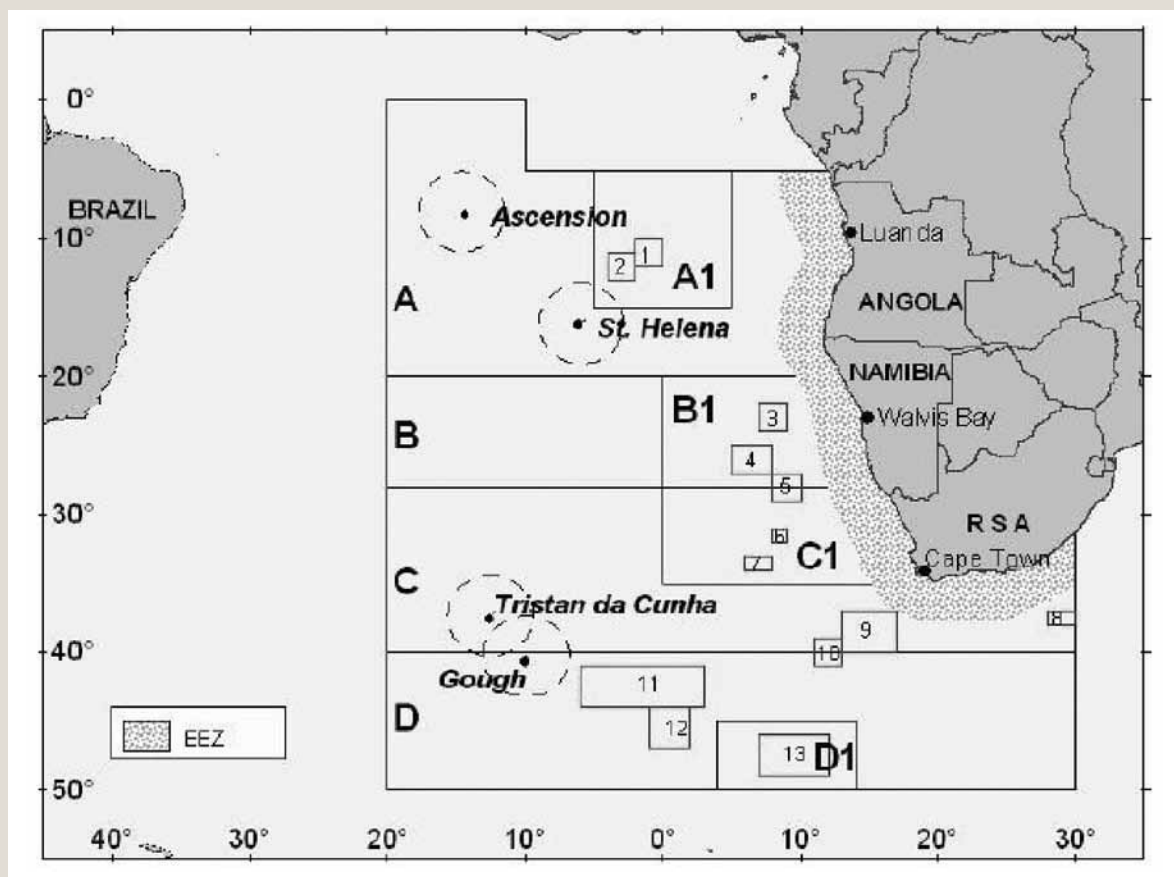


Figure A: Seamounts closed to fisheries by CM 06/06.
 Sub-division A1: 1 Dampier Seamount, 2 Malahit Guyot Seamount.
 Sub-division B1: 5 Molloy Seamount.
 Division C: 9 Schmidt-Ott Seamount and Erica Seamount, 8 Africana Seamount, 10 Panzarini Seamount.
 Sub-division C1: 6 Vema Seamount, 7 Wust Seamount.
 Division D: 11 Discovery, Junoy, Shannon Seamounts, 12 Schwabenland and Herdman Seamounts. (SEAFO, 2006)
 CM 06/06 also required Contracting Parties to provide information

on past fishing activities in the areas for the years 2004, 2005 and 2006. Vessels were only allowed to fish in the permitted areas from 1 January 2008, and were required to carry a scientific observer on board. Later, in 2007, the Scientific Committee report states that, as there was no information available on the spatial distribution of vulnerable habitats and fishing activity on the individual seamounts in the closed areas, it considered it inappropriate to recommend that areas could be opened to fishing.

A second joint Spanish-Namibian survey was conducted in 2009.

The 2010 Scientific Committee report noted that biological knowledge on seamount VMEs and chemosynthetic communities remained sparse. Mapping and a report by the National Oceanography Centre, Southampton (NOCS) in the UK (NOCS, 2010) concluded that “any isolated topographic feature that rises to within 1,000 m of the ocean/sea surface should be regarded as having the potential to host vulnerable marine ecosystems”. The Scientific Committee was of the view that the report provided a basis to proceed with caution. To account for the possible existence, indicated in the NOCS Report, of chemosynthetic communities at depths greater than 1,000 m and that the maximum potential depth of deep-water fishing is around 2,000 m, seamounts penetrating into the upper 2,000 m of the water column were considered in the decision making process. No further

information on VMEs from the joint Spanish-Namibian, Norwegian or MAR-ECO surveys were available at that time and information from observers indicated that there were no records of the VME encounter threshold levels being exceeded in 2010.

Based on the available information, the Scientific Committee reviewed the existing closed/open areas (figure A) in the light of the new information.

The Scientific Committee adopted a stepwise approach to the review process (SEAFO, 2010a):

Step 1: The existing closed/open areas were reviewed to determine if they were fit for purpose in relation to the new and improved information available on the distribution of seamounts;

Step 2: Any changes necessary to the existing closed/open areas were identified;

Step 3: The available information on the distribution of VME indicator species was considered;

Step 4: Any revisions to the existing closed/open areas were made using the modified NOCS criteria;

Step 5: Potential new seamount areas were identified on the basis of the modified NOCS criteria;

Step 6: Existing closed/open areas (including those proposed to be modified) and proposed new areas were reviewed, taking into account the available information on the historical spatial distribution of fishing;

Step 7: Suggested closed areas for inclusion in a revised Regulation 06/06 were identified.

Despite a lack of consensus on some aspects (these were recorded in the revised text), CM 06/06 was revised to incorporate the new information, and at the 2010 annual meeting the Commission agreed to the revision and closed 11 seamount areas recommended by the Scientific Committee (figure B) (SEAFO, 2010b). The closures applied from 1 January 2011 to an undetermined future date.

The eleven closures encompass large areas of seamounts and ridge systems at fishable depths within the SEAFO convention area. The five closures along the Southern Mid Atlantic Ridge (MAR) are designed to incorporate representative areas of the five biogeochemical provinces within the SEAFO area as recommended by the NOCS Report. However, large areas of seamounts and ridge systems remain open to continued bottom fishing, including areas where VMEs are likely to occur. No impact assessments have been conducted to determine whether significant adverse impacts would occur to VMEs from bottom fishing in the open areas. The only conservation measure in effect to protect VMEs in these areas is a move-on rule with threshold limits of 60 kg of live corals and 800 kg of live sponges.

The approach to the protection of VMEs by SEAFO is similar to the approach adopted by NEAFC along the northern Mid Atlantic Ridge and by New Zealand in the South Pacific – with bottom fishing closures largely located in areas of little or no interest to commercial fishing operations and encompassing ‘representative’ areas of VMEs.

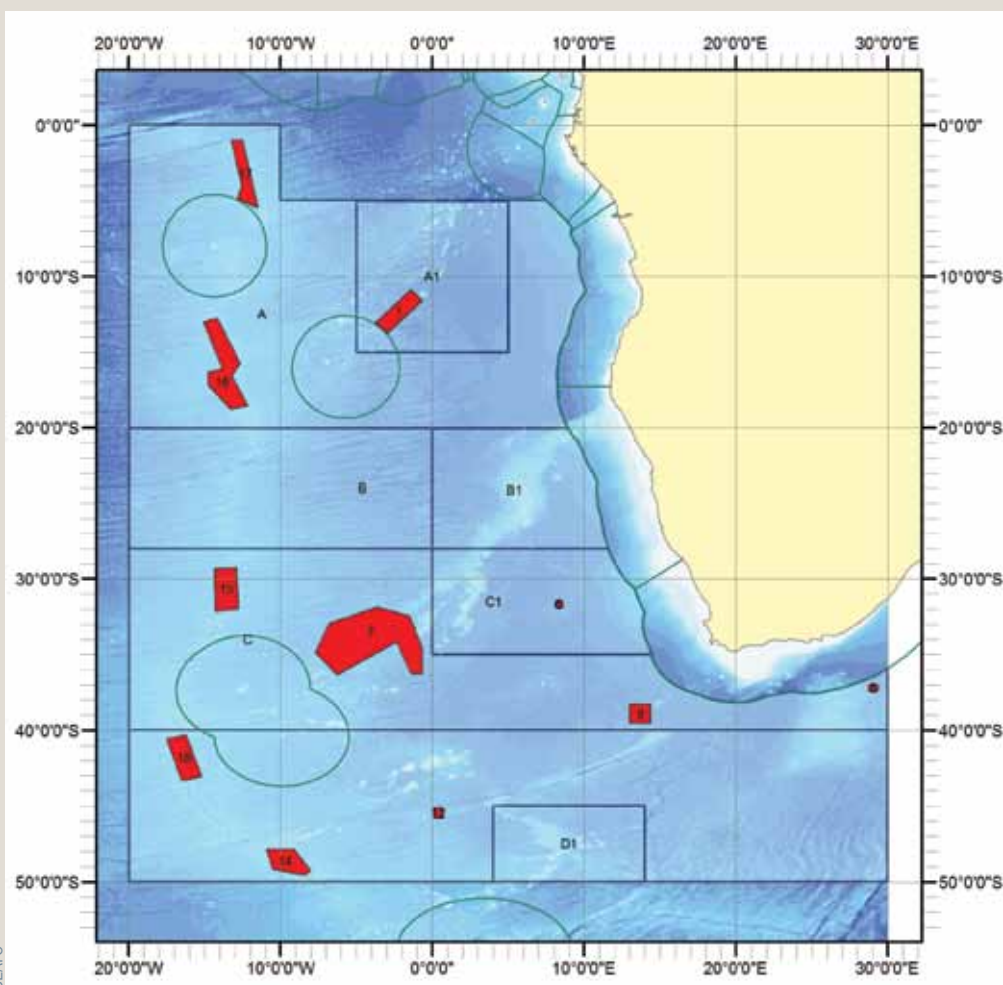


Figure B: Closed seamounts amended under revised CM 06/06 and their status as considered by SEAFO Scientific Committee
 Division A: 16 Kreps seamount (unexploited), 17 unnamed (unexploited).
 Sub-division A1: 1 Malachit Guyot Seamount (unexploited).
 Division C: 7 Wüst seamount (slightly exploited); 8 Africana seamount (unexploited); 9 Schmidt-Ott Seamount (slightly exploited); 15 unnamed (unexploited).
 Sub-division C1: 6 Vema Seamount (slightly exploited).
 Division D: 12 Herdman Seamounts (unexploited); 14 Unnamed (unexploited); 18 unnamed (slightly exploited) (SEAFO, 2010b).

References

- Agnew, D.J., Pearce, J., Pramod, G., Peatman, T., Watson, R., et al. (2009) Estimating the Worldwide Extent of Illegal Fishing. *PLoS ONE*, 4(2): e4570. doi:10.1371/journal.pone.0004570
- Ainley, D.G., Ballard, G., Olmastro, S. (2009) An apparent decrease in the prevalence of “Ross Sea killer whales” in the southern Ross Sea. Document SC/61/SM26, submitted to the Scientific Committee for the Conservation of Antarctic Marine Living Resources, 16pp.
- Althaus, F., Williams, A., Schlacher, T.A., Kloser, R.J., Green, M.A., Barker, B.A., Bax, N.J., Brodie, P., Schlacher-Hoenlinger, M.A. (2009) Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. *Marine Ecology Progress Series* 397: 279-294.
- Amante, C., Eakins, B.W. (2009) ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24, 19 pp, March 2009.
- Anderson, O.F. (2006) A summary of biological information on the New Zealand fisheries for orange roughy (*Hoplostethus atlanticus*) for the 2003-04 fishing year. New Zealand Fisheries Assessment Report No. 2006/16. 25pp
- Ardron, J.A. (2005) Protecting British Columbia's Corals and Sponges from Bottom Trawling. A Report by Living Oceans Society, Sointula, British Columbia, Canada, 21pp.
- Auster, P.J., Gjerde, K., Heupel, E., Watling, L., Grehan, A., Rogers, A.D. (2011) Definition and detection of vulnerable marine ecosystems on the high seas: problems with the “move-on” rule. *ICES Journal of Marine Science* 68(2), 254–264. doi:10.1093/icesjms/fsq074
- Bailey, D.M., Collins, M.A., Gordon, J.D.M., Zuur, A.F., and Priede, I.G. (2009) Long-term changes in deep-water fish populations in the northeast Atlantic: a deeper reaching effect of fisheries? *Proc. R. Soc. Lond. B Biol. Sci.*, 276(1664), 1965-1969. doi: 10.1098/rspb.2009.0098
- Benn, A.R., Weaver, P.P.E., Billett, D.S.M., van den Hove, S., Murdock, A.P., et al. (2010) Human Activities on the Deep Seafloor in the North East Atlantic: An Assessment of Spatial Extent. *PLoS ONE*, 5(9): e12730. doi:10.1371/journal.pone.0012730
- Bensch, A., Gianni, M., Grébroval, D., Sanders, J.S., Hjort, A. (2008) Worldwide review of bottom fisheries in the high seas. *FAO Fisheries and Aquaculture Technical Paper No. 522*, Food and Agricultural Organization of the United Nations, Rome, Italy, 145pp.
- Best, M., Kenchington, E., Maclsaac, K., Wareham, V.E., Fuller, S.D. and Thompson, A.B. (2010) Sponge Identification Guide NAFO Area. *Scientific Council Studies*, 43: 1–50. doi:10.2960/S.v43.m1
- Brooke, S.D., Lim, T.Y., and Ardron, J.A. (2010) Surveillance and enforcement of remote maritime areas. Paper 1: surveillance technical options. *Marine Conservation Biology Institute, USA*. Version 1.2; 39pp.
- CCAMLR (2007) Schedule of Conservation Measures in Force, 2007/08. CCAMLR, Hobart, Australia: 192pp.
- CCAMLR (2008) Report of the twenty-seventh meeting of the Commission. Hobart, Australia, 27 October–7 November, 2008, CCAML R-XX VII, Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, Australia, 203pp.
- CCAMLR (2009) CCAMLR VME Taxa Identification Guide Version 2009. Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, Australia. 4 pp. Available at www.ccamlr.org/pu/e/e_pubs/VME_guide.pdf
- CCAMLR (2010) Schedule of Conservation Measures in Force 2010/2011 Season. Commission for the Conservation of the Antarctic Living Resources, Hobart, Tasmania, Australia, 224pp.
- Clark, M.R. (2008) Descriptive analysis of orange roughy fisheries in the New Zealand region outside the EEZ: Lord Howe Rise, Northwest Challenger Plateau, West Norfolk Ridge, South Tasman Rise, and Louisville Ridge to the end of the 2005/06 fishing year. *New Zealand Fisheries Assessment Report No. 2008/12*. 46pp.
- Clark, M.R., Dunn, M. R., Anderson, O.F. (2010) Development of estimates and sustainable catches for orange roughy fisheries in the New Zealand region outside the EEZ: CPUE analyses, and application of the “seamount meta-analysis” approach. *New Zealand Fisheries Assessment Report*. 2010/19.
- Clark, M.R., Koslow, J.A. (2007) Impacts of fishing on seamounts. In: Pitcher T.J., Morato, T., Hart, P.J.B., Clark, M.R., Haggan, N., Santos, R.S. (eds) *Seamounts: Ecology, Fisheries and Conservation*, Fish and Aquatic Resources Series 12, Blackwell Publishing, Oxford, UK, pp.413–441
- Clark, M.R., O'Driscoll, R. (2003) Deep-water fisheries and aspects of their impact on seamount habitat in New Zealand. *Journal of Northwest Atlantic Fishery Science* 31: 441–458.
- Clark, M.R., Roberts, C.D. (2008) Fish and invertebrate biodiversity on the Norfolk Ridge and Lord Howe Rise, Tasman Sea (NORFANZ voyage, 2003). *Aquatic Environment and Biodiversity Report No. 28*. 131pp.
- Clark, M.R., Rowden, A.A. (2009) Effect of deepwater trawling on the macro-invertebrate assemblages of seamounts on the Chatham Rise, New Zealand. *Deep-Sea Research I* 56: 1540–1554.
- Clark, M.R., Rowden, A.A., Schlacher, T., Williams, A., Consalvey, M., Stocks, K.I., Rogers, A.D., O'Hara, T.D., White, M., Shank, T.M., Hall-Spencer, J. (2010) The ecology of seamounts: structure, function, and human impacts. *Annual Review of Marine Science* 2: 253–278.
- Clark, M.R., Tittensor, D., Rogers, A.D., Brewin, R., Schlacher, T., Rowden, A., Stocks, K., Consalvey, M. (2006) Seamounts, deep-sea corals and fisheries: vulnerability of deep-sea corals to fishing on seamounts beyond areas of national jurisdiction. *UNEPWCMC*, Cambridge, UK.
- Davies, A.J., Guinotte, J.M. (2011) Global Habitat Suitability for Framework-Forming Cold-Water Corals. *PLoS One* 6(4): e18483. doi:10.1371/journal.pone.0018483
- Davies, A.J., Wisshak, M., Orr, J.C., Roberts, J.M. (2008) Predicting suitable habitat for the cold-water coral *Lophelia pertusa* (Scleractinia). *Deep-Sea Research I* 55, 1048–1062.

- Devine, J.A., Baker, K.D., Haedrich, R.I. (2006) Deep-sea fishes qualify as endangered. *Nature* 439: 29.
- Devine, J.A., Haedrich, R.L. (2008) Population trends and status of two exploited Northwest Atlantic grenadiers, *Coryphaenoides rupestris* and *Macrourus berglax*. In: Orlov, A.M., Iwamoto, T. (eds) Grenadiers of the World Oceans: Biology, Stock Assessment and Fisheries. American Fisheries Symposium 63: Springer, Heidelberg.
- DeVries, A.L., Ainley, D.G., Ballard, G. (2007) Decline of the Antarctic toothfish and its predators in McMurdo Sound and the Southern Ross Sea, and recommendations for restoration. CCAML R WG-EMM 08/07, 20pp.
- Drazen, J.C. (2008) Energetics of grenadier fishes, in Orlov AM, Iwamoto T (eds.) Grenadiers of the World Oceans: Biology, Stock assessment, and Fisheries. American Fisheries Society, pp.203–223.
- Durán Muñoz, P, Murillo, F.J., Sayago-Gil, M., Serrano, A., Laporta, M. Otero, I. and Gómez, C. (2011) Effects of deep-sea bottom longlining on the Hatton Bank fish communities and benthic ecosystem, north-east Atlantic. *Journal of the Marine Association of the United Kingdom*, 91: 939–952.
- Durán Muñoz, P and Sayago-Gil, M. (2011) An overview of cold-water coral protection on the High Seas: The Hatton Bank (northeast Atlantic) – a case study. *Marine Policy*, 35: 615–622.
- Durán Muñoz, P, Sayago-Gil, M., Cristobo, J., Parra, S., Serrano, A., Díaz del Rio, V., Patrocinio, T., Sacau, M., Murillo, F. J., Palomino, D., and Fernández-Salas, L. M. (2009) Seabed mapping for selecting cold-water coral protection areas on Hatton Bank, Northeast Atlantic. *ICES Journal of Marine Science*, 66: 2013–52.
- Eastwood, P.D., Mills, C.M., Aldridge, J.N., Houghton, C.A. and Rogers, S.I. 2007. Human activities in UK offshore waters: an assessment of direct, physical pressure on the seabed. *ICES Journal of Marine Science*, 64, 453-463.
- Edinger, E., Baker, K., Devillers, R., et al. (2007) Coldwater Corals off Newfoundland and Labrador: Distribution and Fisheries Impacts. WWF-Canada, Toronto, Canada, 41pp.
- Edinger, E., Wareham, V., Baker, K., Haedrich, R. (2009) Relationships between deep-sea corals and groundfish. In: Gilkinson, K., Edinger, E. (eds) The ecology of deep-sea corals of Newfoundland and Labrador waters: biogeography, life history, biogeochemistry, and relation to fishes. Canadian Technical Report of fisheries and Aquatic Science, no. 2830, vi + 136pp.
- European Commission (2006) Corrigendum to Council Regulation (EC) No 1966/2006 of 21 December 2006 on electronic recording and reporting of fishing activities and on means of remote sensing. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:036:0003:0005:en:pdf>.
- European Commission (2008a) Council Regulation (EC) No 734/2008 of 15 July 2008 on the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears. *Official Journal of the European Union*, L 201/8.
- European Commission (2008b) Council Regulation (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy. *Official Journal of the European Union*, [Online] <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:060:0001:0012:en:pdf>.
- European Commission (2009a) Council Regulation (EC) No 43/2009 of 16 January 2009 fixing for 2009 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required. *Official Journal of European Union*, L 22/1-205.
- European Commission (2009b) List of ports where landing or transshipping is allowed of frozen fish caught third-country fishing vessels in the north-east Atlantic fisheries convention area *Official Journal of European Union*, 2009/C 134/06.
- European Commission (2009c) Council Regulation (EC) No 1288/2009 of 27 November 2009 establishing transitional technical measures from 1 January 2010 to 30 June 2011. *Official Journal of the European Union* L 347, 24 December 2009. 3pp.
- FAO (2002) Guidelines for developing an at-sea fishery observer programme. Davies, SL and Reynolds, JE (eds.) FAO Fisheries Technical Paper. No.414. Food and Agriculture Organization of the United Nations, Rome, Italy. 116pp.
- FAO (2005) Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries. Part 1: Conference reports 1–5 December 2003 Queenstown, New Zealand. Food and Agriculture Organization of the United Nations, Rome, Italy. 718pp
- FAO (2006b) General Fisheries Commission for the Mediterranean. Report of the ninth session of the Scientific Advisory Committee. Rome, Italy, 24-27 October 2006. FAO Fisheries Report No. 814. Food and Agriculture Organization of the United Nations, Rome, Italy. 106pp
- FAO (2007a) Report of the Expert Consultation on the Use of Vessel Monitoring Systems and Satellites for Fisheries Monitoring, Control and Surveillance, Rome, 24–26 October 2006. FAO Fisheries Report. No. 815. Food and Agriculture Organization of the United Nations, Rome, Italy. 68pp.
- FAO (2007b) Model Scheme on Port State Measures to Combat Illegal, Unreported, and Unregulated Fishing. Food and Agriculture Organization of the United Nations, Rome, Italy. 46pp.
- FAO (2008) Deep-sea fisheries in the high seas: a trawl industry perspective on the International Guidelines for the Management of Deep-sea Fisheries in the High Seas. FAO Fisheries and Aquaculture Circular, No. 1036, Food and Agriculture Organization of the United Nations, Rome, Italy. 22pp.
- FAO (2009a) International Guidelines for the Management of Deep-Sea Fisheries in the High Seas. Food and Agricultural Organization of the United Nations, Food and Agriculture Organization of the United Nations, Rome, Italy. 73pp.

References

- FAO (2009b) Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing. Rome, FAO. Online: FAO 2006a Report and documentation of the Expert Consultation on Deep-sea Fisheries in the High Seas. Bangkok, Thailand, 21–23 November 2006. FAO Fisheries Report. No. 838. Food and Agriculture Organization of the United Nations, Rome, Italy. 203pp.
- Ferre, B., Durrieu de Madron, X., Estournel, C., Ulses, C., Le Corre, G. (2008) Impact of natural (waves and currents) and anthropogenic (trawl) resuspension on the export of particulate matter to the open ocean Application to the Gulf of Lion (NW Mediterranean). *Continental Shelf Research* 28 (2008) 2071–2091
- Fisheries Agency of Japan (2008a) Report on Identification of Vulnerable Marine Ecosystems in the Emperor Seamount and Northern Hawaiian Ridge in the Northwest Pacific Ocean and assessment of impacts caused by bottom fishing activities on such vulnerable marine ecosystems or marine species as well as conservation and management measures to prevent significant adverse impacts (Bottom Trawl), December 2008. Appendix H. Yamigamoto, T., Takao, Y., Abe, K. Distribution of four orders of corals observed by ROV survey. Powerpoint presentation, 23 slides.
- Fisheries Agency of Japan (2008b) Report on Identification of Vulnerable Marine Ecosystems in the Emperor Seamount and Northern Hawaiian Ridge in the Northwest Pacific Ocean and Assessment of Impacts Caused by Bottom Fishing Activities on such Vulnerable Marine Ecosystems or Marine Species as well as Conservation and Management Measures to Prevent Significant Adverse Impacts (Bottom Trawl). 17pp.
- Fisheries Agency of Japan (2008c) Report on Identification of Vulnerable Marine Ecosystems in the Emperor Seamount and Northern Hawaiian Ridge in the Northwest Pacific Ocean and Assessment of Impacts Caused by Bottom Fishing Activities on such Vulnerable Marine Ecosystems or Marine Species as well as Conservation and Management Measures to Prevent Significant Adverse Impacts (Bottom Gillnet) 17pp.
- Flothmann, S., von Kistowski, K., Dolan, E., Lee, E., Meere, F., Album, G. (2010). Closing Loopholes: Getting Illegal Fishing Under Control. *Science* 328:1235-1236.
- Fosså, J., Mortensen, P., Furevik, D. (2002) The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. *Hydrobiologia* 471: 1–12.
- Freese, L., Auster, P.J., Heifetz, J., Wing, B.L. (1999) Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. *Marine Ecology Progress Series* 182: 119–126.
- Gass, S.E., Willison, J.H.M. (2005) An assessment of the distribution of deep-sea corals in Atlantic Canada by using both scientific and local forms of knowledge. In: Freiwald, A., Roberts, J.M. (eds) *Cold-Water Corals and Ecosystems*, Springer-Verlag, Berlin Heidelberg, Germany, pp. 223–245.
- Gerritsen, H., and Lordan, C. (2010) Integrating vessel monitoring systems (VMS) data with daily catch data from logbooks to explore the spatial distribution of catch and effort at high resolution. *ICES Journal of Marine Science*, doi:10.1093/icesjms/fsq137.
- Gianni, M., and Bos O. G., (in press) Protecting ecologically and biologically significant areas: lessons learned from the implementation of UN resolutions to protect deep-sea biodiversity. IMARES - Institute for Marine Resources & Ecosystem Studies. Wageningen, Netherlands.
- Hall-Spencer, J., Allain, V., Fosså, J.H. (2002) Trawling damage to Northeast Atlantic ancient coral reefs. *Proceedings of the Royal Society of London, Series B: Biological Sciences* 269: 507–511.
- Hall-Spencer, J.M., Tasker, M., Soffker, M., Christiansen, S., Rogers, S., et al. (2009) Design of Marine Protected Areas on high seas and territorial waters of Rockall Bank. *Marine Ecology Progress Series*, 305–308.
- Henry, L.-A., Roberts, J.M., (2007) Biodiversity and ecological composition of macrobenthos on cold-water coral mounds and adjacent off-mound habitat in the bathyal Porcupine Seabight, northeast Atlantic. *Deep-Sea Research Part 1*, 54, 654-672.
- Hibberd, T., Moore, K. (2009) Field identification guide to heard Island and macDonal Island benthic invertebrates: a guide for scientific observers aboard fishing vessels. Australian Government, Australia Antarctic Research Division, Hobart, Tasmania, Australia, 152pp.
- Hiddink, J.G., Jennings, S. and Kaiser, M.J. (2006) Indicators of the Ecological Impact of Bottom-Trawl Disturbance on Seabed Communities. *Ecosystems*, 9, 1190-1199.
- Hogg, M.M., Tendal, O.S., Conway, K.W., Pomponi, S.A., van Soest, R.W.M., Gutt, J., Krautter, M., Roberts, J.M. (2010) Deep-sea Sponge Grounds: Reservoirs of Biodiversity. UNEPWCMC Biodiversity Series No. 32. UNEP-WCMC, Cambridge, UK.
- ICES (2006) Report of the Working Group on Deep-water Ecology (WGDEC), 4–7 December 2005, Miami, USA. ICES CM 2006/ACE:04. 79pp.
- ICES (2007) Report of the Working Group on Deep-Water Ecology (WGDEC), 26–28 february 2007, ICES Cm 2007/aCE:01 Ref IRC. International Council for the Exploration of the Sea, Copenhagen, Denmark, 57pp.
- ICES (2008) Report of the ICES-NAFO Joint Working Group on Deep Water Ecology (WGDEC), 10–14 March 2008, Copenhagen, Denmark. ICES CM 2008/ACOM: 45. 126 pp.
- ICES (2009) Report of the ICES Advisory Committee, 2009. ICES Advice, 2009, Book 9, 1-6.
- ICES (2010) Report of ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 22–26 March 2010, Copenhagen, Denmark. ICES CM 2010/ACOM:26. 160pp
- ICES (2011) Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 28 February–4 March, Copenhagen, Denmark. ICES CM 2011/ACOM:27. 104pp.
- ISA (2010) Recommendations for the guidance of the contractors for the assessment of the possible environmental impacts arising from exploration for polymetallic nodules in the Area. Seventh session Kingston, Jamaica, 2–13 July 2001/ISBA/7/LTC/1/Rev.1.

- ISA (2011) Advisory opinion of the Seabed Disputes Chamber on the responsibilities and obligations of States sponsoring persons and entities with respect to activities in the Area. Seventeenth session, Kingston, Jamaica, 11–22 July 2011. ISBA/17/C/6–ISBA/17/LTC/5.
- IWC (2005) Report of the VMS Technical Specialist Group. http://www.iwcoffice.org/_documents/commission/RMSdocs/RMS3AnnexII.D.pdf
- Jensen, A., and Frederiksen, R. 1992. The fauna associated with the bank forming deepwater coral *Lophelia pertusa* (Scleractinaria) on the Faroe shelf. *Sarsia*, 77: 53–69.
- Kenchington, E., Best, M., Cogswell, A., MacIsaac, K., Murillo-Perez, F.J., MacDonald, B., Wareham, V., Fuller, S.D., Jørgensbye, H.I.Ø., Sklya, V. and Thompson, A.B. (2009) Coral Identification Guide NAFO Area. *Scientific Council Studies*, 42: 1-35. doi:10.2960/S.v42.m1.
- Koslow, J.A., Boehlert, G.W., Gordon, J.D.M., Haedrich, R.L., Lorange, P., Parin, N., (2000) Continental slope and deep-sea fisheries: implications for a fragile ecosystem. *ICES J. Mar. Sci.* 57, 548–557, doi:10.1006/jmsc.2000.0722.
- Koslow, J.A., Gowlett-Holmes, K. (1998) The seamount fauna off southern Tasmania: benthic communities, their conservation and impacts of trawling: Final Report to Environment Australia and the Fisheries Research and Development Corporation. Rep. FRDC Project 95/058, CSIRO, Hobart, Tasmania, Australia, 104pp.
- Koslow, J.A., Gowlett-Holmes, K., Lowry, J.K., et al. (2001) Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. *Marine Ecology Progress Series*, 213: 111–125.
- Krieger, K. (1998) Primnoa spp. observed inside and outside a bottom trawl path from a submersible. abstract. 10th Western Groundfish Conference, Asilomar, California, USA.
- Krieger, K.J. (2001) Coral (Primnoa) impacted by fishing gear in the Gulf of Alaska. In: Willison. J.H.M., Gass, S.E., Kenchington, E.I.R., et al. (eds) Proceedings of the first International Symposium on Deep-Sea Corals, Ecology Action Centre and Nova Scotia museum, Halifax, Nova Scotia, Canada, pp. 106–116.
- Large, P.A., Diez, G., Drewery, J., Laurans, M., Pilling, G. M., Reid, D. G., Reinert, J., South, A. B., and Vinnichenko, V. I. (2010) Spatial and temporal distribution of spawning aggregations of blue ling (*Molva dypterygia*) west and northwest of the British Isles. *ICES Journal of Marine Science*, 67: 494–501.
- López-Abellán, L.J., Holtzhausen, J.A., Agudo, L.M., Jiménez, P., Sanz, J.L., González-Porto, M., Jiménez, S., Pascual, R., González, J.F., Presas, C., Fraile, E. and Ferrer, M. (2008) Preliminary report of the multidisciplinary research cruise on the Walvis Ridge seamounts (Atlantic Southeast-SEAFO). Part II: 191pp. <http://www.repositorio.ieo.es/e-ieo/handle/10508/370?mode=full>
- Mora C., Tittensor D.T., Myers R.A. (2008) The completeness of taxonomic inventories for describing the global diversity and distribution of marine fishes. *Proceedings of the Royal Society B.*, 275, 149–155. doi:10.1098/rspb.2007.1315.
- Morato, T., Cheung, W.W.L., Pitcher, T.J. (2006a) Vulnerability of seamount fish to fishing: fuzzy analysis of life history attributes. *Journal of Fish Biology*, 68: 209-251.
- Morato, T., Watson, R., Pitcher, T.J., Pauly, D. (2006b) Fishing down the deep. *Fish and Fisheries*, 7, 24–34.
- Mortensen, P.B., Buhl-Mortensen, L., Gordon, D.C., et al. (2005) Evidence of fisheries damage to deep-water gorgonians in the Northeast Channel, Nova Scotia. In: Thomas, J., Barnes, P. (eds) Proceeding from the Symposium on the Effects of Fishing Activities on Benthic Habitats: Linking Geology, Biology, Socioeconomics and Management, American Fisheries Society, November 12–14, 2002, Florida, USA.
- Mortensen, P.B., Hovland, M.T., Fosså, J.H. and Furevik, D.M. (2001) Distribution, abundance and size of *Lophelia pertusa* coral reefs in mid-Norway in relation to seabed characteristics. *Journal of the Marine Biological Association of the UK* 81:581-597.
- Moura, T., Silva, M.C., Figueiredo, I., Neves, A., Coelho, M.M., Durán Muñoz, P. and Gordo, L.S. (2008) Molecular barcoding of northeast Atlantic deep-water sharks: species identification and application to fisheries management and conservation. *Marine and freshwater research* 59 (3) 214-223.
- MRAG (2005) IUU Fishing on the High Seas: Impacts on Ecosystems and Future Science Needs. MRAG, London 71pp.
- Murillo, F.J., Durán Muñoz, P., Altuna, A., and Serrano, A. (2011) Distribution of deep-water corals of the Flemish Cap, Flemish Pass, and the Grand Banks of Newfoundland (Northwest Atlantic Ocean): interaction with fishing activities. *ICES Journal of Marine Science*, 68: 319–332.
- NAFO (2009) Report of the Ad Hoc Working Group of Fishery Managers and Scientists on Vulnerable Marine Ecosystems (WGFMS) 19–20 March 2009. Vigo, Spain. NAFO FC Document 09/2, Serial No. N5625.
- NAFO (2011) NAFO Conservation and Enforcement Measures 2011. Available: <http://www.nafo.int/about/frames/about.html> [Accessed 24 May 2011]
- NEAFC (2010) Report of the 28th Annual Meeting of the North East Atlantic Fisheries Commission 9–13 November 2009. North East Atlantic Fisheries Commission, London, 25pp + Annexes (113pp total).
- NEAFC (2011) NEAFC Scheme of Control and Enforcement 2011. Available: <http://www.neafc.org/scheme> [Accessed 18 May 2011].
- NEAFC (2011) Consolidated text of all NEAFC recommendations on regulating Bottom Fishing. Article 5. Available: http://www.neafc.org/system/files/consolidated_bottomfishing_regulations.pdf
- Neat, F., Burns, F. (2010) Stable abundance, but changing size structure in grenadier fishes (Macrouridae) over a decade (1998–2008) in which deepwater fisheries became regulated. *Deep-Sea Research I*, 57, 434–440
- New Zealand Government (2010) Orange Roughy Challenger Plateau (ORH 7A) Fishery Summary. Available at: http://fs.fish.govt.nz/Doc/22207/54_ORH7A_2010.pdf.ashx, 10pp

References

- New Zealand Ministry of Fisheries (2008) Bottom Fishery Impact Assessment. Bottom Fishing Activities by New Zealand Vessels Fishing in the High Seas in the SPRFMO Area during 2008 and 2009. Available online: <http://www.southpacificrfmo.org/assets/Science/Benthic-Impact-Assessments/New-Zealand/New-Zealand-Bottom-Fishery-Impact-Assessment-v1.3-2009-05-13.pdf>
- NOAA National Marine Protected Areas Center (2005) Enforcing US Marine Protected Areas: Synthesis Report. <http://mpa.gov/pdf/publications/enforcement.pdf>
- NOCS (2010) Preparation of a bathymetric map and GIS of the South Atlantic Ocean and a review of available biologically relevant South Atlantic Seamount data for the SEAFO Scientific Committee. NOCS Research and Consultancy Report No.71. National Oceanography Centre, Southampton. 18pp.
- OSPAR (2003a) Guidance on developing an ecologically coherent network of OSPAR marine protected areas (reference Number 2003-3), www.ospar.org
- OSPAR (2003b) Guidelines for the Management of Marine Protected Areas in the OSPAR Maritime Area (Reference Number: 2003-18), www.ospar.org
- OSPAR (2007) Guidance to assess the effectiveness of management of OSPAR MPAs: a self-assessment scorecard (Reference number: 2007-5), www.ospar.org.
- Penney, A., Parker S.J., Brown, J., Cryer, M., Clark, M., Sims, B. (2008) New Zealand Implementation of the SPRFMO Interim Measures for High Seas Bottom Trawl Fisheries in the SPRFMO Area. Document SPRFMO-V-SWG-09. South Pacific Regional Fishery Management Organisation, Wellington.
- Penney, A.J., Parker, S.J., Brown, J.H. (2009) Protection measures implemented by new Zealand for vulnerable marine ecosystems in the South Pacific Ocean. *Marine Ecology Progress Series* 397: 341-354.
- Portela J.M., Pierce, G.J., del Río, J.L., Sacau, M., Patrocinio, T., Vilela, R. (2010) Preliminary description of the overlap between squid fisheries and VMEs on the high seas of the Patagonian Shelf. *Fisheries Research*, 106: 229-238.
- Priede, I.G., Godbold, J.A., Niedzielski, T., Collins, M.A., Bailey, D.M., et al. (2011) A review of the spatial extent of fishery effects and species vulnerability of the deep-sea demersal fish assemblage of the Porcupine Seabight, Northeast Atlantic Ocean (ICES Subarea VII). *ICES Journal of Marine Science*, 68, 281-289.
- Ramirez-Llodra, E., Brandt, A., Danovaro, R., Mol, B.D., Escobar, E., et al. (2010) Deep, diverse and definitely different: unique attributes of the world's largest ecosystem. *Biogeosciences*, 7, 2851–2899.
- Reed, J.K., Shepard, A.N., Koenig, C.C., et al. (2005) Mapping, habitat characterization, and fish surveys of the deep-water *Oculina* coral reef Marine Protected Area: a review of historical and current research. In: Freiwald, A., Roberts, J.M. (eds) *Cold-Water Corals and Ecosystems*, Springer-Verlag, Berlin Heidelberg, pp.443–465.
- Rice, J. (2010) Review of Progress on Implementation of the FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas – Experience of RFMO/As with identifying and protecting VMEs. Discussion paper 2. FAO workshop on implementation of the Deepwater Guidelines, Busan, May 2010.
- Roark, E.B., Guilderson, T.P., Dunbar, R.B., Ingram, B.L. (2006) Radiocarbon-based ages and growth rates of Hawaiian deep-sea corals. *Mar Ecology Progress Series* 327:1–14.
- Roberts, J., Wheeler, A.J., Freiwald, A. (2006). *Reefs of the Deep: The Biology and Geology of Cold-Water Coral Ecosystems*. *Science* 312: 543-547.
- Roberts, J.M., Davies, A.J., Henry, L.A., Duineveld, G., Lavaleye, M., Dodds, L.A., Maier, C., Van Soest, R.W.M., Bergman, M.I.N., Hühnerbach, V., Sinclair, D., Watmough, T., Long, D., Van Haren, H. (2009) The Mingulay reef complex, Northeast Atlantic: an interdisciplinary study of coldwater coral habitat, hydrography and biodiversity. *Marine Ecology Progress Series* 397: 139–151.
- Rogers, A.D., Clark, M.R., Hall-Spencer, J.M. and Gjerde, K.M. (2008) The Science behind the Guidelines: A Scientific Guide to the FAO Draft Guidelines (December 2007) for the Management of Deep-Sea Fisheries in the High Seas and Examples of How the Guidelines may be practically implemented. *IUCN Global Marine Programme Report*, 39pp.
- Rogers, A.D., Gianni, M. (2010) The Implementation of UNGA Resolutions 61/105 and 64/72 in the Management of Deep-Sea Fisheries on the High Seas. Report prepared for the Deep-Sea Conservation Coalition. International Programme on the State of the Ocean, London, United Kingdom, 97pp.
- Rowden, A.A., Clark, M.R., O’Shea, S. (2004) The influence of deep-water coral habitat and fishing on benthic faunal assemblages of seamounts on the Chatham Rise, New Zealand. *ICES CM2004/AA:09*.
- Sayago-Gil, M., Long, D., Fernández-Salas, L.M., Hitchen, K., López-González, N., Díaz-del-Río, V. and Durán-Muñoz, P. (2009) Geomorphology of the Talismán Slide (Western slope of Hatton Bank, northeast Atlantic Ocean). D.C. Mosher et al. (eds.), *Submarine Mass Movements and Their Consequences*, 289 *Advances in Natural and Technological Hazards Research*, Vol 28, © Springer Science + Business Media B.V. 2010.
- Sayago-Gil, M., Durán-Muñoz, P., Vázquez, J.T., and Díaz-del-Río, V. (2010a) Western slope of Hatton Bank (northeast Atlantic Ocean): geo-environmental constraints in relationship to deep sea ecosystems. *GeoTemas*, 11:155-156.
- Sayago-Gil, M. Long, D., Hitchen, K., Díaz-del-Río, V., Fernández-Salas, L.M., and Durán-Muñoz, P. (2010b) Evidence for current-controlled morphology along the western slope of Hatton Bank (Rockall Plateau, northeast Atlantic Ocean). *Geo-Marine Letters*, 30: 99-111.
- SEAFO (2006) Conservation Measures 06/06 on the Management Of Vulnerable Deep Water Habitats And Ecosystems In The SEAFO Convention Area (Approved 10/2006). South East Atlantic Fisheries Organization. 5pp.
- SEAFO (2007a) Conservation measure 11/07 laying down conditions for the resumption of fishing activities in areas

- subject to closure through conservation measure 06/06. South East Atlantic Fisheries Organisation <http://www.seafo.org/ConservationManagementMeasures.html>
- SEAFO (2007b) Report of the SEAFO Scientific Committee 2007. 56pp. Available at: <http://www.seafo.org/SCAnnualReports.html>
- SEAFO (2008) Report of the SEAFO Scientific Committee 2008. Available at: <http://www.seafo.org/SCAnnualReports.html>
- SEAFO (2009) Identification Guide for corals and sponges for use by sea-going observers in the SEAFO Convention Area. 10pp. Available at: <http://www.seafo.org/GuideCorals.html>
- SEAFO (2010a) Report of the SEAFO Scientific Committee 2010. 52pp. Available at: <http://www.seafo.org/SCAnnualReports.html>
- SEAFO (2010b) Report of the 7th Annual Meeting of the Commission, 2010. 152pp. <http://www.seafo.org/CommAnnualReports.html>
- Sharp, B.R. (2009) An impact assessment framework for bottom fishing methods in CCAMLR Convention Area. *CCAMLR Science* 16, 195-201.
- Shester, G., Ayers, J. (2005) A cost effective approach to protecting deep-sea coral and sponge ecosystems with an application to Alaska's Aleutian Islands region. In: Freiwald, A., Roberts, J.M. (eds) *Cold-Water Corals and Ecosystems*, Springer-Verlag, Berlin Heidelberg, pp. 1151–1169.
- Smith, A.D.M., Brown, C.J., Bulman, C.M., Fulton, E.A., Johnson, P., Kaplan, I.C., Lozano-Montes, H., Mackinson, S., Marzloff, M., Shannon, L.J., Shin, Y-J., Tam, J. (2011) Impacts of Fishing Low-Trophic Level Species on Marine Ecosystems. *Science* 21 July 2011: 1209395DOI:10.1126/science.1209395.
- Stone, R.P. (2006) Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. *Coral Reefs* 25: 229–238.
- Stone, R.P., Masuda, M.M., Malecha, P.W. (2005) Effects of bottom trawling on soft sediment epibenthic communities in the Gulf of Alaska. In: Barnes, P.B., Thomas, J.P. (eds) *Benthic habitats and the effects of fishing*. American Fisheries Society, Symposium 41, Bethesda, Maryland, USA, pp. 461–475.
- Stuart, C.T., Rex, M.A. and Etter R.J. (2003) Large-scale spatial and temporal patterns of deep-sea benthic species diversity. pp.295–311. In: *Ecosystems of the World*. Tyler, P.A. (ed). Elsevier.
- Swartz, W., Sala, E., Tracey, S., Watson, R., Pauly, D. (2010) The Spatial Expansion and Ecological Footprint of Fisheries (1950 to Present). *PLoS ONE* 5(12): E15143. doi:10.1371/journal.pone.0015143.
- Tittensor, D.P., Baco, A.R., Brewin, P.E., Clark, M.R., Consalvey, M., Hall-Spencer, J.M., Rowden, A.A., Schlacher, T., Stocks, K.I., Rogers, A.D. (2009) Predicting global habitat suitability for stony corals on seamounts. *Journal of Biogeography*, 36, 1111–1128.
- Tracey, D.M., Neil, H., Marriott, P., Andrews, A.H., Cailliet, G.M., Sanchez, J.A. (2007) Deep-sea scleractinian coral age and depth distributions in the northwest Atlantic for the last 225,000 years. *Bulletin of Marine Science* 81(3) 393–408.
- UNEP (2007) *Deep-sea Biodiversity and Ecosystems: a scoping report on their socio-economy, management and governance*. UNEP-WCMC Cambridge, UK. 84pp.
- UNGA (2004) Resolution 59/25 Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. UNGA A/RES/59/25.16pp. Available at: http://www.un.org/Depts/los/general_assembly/general_assembly_reports.htm.
- UNGA (2007) Resolution 61/105 Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. UNGA A/RES/61/105. 21pp. Available at: http://www.un.org/Depts/los/general_assembly/general_assembly_resolutions.htm
- UNGA (2009) Resolution 64/72 Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. 26pp. Available at: http://www.un.org/Depts/los/general_assembly/general_assembly_resolutions.htm
- Waller, R., Watling, L., Auster, P, et al. (2007) Anthropogenic impacts on the Corner Rise Seamounts, north-west Atlantic Ocean. *Journal of the Marine Biological Association of the UK* 87(5): 1075–1076.
- WGEAFM (2008) Report of the NAF O SC Working Group on Ecosystem Approach to Fisheries Management (WGEAFM) Response to Fisheries Commission Request 9.a. NAF O Scientific Council Meeting October 2008, Serial Number 5592, NAFO SCS Doc. 08/24, 19pp.
- WGEAFM (2009) Report of the NAFO Scientific Council Working Group on Ecosystem Approach to Fisheries Management (WGEAFM). Northwest Atlantic Fisheries Organisation Scientific Council Meeting, June 2008 Ser. No. N5511 NAF O SCS Doc 08/10, 70pp.
- Wheeler, A.J., Bett, B.J., Billett, D.S., et al. (2005) The impact of demersal trawling on northeast Atlantic coral habitats: The case of the Darwin mounds, United Kingdom. In: Barnes, P.W., Thomas, J.P. (eds) *Benthic habitats and the Effects of fishing*, American Fisheries Society Symposium 41, Bethesda, Maryland, USA, pp. 807–817.
- Wilson, M. F. J., O'Connell, B., Brown, C., Guinan, J.C., Grehan, A.J. (2007). Multi-scale terrain analysis of multibeam bathymetry data for habitat mapping on the continental slope. *Marine Geodesy* 30, 3-35.

Annexes

ANNEX 1

Key paragraphs in UNGA resolution 61/105

61/105 83(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;

61/105 83(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 deep sea fish stocks, *inter alia*, by improving scientific research and data collection and sharing, and through new and exploratory fisheries”.

61/105 83(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;”

61/105 83(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.”

“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...”

ANNEX 2

Key paragraphs in UNGA 64/72

64/72 119(a): “Conduct the assessments called for in paragraph 83 (a) of its resolution 61/105, consistent with the [FAO] Guidelines, and to ensure that vessels do not engage in bottom fishing until such assessments have been carried out;”

64/72 119(b): “Conduct further marine scientific research and use the best scientific and technical information available to identify where vulnerable marine ecosystems are known to occur or are likely to occur and adopt conservation and management measures to prevent significant adverse impacts on such ecosystems consistent with the [FAO] Guidelines, or close such areas to bottom fishing until conservation and management measures have been established, as called for in paragraph 83 (c) of its resolution 61/105;”

64/72 119(c): “Establish and implement appropriate protocols for the implementation of paragraph 83 (d) of its resolution 61/105, including definitions of what constitutes evidence of an encounter with a vulnerable marine ecosystem, in particular threshold levels and indicator species, based on the best available scientific information and consistent with the Guidelines, and taking into account any other conservation and management measures to prevent significant adverse impacts on vulnerable marine ecosystems, including those based on the results of assessments carried out pursuant to paragraph 83 (a) of its resolution 61/105 and paragraph 119 (a) of the present resolution;”

64/72 119(d): “Adopt conservation and management measures, including monitoring, control and surveillance measures, on the basis of stock assessments and the best available scientific information, to ensure the long-term sustainability of deep sea fish stocks and non-target species, and the rebuilding of depleted stocks, consistent with the Guidelines; and, where scientific information is uncertain, unreliable, or inadequate, ensure that conservation and management measures are established consistent with the precautionary approach, including measures to ensure that fishing effort, fishing capacity and catch limits, as appropriate, are at levels commensurate with the long-term sustainability of such stocks”.

64/72 120: Calls upon Flag States, members of regional fisheries management organizations or arrangements with the competence to regulate bottom fisheries and States participating in negotiations to establish such organizations or arrangements to adopt and implement

measures in accordance with paragraphs 83, 85 and 86 of resolution 61/105, paragraph 119 of the present resolution, and international law, and consistent with the Guidelines, and not to authorize bottom fishing activities until such measures have been adopted and implemented.

64/72 122. Calls upon States and regional fisheries management organizations or arrangements to enhance efforts to cooperate to collect and exchange scientific and technical data and information related to the implementation of the measures called for in the relevant paragraphs of its resolution 61/105 and the present resolution to manage deep sea fisheries in areas beyond national jurisdiction and to protect vulnerable marine ecosystems from significant adverse impacts of bottom fishing by, *inter alia*:

(a) **Exchanging** best practices and developing, where appropriate, regional standards for use by States engaged in bottom fisheries in areas beyond national jurisdiction and regional fisheries management organizations or arrangements with a view to examining current scientific and technical protocols and promoting consistent implementation of best practices across fisheries and regions, including assistance to developing States in accomplishing these objectives;

(b) **Making** publicly available, consistent with domestic law, assessments of whether individual bottom fishing activities would have significant adverse impacts on vulnerable marine ecosystems and the measures adopted in accordance with paragraphs 83, 85 and 86, as appropriate, of its resolution 61/105, and promoting the inclusion of this information on the websites of regional fisheries management organizations or arrangements;

(c) **Submission** by flag States to the Food and Agriculture Organization of the United Nations of a list of those vessels flying their flag authorized to conduct bottom fisheries in areas beyond national jurisdiction, and the measures they have adopted to give effect to the relevant paragraphs of its resolution 61/105 and the present resolution;

(d) **Sharing** information on vessels that are engaged in bottom fishing operations in areas beyond national jurisdiction where the flag State responsible for such vessels cannot be determined;

64/72 123. Encourages States and regional fisheries management organizations or arrangements to develop or strengthen data collection standards, procedures and protocols and research programmes for identification of vulnerable marine ecosystems, assessment of impacts on such ecosystems, and assessment of fishing activities on target and non-target species, consistent with the Guidelines and in accordance with the Convention, including Part XIII;

ANNEX 3

Key paragraphs of the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas

Paragraph 47 of the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas establishing internationally agreed criteria for **conducting impact assessments**:

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 longterm conservation and sustainable utilization of low-productivity fishery resources, and the measures to be used to monitor effects of the fishing operations.”

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Paragraph 42 of the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas establishing internationally agreed criteria for **identifying vulnerable marine ecosystems**:

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 or ecosystems. 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 the Annex (to the Guidelines).”

Paragraphs 16–20 of the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas establishing internationally agreed criteria for **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 of its 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 should maintain and periodically update vessel registers or records to document changes in fleet characteristics. Registers or records of vessels authorised to fish should contain detailed information on each vessel...”

“States should adopt and implement, consistent with international law and in a transparent and non-discriminatory manner, trade-related measures, such as catch and trade documentation schemes...”

States and RFMO/As should apply the precautionary approach in their determinations regarding the nature and duration of impacts.

Paragraphs 54–60 of the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas establishing internationally agreed criteria for enforcement and compliance.

54. MCS frameworks should be developed and implemented as vital components for regional and national conservation and management measures for DSFs. States, both individually and cooperatively through RFMO/As, should work to implement effective MCS frameworks. States and RFMO/As should ensure compliance with conservation and management measures for DSFs through effective MCS programmes, which may include, inter alia, on-board observers, electronic monitoring and satellite-based vessel monitoring systems (VMS) in order to provide information on the location of fishing vessels engaged in DSFs, better assess fishing effort by gear, verify catch data, improve compliance with temporal and spatial management measures and provide sufficient evidence to document infractions. Such frameworks should ensure that all DSFs fishing operations are effectively monitored. States are encouraged to participate in the voluntary International Monitoring, Control and Surveillance Network for Fisheries-Related Activities.

55. National or international cooperative observer programmes should be implemented for all DSFs. Observer coverage for established fisheries, at levels adequate to ensure effective monitoring and assessment and in combination with other MCS tools, should be determined by RFMO/As with competence over those fisheries. Higher levels of coverage are required, in particular for experimental and exploratory stages of a fishery's development under a RFMO/A and for fisheries outside of a RFMO/A. In the latter case, levels of coverage should remain high until measures in place to manage these fisheries and prevent significant adverse impacts are evaluated and determined to be effective.

56. States should maintain and periodically update vessel registers or records to document changes in fleet characteristics. Registers or records of vessels

authorised to fish should contain detailed information on each vessel including, at a minimum: length, tonnage, types of gear, and the areas, fisheries and species for which the vessels are authorized to fish, and whether the vessels are authorized for DSFs. Flag States should ensure that all vessels conducting DSFs have a permanent identification (such as an International Maritime Organization number).

57. States should submit vessel register or record data on at least an annual basis to RFMO/As, where applicable, or, for areas where RFMO/As do not exist, to FAO together with information on the measures they have adopted to regulate the activities of such vessels. RFMO/As and FAO should make such data and information publicly available by FAO Statistical Area.

58. States should adopt and implement national legislation and measures aimed at preventing, deterring and eliminating IUU fishing in DSFs, including using the IPOA-IUU, the 2005 FAO Model Scheme on Port State Measures to Combat Illegal, Unreported and Unregulated Fishing and other relevant instruments.

59. States and RFMO/As should cooperate to prevent, deter and eliminate IUU fishing in DSFs, and to take action related to IUU vessels and their listing.

60. States should adopt and implement, consistent with international law and in a transparent and non-discriminatory manner, trade-related measures, such as catch and trade documentation schemes, in order to:
i. enhance their ability to identify vessels and their DSF catch harvested outside or in contravention of applicable conservation and management measures; and
ii. adopt measures in respect of IUU vessels and catches from DSFs including, as appropriate, measures to prevent products from IUU DSFs from entering international trade. States should actively promote wide international cooperation in order to attain such goals.

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ANNEX 4

Preliminary questions to participants prior to the Lisbon workshop

Impact assessments

1. Have bottom fishing nations and RFMOs carried out the impact assessments on individual fisheries consistent with the criteria established in paragraph 47 of the FAO Guidelines?
2. If not, what more should be done to ensure effective impact assessments?
3. Where impact assessments have been carried out, has the quality of the impact assessments been sufficient to:
 - a. identify all areas where VMEs are known or likely to occur?
 - b. determine whether significant adverse impacts to VMES would occur as a result of bottom fishing?
4. Are the mitigation and management measures established in areas where bottom fishing continues to be permitted on the high seas sufficient to prevent significant adverse impacts on VMEs and the long-term sustainability of deep-sea fish stocks based on the findings of the impact assessments?

Identify VMEs and close areas where VMES are known or likely to occur, unless bottom fisheries in these areas can be managed to prevent significant adverse impacts

1. Have the criteria for indentifying VMEs been comprehensively applied?
2. Have sufficient areas where VMEs are known or likely to occur been closed to bottom fishing to prevent significant adverse impacts on VMEs?
3. For those areas that have been closed to bottom fishing, are the duration and extent of closures sufficient?
4. Are the management measures in place for the fisheries sufficient to prevent significant adverse impacts to VMEs where bottom fisheries are permitted in areas where VMEs are known or likely to occur?

Sustainability of deep-sea fish stocks

1. Are the management measures in place sufficient to ensure the long-term sustainability of deep-sea fish stocks and non-target species, and the rebuilding of depleted stocks?
2. Is the precautionary approach being applied to setting limits on the catch or bycatch of deep-sea species where scientific information is uncertain, unreliable or inadequate?
3. If not, what more should be done to ensure the long-term sustainability of target and bycatch species in the deep-sea fisheries?

Move-on rule

1. How effective are the move-on rules as they apply to both mobile gears (trawling), and static gears (longlining)?
2. Are the threshold limits established to trigger the move-on rule sufficient to protect VMEs? Can they ever be? If so, how?
3. How effective in preventing significant adverse impacts on VMEs is the relocation by 2 nm, when the trawl may be 30 km in length?
4. Has CCAMLR made the move-on rule effective with respect to bottom longline gear?



The crab *Lithoides* sp. and coral *Lophelia* sp.

